New Jersey
Department of Environmental Protection

VAPOR INTRUSION SCREENING LEVELS

BASIS AND BACKGROUND

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1. Introduction

The Department has updated the March 2013 Vapor Intrusion Screening Levels (VISL) based on promulgation of the Department's Indoor Air Remediation Standards for the vapor intrusion (VI) exposure pathway at N.J.A.C. 7:26D. The updated VISL were developed consistent with the risk-based information (e.g., toxicity factors, exposure parameters) utilized in the develop of the Indoor Air Remediation Standards that may be accessed at https://www.nj.gov/dep/srp/guidance/rs/index.html.

The VISL include Ground Water Screening Levels (GWSL), Soil Gas Screening Levels (SGSL) and Indoor Air Rapid Action Levels (RAL) are used in the evaluation of a site for the VI exposure pathway as outlined in the Department's *Vapor Intrusion Technical Guidance (VIT)*, Version 5.0 (https://www.nj.gov/dep/srp/guidance/vaporintrusion/index.html). The screening levels presented in Tables 1 through 3 of the *Vapor Intrusion Screening Levels and Indoor Air Remediation Standards Tables* (https://www.nj.gov/dep/srp/guidance/vaporintrusion/index.html) have been developed for the Indoor Air Remediation Standards list of contaminants. Table 1 includes the GWSL and SGSL, in addition to the associated Indoor Air Remediation Standards. Table 2 presents the indoor air RAL. Table 3 includes GWSL based on the determination of alternate soil textures at a site.

The procedures used in the development of the Department's VISL are outlined below. Tables A-1 through A-5, located at the end of this document, present the information included in the generation of the VISL. Application of the VISL and the development of alternative values are discussed in Appendix G of the Department's *VIT* guidance document (https://www.nj.gov/dep/srp/guidance/vaporintrusion/index.html). Contacts for technical questions on the VISL can be found at https://www.nj.gov/dep/srp/guidance/vaporintrusion/vicontacts.htm.

2. Ground Water Screening Levels

The Johnson and Ettinger (J&E) model was used to calculate GWSL for VI (Johnson and Ettinger 1991; USEPA 2002). The United States Environmental Protection Agency (USEPA) has released a series of spreadsheets that incorporate the model and calculate GWSL (USEPA 2004). New Jersey versions of the USEPA 2004 Version 3.1 spreadsheets have been prepared and released by the Department containing updated toxicity factors, chemical properties, and an appropriate ground water temperature. A recently released update to the USEPA version of the spreadsheet (Version 6.0, 2017) is not yet being used by the Department because some errors were identified in the functioning of the spreadsheet, and the value for one key default building parameter was changed without documentation that justified the new value. Communication with the USEPA indicated that the spreadsheet is still under development and not yet suitable for use. However, the updated chemical database in this spreadsheet was useful for obtaining values for the critical temperature and ethalpy of vaporization for certain contaminants (see Table A-2).

In accordance with Departmental policy, when calculated health-based screening values were below the current New Jersey Ground Water Remediation Standards (GWRS), the screening levels were set at the higher GWRS instead of the calculated values. Table A-1 presents the calculated health-based screening values and the applicable GWRS. Table 1 of the *Vapor Intrusion Screening Levels and Indoor Air Remediation Standards Tables*

(https://www.nj.gov/dep/srp/guidance/vaporintrusion/index.html) reflects the GWSL after consideration of the calculated values and the GWRS.

2.1. Input Parameters for the Johnson and Ettinger (J&E) Model

2.1.1. Soil Texture

Sandy soil is common in much of the southern half of New Jersey (Tedrow 1986). Therefore, this soil texture is appropriate for estimating GWSL for the VI pathway, since heavier soil types (sandy loam, loam, etc.) provide more resistance to contaminant diffusion through the soil column. Additionally, the USEPA generic ground water screening levels in their *Draft Subsurface Vapor Intrusion Guidance* (USEPA 2002) use an attenuation factor of 1×10^{-3}, which corresponds to the approximate attenuation factor calculated using the J&E model with sand soil. Therefore, this soil texture was selected for development of the GWSL, and was used in all locations in the spreadsheet where a soil texture was required (soil texture just above water table, soil texture in vadose zone for estimation of soil physicochemical properties, and soil texture to estimate soil permeability).

2.1.2. Soil Chemical and Physical Properties

These parameters are pre-set in the spreadsheet according to the soil texture. Since sand was used for the calculations, the following values were incorporated: vadose zone dry soil bulk density, 1.66 gm/cm^3; vadose zone soil total porosity, 0.375; vadose zone soil water-filled porosity, 0.054; vadose zone soil effective permeability, 9.98E-08 cm^2. The soil organic carbon fraction is fixed at 0.002 in the GW-SCREEN spreadsheet, but does not affect results when the source of the contamination is the ground water.

2.1.3. Chemical Properties

Chemical properties in the spreadsheet were updated to those listed in the USEPA Regional Screening Levels (RSL) Tables (https://www.epa.gov/risk/regional-screening-levels-rsls). The USEPA data sources have become a de facto national reference source for regulatory chemical properties and toxicity factors. Values were drawn from the May 2018 listing of chemical properties (see Table A-2). The chemical properties used in the J&E spreadsheet are the organic carbon partition coefficient, the diffusivity in air, the diffusivity in water, the water solubility, the Henry's law constant, the boiling point, the critical temperature, and the enthalpy of vaporization at the normal boiling point. Boiling point, critical temperature, and enthalpy of vaporization are not listed in the above tables. Boiling points were determined using USEPA's EPI Suite Program (https://www.epa.gov/tsca-screening-tools), the same program used by the USEPA for determining their above listed chemical properties. Critical temperatures, and enthalpies of vaporization at the normal boiling point, were taken from the Hazardous Substances Databank (HSDB), https://pubchem.ncbi.nlm.nih.gov/source/Hazardous%20Substances%20Data%20Bank%20(HSDB) or the USEPA J&E spreadsheets when not available on the HSDB. When the J&E spreadsheets were needed for chemical properties, the newest chemical database, in the Version 6.0 update of the J&E spreadsheets, at https://www.epa.gov/vaporintrusion/epa-spreadsheet-modeling-subsurface-vapor-intrusion, was used.

2.1.4. Exposure Parameters and Toxicity Factors

The GWSL were based on residential land use and incorporate the residential exposure parameters utilized in the development of the Indoor Air Remediation Standards for the VI exposure pathway. The Department, as mandated by the Brownfield Contaminated Site Remediation Act (N.J.S.A. 58:10B-1 et seq.), used an incremental lifetime cancer risk of 1 x 10^{-6} and a Hazard Quotient (HQ) of 1 in the development of the screening levels. Other parameters were: averaging time for carcinogens, 70 years; averaging time for non-carcinogens, 26 years; exposure duration, 26 years; exposure frequency, 350 days/year. The toxicity factors used were consistent with those used in the development of the Indoor Air Remediation Standards for the VI exposure pathway (see Table A-3).

2.1.5. Chemical-specific adjustments

In order to make an allowance for known hydrocarbon degradation under VI scenarios, the GWSLs for these chemicals calculated using the J&E model were multiplied by a factor of ten. The chemicals for which this adjustment was made were benzene, cyclohexane, ethyl benzene, n-hexane, naphthalene, styrene, toluene, 1, 2, 4- trimethylbenzene and xylene.

2.1.6. Building Parameters

As recommended and discussed in the USEPA *Draft Subsurface Vapor Intrusion Guidance* (USEPA 2002), the soil gas entry rate (Qsoil) was set at 5 L/min. The building air exchange rate is fixed in GW-SCREEN at 0.25/hr according to USEPA recommendations. The building type used for generation of screening numbers was the generic size recommended for buildings with basements – a floor area of 10 m by 10 m and a height of 3.66 m. Contaminants entering the building are assumed to immediately mix into this volume.

2.1.7. Other Parameters

The depth to ground water was fixed at 352.5 cm below ground surface. This is equivalent to 5 feet below the building foundation (which extends to a depth of 200 cm, or 6.5 feet) and is the minimum separation between the building and the ground water recommended for using the J&E model (USEPA 2002). The ground water temperature for the Department's screening criteria was set at 13°C. This is equivalent to the average temperature of two shallow ground water monitoring wells in the Kirkwood-Cohansey aquifer that had installed temperature monitors at depth (United States Geological Survey 2003). Shallow ground water temperatures in New Jersey generally fluctuate between 10 and 15°C.

2.2. Default Screening Numbers for Alternate Soil Textures

Using the J&E model, the Department has developed GWSL for Alternate Soil Textures, which are shown in Table 3 of the *Vapor Intrusion Screening Levels and Indoor Air Remediation Standards Tables* (https://www.nj.gov/dep/srp/guidance/vaporintrusion/index.html). The screening levels were developed using the same "default" values and assumptions used in the generic GWSL except for those based on soil texture. Table 3 includes screening levels for loamy sand, sandy loam and loam soil textures. Values for vadose zone soil bulk density, total porosity and water filled porosity are built into the J&E spreadsheet and set according to the selected soil texture. Use of these values requires the determination of site-specific soil texture

as described in the NJDEP *VIT* Guidance document (see Appendix G) that may be accessed at https://www.nj.gov/dep/srp/guidance/vaporintrusion/index.html.

3. Soil Gas Screening Levels

The following equation, used in the generation of the previous SGSL, was used in the development of the residential and nonresidential health-based soil gas screening values.

3.1. Health-Based Soil Gas Screening Level:

$$Health-based\ Screening\ Value\left(\frac{\mu g}{m^3}\right) = Health-based\ Indoor\ Air\ Value\left(\frac{\mu g}{m^3}\right) \Big/ \alpha$$

The residential and nonresidential health-based soil gas screening values were calculated by dividing the applicable Indoor Air Remediation Standards human health-based indoor air criteria by an attenuation factor (α) of 0.02. The attenuation factor is the ratio of the indoor air concentration measured in a residence to the vapor concentration measured in the subsurface materials underlying or adjacent to the residence (USEPA 2002). The USEPA, in its current vapor intrusion guidance (USEPA 2015), recommends an attenuation factor of 0.03, which is drawn from a report on the USEPA Vapor Intrusion Database (USEPA 2012). The Department has also evaluated the 2012 report and feels that the current New Jersey value of 0.02 continues to be satisfactory (see Appendix B of this document).

Consistent with the development of the Indoor Air Remediation Standards for the VI exposure pathway, the health-based soil gas screening criteria default to the analytical reporting limit, when higher (see Table A-4). The resulting SGSL are presented in Table 1 of the *Vapor Intrusion Screening Levels and Indoor Air Remediation Standards Tables* (https://www.nj.gov/dep/srp/guidance/vaporintrusion/index.html).

4. Indoor Air Rapid Action Levels (RAL)

Residential and nonresidential indoor air RAL have been developed for the Indoor Air Remediation Standards list of contaminants. The RAL were calculated by applying a factor of 100 times for carcinogens and a factor of 2 times for non-carcinogens to the rounded Indoor Air Remediation Standards human health-based indoor air criteria (see Table A-5). The resulting RAL, presented in Table 2 of the *Vapor Intrusion Screening Levels and Indoor Air Remediation Standards Tables* (https://www.nj.gov/dep/srp/guidance/vaporintrusion/index.html), are the lower of the cancer and non-cancer values that default to the analytical reporting limits, when higher.

5. Elemental Mercury

Residential and nonresidential RAL have been developed for elemental mercury as outlined above. The Department recommends use of NIOSH Method 6009 for the analysis of elemental mercury in indoor air. NIOSH Method 6009 notes that the Limit of Detection for the method is 0.03 µg. The method further states that 2 to 100 L of air may be sampled. Based on this information, the theoretical reporting limit could be 0.03 µg/100L or 0.3 µg/m^3. Allowing for

differences in sampling variability and recognizing a reporting limit of 0.3 µg/m^3 may be unrealistic at this time, the Department is requiring a reporting limit of 1 µg/m^3. As indicated in Table A-5, this reporting limit has been considered in the development of the above values.

Elemental mercury SGSL and GWSL have not been included in the *Vapor Intrusion Screening Levels and Indoor Air Remediation Standards Tables* since (1) the contaminant is typically associated with use within a building rather than related to the VI exposure pathway and (2) sample collection and analytical methods used are an issue when evaluating the levels of elemental mercury (rather than total mercury) present in soil gas and/or ground water. The Department should therefore be contacted concerning the appropriate analytical methods and screening levels to be used if VI is determined to be an issue for elemental mercury at a site. Contacts for technical questions can be found at https://www.nj.gov/dep/srp/guidance/vaporintrusion/vicontacts.htm.

6. Calculation Procedures Used in the Development of the Screening Levels

The VISL have been rounded to two significant figures, consistent with the development of the Indoor Air Remediation Standards for the VI exposure pathway. As noted previously, the screening levels were determined as the lower of the cancer and non-cancer health-based values that default to the analytical reporting limits, when higher. With the exception noted below, the air analytical reporting limits used in the development of the SGSL and RAL were based on the NJDEP Low Level Method TO-15 (https://www.nj.gov/dep/srp/guidance/vaporintrusion/newmethod2007/llto15.pdf). The analytical reporting limit used in the development of the elemental mercury screening levels was based on NIOSH Method 6009 and the Department's discussion above (see Elemental Mercury section) regarding sampling variability for elemental mercury in indoor air.

In accordance with Departmental policy, when the ground water health-based screening values were below the current New Jersey GWQS, the screening levels were set at the higher GWQS. The derivation of the VISL, including the health-based values and applicable analytical reporting limits or GWQS, are presented in Tables A-1 through A-5.

References

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APPENDIX A

TABLES

TABLE A-1

DERIVATION OF THE NJDEP VAPOR INTRUSION GROUND WATER SCREENING LEVELS (GWSL)

Chemical	CAS No.	Cancer/ Noncancer[a]	Health-Based Ground Water to Indoor Air Values (µg/L)	NJDEP Ground Water Remediation Standards (µg/L)	NJDEP Ground Water Screening Levels (µg/L)[b]
Acetone (2-Propanone)	67-64-1		-	6,000	**-**
Benzene	71-43-2	C	23[c]	1	**23[c]**
Bromodichloromethane (Dichlorobromomethane)	75-27-4		-	1	**-**
Bromoform	75-25-2		-	4	**-**
Bromomethane (Methyl bromide)	74-83-9	N	20	10	**20**
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	N	2,500,000	300	**2,500,000**
Carbon disulfide	75-15-0	N	1,500	700	**1,500**
Carbon tetrachloride	56-23-5	C	0.81	1	**1.0**
Chlorobenzene	108-90-7	N	770	50	**770**
Chloroethane (Ethyl chloride)	75-00-3	N	26,000	5	**26,000**
Chloroform	67-66-3	N	1,000	70	**1,000**
Chloromethane (Methyl chloride)	74-87-3	N	240	-	**240**
Cyclohexane	110-82-7	N	16,000[c]	-	**16,000[c]**
Dibromochloromethane (Chlorodibromomethane)	124-48-1		-	1	**-**
1,2-Dibromoethane (Ethylene dibromide)	106-93-4	C	0.45	0.03	**0.45**
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	N	6,800	600	**6,800**
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	N	21,000	75	**21,000**
Dichlorodifluoromethane (Freon 12)	75-71-8		-	1,000	**-**
1,1-Dichloroethane	75-34-3		-	50	**-**
1,2-Dichloroethane	107-06-2	N	230	2	**230**
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	N	26	1	**26**
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	159-59-2		-	70	**-**
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5		-	100	**-**
1,2-Dichloropropane	78-87-5	C	11	1	**11**
1,3-Dichloropropene (total)	542-75-6	C	8.4	1	**8.4**
1,4-Dioxane	123-91-1	C	2,500	0.4	**2,500**
Ethylbenzene	100-41-4	C	70[c]	700	**700**

TABLE A-1

DERIVATION OF THE NJDEP VAPOR INTRUSION GROUND WATER SCREENING LEVELS (GWSL)

Chemical	CAS No.	Cancer/ Noncancer[a]	Health-Based Ground Water to Indoor Air Values (µg/L)	NJDEP Ground Water Remediation Standards (µg/L)	NJDEP Ground Water Screening Levels (µg/L)[b]
Hexachloro-1,3-butadiene	87-68-3		-	1	**-**
n-Hexane	110-54-3	N	160[c]	30	**160[c]**
Mercury (elemental)	7439-97-6	N	-	-	-
Methylene chloride (Dichloromethane)	75-09-2	C	2,600	3	**2,600**
4-Methyl-2-pentanone (MIBK)	108-10-1	N	900,000	-	**900,000**
Methyl tert-butyl ether (MTBE)	1634-04-4	C	690	70	**690**
Naphthalene	91-20-3	C	110[c]	300	**300**
Styrene	100-42-5	N	180,000	100	**180,000**
1,1,2,2-Tetrachloroethane	79-34-5		-	1	**-**
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	C	36	1	**36**
Toluene	108-88-3	N	330,000[c]	600	**330,000[c]**
1,2,4-Trichlorobenzene	120-82-1	N	130	9	**130**
1,1,1-Trichloroethane	71-55-6	N	13,000	30	**13,000**
1,1,2-Trichloroethane	79-00-5		-	3	**-**
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	C	3.0	1	**3.0**
Trichlorofluoromethane (Freon 11)	75-69-4		-	2,000	**-**
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF)	76-13-1	N	620	20,000	**20,000**
1,2,4-Trimethylbenzene	95-63-6	N	6,000[c]	100	**6,000[c]**
Vinyl chloride	75-01-4	C	0.59	1	**1.0**
Xylenes (total)	1330-20-7	N	7,800[c]	1,000	**7,800[c]**

NOTES

[a] Values based on cancer (C) or noncancer (N) effects.

[b] Levels are the higher of the health-based values and the GWRS

[c] Health-based screening value incorporates a factor of ten to reflect degradation of chemical in the unsaturated soil zone.

"-" = Not available.

TABLE A-2

CHEMICAL PROPERTIES [a, b]

CAS No.	Chemical	Org. Car. partition coefficient K_{oc} (cm^3/g)	Diffusivity in air D_a (cm^2/s)	Diffusivity in water D_w (cm^2/s)	Pure component water sol S (mg/L)	Henry's law constant H' (unitless)	Normal boiling point (bp) T_B (^oK)[c]	Critical Temp T_C (^oK)[d]	Enthalpy of vaporization at normal bp $\Delta H_{v,b}$ (cal/mol)[d]
67-64-1	Acetone (2-Propanone)	2.364	1.0592E-01	1.1471E-05	1000000	1.4309E-03	328.65	508.1	6,955
71-43-2	Benzene	145.8	8.9534E-02	1.0263E-05	1790	2.2690E-01	353.15	562	7,342[e]
75-27-4	Bromodichloromethane	31.82	5.6263E-02	1.0731E-05	3032	8.6672E-02	363.15	585.85[e]	7,800[e]
75-25-2	Bromoform	31.82	3.5732E-02	1.0356E-05	3100	2.1872E-02	422.25	633.38[e]	9,479
74-83-9	Bromomethane (Methyl bromide)	13.22	1.0050E-01	1.3468E-05	15200	3.0008E-01	276.65	467.15	5,714[e]
78-93-3	2-Butanone (Methyl ethyl ketone)	4.51	9.1446E-02	1.0193E-05	223000	2.3262E-03	352.65	536.7	7,481
75-15-0	Carbon disulfide	21.73	1.0644E-01	1.2977E-05	2160	5.8872E-01	319.15	553.15	6,402
56-23-5	Carbon tetrachloride	43.89	5.7143E-02	9.7849E-06	793	1.1284E+00	349.95	556.35	7,127[e]
108-90-7	Chlorobenzene	233.9	7.2130E-02	9.4765E-06	498	1.2715E-01	404.85	632	8,410[e]
75-00-3	Chloroethane (Ethyl chloride)	21.73	1.0376E-01	1.1619E-05	6710	4.5380E-01	285.45	460.15	5,879[e]
67-66-3	Chloroform	31.82	7.6920E-02	1.0891E-05	7950	1.5004E-01	334.25	536.4	6,988[e]
74-87-3	Chloromethane (Methyl chloride)	13.22	1.2396E-01	1.3648E-05	5320	3.6059E-01	249.15	416.25	5,115
110-82-7	Cyclohexane	145.8	7.9973E-02	9.1077E-06	55	6.1325E+00	353.85	553.45	7164
124-48-1	Dibromochloromethane	31.82	3.6636E-02	1.0561E-05	2700	3.2011E-02	393.15	678.2[e]	5,900[e]
106-93-4	1,2-Dibromoethane	39.6	4.3035E-02	1.0439E-05	3910	2.6574E-02	404.75	582.95	8,310[e]
95-50-1	1,2-Dichlorobenzene (o)	382.9	5.6170E-02	8.9213E-06	156	7.8496E-02	453.15	690.35	9,700[e]
106-46-7	1,4-Dichlorobenzene (p)	375.3	5.5043E-02	8.6797E-06	81.3	9.8528E-02	447.15	669	9,271[e]
75-71-8	Dichlorodifluoromethane (Freon 12)	43.89	7.6029E-02	1.0839E-05	280	1.4023E+01	243.35	384.9	4,804
75-34-3	1,1-Dichloroethane	31.82	8.3645E-02	1.0621E-05	5040	2.2976E-01	330.55	523.4	6,895[e]
107-06-2	1,2-Dichloroethane	39.6	8.5722E-02	1.0995E-05	8600	4.8242E-02	356.65	563	7,643[e]
75-35-4	1,1-Dichloroethene	31.82	8.6311E-02	1.0956E-05	2420	1.0670E+00	304.75	493.95	6,247[e]
156-59-2	1,2-Dichloroethene (cis)	39.6	8.8406E-02	1.1335E-05	6410	1.6680E-01	328.15	544.2	7,192[e]
156-60-5	1,2-Dichloroethene (trans)	39.6	8.7609E-02	1.1191E-05	4520	3.8348E-01	328.15	516.5	7,144

TABLE A-2

CHEMICAL PROPERTIES [a, b]

CAS No.	Chemical	Org. Car. partition coefficient K_{oc} (cm^3/g)	Diffusivity in air D_a (cm^2/s)	Diffusivity in water D_w (cm^2/s)	Pure component water sol S (mg/L)	Henry's law constant H' (unitless)	Normal boiling point (bp) T_B (^oK)[c]	Critical Temp T_C (^oK)[d]	Enthalpy of vaporization at normal bp $\Delta H_{v,b}$ (cal/mol)[d]
78-87-5	1,2-Dichloropropane	60.7	7.3340E-02	9.7252E-06	2800	1.1529E-01	368.65	572[e]	7,590[e]
542-75-6	1,3-Dichloropropene (total)	72.17	7.6272E-02	1.0123E-05	2800	1.4513E-01	385.15	587.38[e]	7,900[e]
123-91-1	1,4-Dioxane	2.633	8.7374E-02	1.0541E-05	1000000	1.9624E-04	374.65	585.15	8,162
100-41-4	Ethylbenzene	446.1	6.8465E-02	8.4558E-06	169	3.2216E-01	409.25	617.1	8,501
87-68-3	Hexachloro-1,3-butadiene	845.2	2.6744E-02	7.0264E-06	3.2	4.2110E-01	488.15	732.23[e]	10,206[e]
110-54-3	n-Hexane	131.5	7.3108E-02	8.1658E-06	9.5	7.3590E+01	341.85	507.5	6,895[e]
7439-97-6	Mercury (elemental)	NA	3.0700E-02	6.3000E-06	0.06	3.5200E-01	629.75	1735.15	14,127[e]
75-09-2	Methylene chloride (Dichloromethane)	21.73	9.9936E-02	1.2512E-05	13000	1.3287E-01	313.15	508.2	6,706
108-10-1	4-Methyl-2-pentanone (MIBK)	12.6	6.9780E-02	8.3477E-06	19000	5.6419E-03	389.65	575.4	8,243[e]
1634-04-4	Methyl tert-butyl ether (MTBE)	11.56	7.5267E-02	8.5904E-06	51000	2.3998E-02	328.35	497.1[e]	7101
91-20-3	Naphthalene	1544	6.0499E-02	8.3770E-06	31	1.7988E-02	491.05	748.4	10,373[e]
100-42-5	Styrene	446.1	7.1114E-02	8.7838E-06	310	1.1243E-01	418.15	636.85	8,737[e]
79-34-5	1,1,2,2-Tetrachloroethane	94.94	4.8921E-02	9.2902E-06	2830	1.5004E-02	419.65	661.15	8,996[e]
127-18-4	Tetrachloroethene (PCE)	94.94	5.0466E-02	9.4551E-06	206	7.2363E-01	394.45	620.25	8,288[e]
108-88-3	Toluene	233.9	7.7804E-02	9.2043E-06	526	2.7146E-01	383.75	591.75	7,930[e]
120-82-1	1,2,4-Trichlorobenzene	1356	3.9599E-02	8.4033E-06	49	5.8054E-02	486.65	726.45	10,471[e]
71-55-6	1,1,1-Trichloroethane	43.89	6.4817E-02	9.5990E-06	1290	7.0319E-01	347.15	585	7,136[e]
79-00-5	1,1,2-Trichloroethane	60.7	6.6890E-02	1.0026E-05	4590	3.3688E-02	386.95	602.00[e]	8,322[e]
79-01-6	Trichloroethene (TCE)	60.7	6.8662E-02	1.0221E-05	1280	4.0270E-01	360.35	544.2	7,505
75-69-4	Trichlorofluoromethane (Freon 11)	43.89	6.5356E-02	1.0048E-05	1100	3.9657E+00	296.85	471.15	5,999
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	196.8	3.7566E-02	8.5920E-06	170	2.1504E+01	320.85	487.4	6.463[e]
95-63-6	1,2,4-Trimethylbenzene	614.3	6.0675E-02	7.9208E-06	57	2.5184E-01	442.45	649.28	9,369
75-01-4	Vinyl chloride	21.73	1.0712E-01	1.2004E-05	8800	1.1365E+00	259.85	424.61	5,250[e]

TABLE A-2

CHEMICAL PROPERTIES [a, b]

CAS No.	Chemical	Org. Car. partition coefficient K_{oc} (cm^3/g)	Diffusivity in air D_a (cm^2/s)	Diffusivity in water D_w (cm^2/s)	Pure component water sol S (mg/L)	Henry's law constant H' (unitless)	Normal boiling point (bp) T_B (^oK)[c]	Critical Temp T_C (^oK)[d]	Enthalpy of vaporization at normal bp $\Delta H_{v,b}$ (cal/mol)[d]
1330-20-7	Xylenes (total)	382.9	6.8515E-02	8.4640E-06	106	2.7105E-01	411.65	616.2[e]	8,523[e]

NOTES

[a] Chemical properties are from USEPA Regional Screening Level Table (May 2018) unless otherwise noted

[b] See Table A-3 for sources of toxicological parameters

[c] Calculated with EPI Suite (USEPA 2012)

[d] From Hazardous Substances Databank (2019) unless otherwise noted

[e] From Version 6.0 (2017) Johnson and Ettinger Spreadsheets (https://www.epa.gov/vaporintrusion/epa-spreadsheet-modeling-subsurface-vapor-intrusion)

TABLE A-3

TOXICITY FACTOR INFORMATION

Chemical	CAS No.	Inhalation Unit Risk (IUR) $(\mu g/m^3)^{-1}$	Source	Reference Concentration (RfC) (mg/m^3)	Source
Acetone (2-Propanone)	67-64-1	-		-	
Benzene	71-43-2	7.8E-06	IRIS	3.0E-02	IRIS
Bromodichloromethane (Dichlorobromomethane)	75-27-4	-		-	
Bromoform	75-25-2	-		-	
Bromomethane (Methyl bromide)	74-83-9	-		5.0E-03	IRIS
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	-		5.0E+00	IRIS
Carbon disulfide	75-15-0	-		7.0E-01	IRIS
Carbon tetrachloride	56-23-5	6.0E-06	IRIS	1.0E-01	IRIS
Chlorobenzene	108-90-7	-		5.0E-02	PPRTV
Chloroethane (Ethyl chloride)	75-00-3	-		1.0E+01	IRIS
Chloroform	67-66-3	-		9.8E-02	ATSDR
Chloromethane (Methyl chloride)	74-87-3	-		9.0E-02	IRIS
Cyclohexane	110-82-7	-		6.0E+00	IRIS
Dibromochloromethane (Chlorodibromomethane)	124-48-1	-		-	
1,2-Dibromoethane (Ethylene dibromide)	106-93-4	6.0E-04	IRIS	9.0E-03	IRIS
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	-		2.0E-01	HEAST
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	-		8.0E-01	IRIS
Dichlorodifluoromethane (Freon 12)	75-71-8	-		-	
1,1-Dichloroethane	75-34-3	-		-	
1,2-Dichloroethane	107-06-2	-		7.0E-03	PPRTV
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	-		2.0E-02	IRIS/C
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	156-59-2	-		-	
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5	-		-	
1,2-Dichloropropane	78-87-5	3.7E-06	PPRTV	4.0E-03	IRIS
1,3-Dichloropropene (total)	542-75-6	4.0E-06	IRIS	2.0E-02	IRIS
1,4-Dioxane	123-91-1	5.0E-06	IRIS	3.0E-02	IRIS
Ethylbenzene	100-41-4	2.5E-06	CAL	1.0E+00	IRIS
Hexachloro-1,3-butadiene	87-68-3	-		-	
n-Hexane	110-54-3	-		7.0E-01	IRIS
Mercury (elemental)	7439-97-6	-		3.0E-04	IRIS

TABLE A-3

TOXICITY FACTOR INFORMATION

Chemical	CAS No.	Inhalation Unit Risk (IUR) $(\mu g/m^3)^{-1}$	Source	Reference Concentration (RfC) (mg/m^3)	Source
Methylene chloride (Dichloromethane)	75-09-2	1.0E-08	IRIS	6.0E-01	IRIS
4-Methyl-2-pentanone (MIBK)	108-10-1	-		3.0E+00	IRIS
Methyl tert-butyl ether (MTBE)	1634-04-4	2.6E-07	CAL	3.0E+00	IRIS
Naphthalene	91-20-3	3.4E-05	CAL	3.0E-03	IRIS
Styrene	100-42-5	-		1.0E+00	IRIS
1,1,2,2-Tetrachloroethane	79-34-5	-		-	
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	2.6E-07	IRIS	4.0E-02	IRIS
Toluene	108-88-3	-		5.0E+00	IRIS
1,2,4-Trichlorobenzene	120-82-1	-		2.00E-03	PPRTV
1,1,1-Trichloroethane	71-55-6	-		5.0E+00	IRIS
1,1,2-Trichloroethane	79-00-5	-		-	
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	4.1E-06	IRIS	2.0E-03	IRIS
Trichlorofluoromethane (Freon 11)	75-69-4	-		-	
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF)	76-13-1	-		5.0E+00	PPRTV
1,2,4-Trimethylbenzene	95-63-6	-		6.0E-02	IRIS
Vinyl chloride	75-01-4	4.4E-06	IRIS	1.0E-01	IRIS
Xylenes (total)	1330-20-7	-		1.0E-01	IRIS

NOTES

Toxicity factors are the same as those used to develop the NJDEP Indoor Air Remediation Standards. For additional information see N.J.A.C. 7:26D, Appendix 11, Table 3.

IRIS = USEPA Integrated Risk Information System.

CAL = CalEPA toxicity value.

HEAST = Health Effects Assessment Summary Tables.

PPRTV = EPA Provisional Peer Reviewed Toxicity Value.

ATSDR = Agency for Toxic Substances Disease Registry toxicity value.

C = NJDEP C-carcinogen policy: RfC includes an additional safety factor of 10

"-" = Not available.

TABLE A-4

DERIVATION OF THE NJDEP VAPOR INTRUSION SOIL GAS SCREENING LEVELS (SGSL)

Chemical	CAS No.	Cancer/ Noncancer [a]	Method TO-15 Reporting Limits	Residential [b]		Nonresidential [b]	
				Health-Based Soil Gas Screening Values	**Residential Soil Gas Screening Levels**	Health-Based Soil Gas Screening Values	**Nonresidential Soil Gas Screening Levels**
			$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
Acetone (2-Propanone)	67-64-1		120	-	**-**	-	**-**
Benzene	71-43-2	C	6.4	18	**18**	79	**79**
Bromodichloromethane (Dichlorobromomethane)	75-27-4		13	-	**-**	-	**-**
Bromoform	75-25-2		21	-	**-**	-	**-**
Bromomethane (Methyl bromide)	74-83-9	N	7.8	260	**260**	1,100	**1,100**
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	N	15	260,000	**260,000**	1,100,000	**1,100,000**
Carbon disulfide	75-15-0	N	16	36,000	**36,000**	150,000	**150,000**
Carbon tetrachloride	56-23-5	C	13	23	**23**	100	**100**
Chlorobenzene	108-90-7	N	9.2	2,600	**2,600**	11,000	**11,000**
Chloroethane (Ethyl chloride)	75-00-3	N	13	520,000	**520,000**	2,200,000	**2,200,000**
Chloroform	67-66-3	N	9.8	5,100	**5,100**	21,000	**21,000**
Chloromethane (Methyl chloride)	74-87-3	N	10	4,700	**4,700**	20,000	**20,000**
Cyclohexane	110-82-7	N	6.9	310,000	**310,000**	1,300,000	**1,300,000**
Dibromochloromethane (Chlorodibromomethane)	124-48-1		17	-	**-**	-	**-**
1,2-Dibromoethane (Ethylene dibromide)	106-93-4	C	15	0.23	**15**	1.0	**15**
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	N	12	10,000	**10,000**	44,000	**44,000**
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	N	12	42,000	**42,000**	180,000	**180,000**
Dichlorodifluoromethane (Freon 12)	75-71-8		25	-	**-**	-	**-**
1,1-Dichloroethane	75-34-3		8.1	-	**-**	-	**-**
1,2-Dichloroethane	107-06-2	N	8.1	360	**360**	1,500	**1,500**
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	N	7.9	1,000	**1,000**	4,400	**4,400**

TABLE A-4

DERIVATION OF THE NJDEP VAPOR INTRUSION SOIL GAS SCREENING LEVELS (SGSL)

Chemical	CAS No.	Cancer/ Noncancer [a]	Method TO-15 Reporting Limits	Residential [b]		Nonresidential [b]	
				Health-Based Soil Gas Screening Values	**Residential Soil Gas Screening Levels**	Health-Based Soil Gas Screening Values	**Nonresidential Soil Gas Screening Levels**
			$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	156-59-2		7.9	-	**-**	-	**-**
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5		7.9	-	**-**	-	**-**
1,2-Dichloropropane	78-87-5	C	9.2	38	**38**	170	**170**
1,3-Dichloropropene (total)	542-75-6	C	9.1	35	**35**	150	**150**
1,4-Dioxane	123-91-1	C	7.2	28	**28**	120	**120**
Ethylbenzene	100-41-4	C	8.7	56	**56**	250	**250**
Hexachloro-1,3-butadiene	87-68-3		21	-	**-**	-	**-**
n-Hexane	110-54-3	N	7.0	36,000	**36,000**	150,000	**150,000**
Mercury (elemental)	7439-97-6	N	-	-	**-**	-	**-**
Methylene chloride (Dichloromethane)	75-09-2	C	17	14,000	**14,000**	61,000	**61,000**
4-Methyl-2-pentanone (MIBK)	108-10-1	N	20	160,000	**160,000**	660,000	**660,000**
Methyl tert-butyl ether (MTBE)	1634-04-4	C	7.2	540	**540**	2,400	**2,400**
Naphthalene	91-20-3	C	26	4.1	**26**	18	**26**
Styrene	100-42-5	N	8.5	52,000	**52,000**	220,000	**220,000**
1,1,2,2-Tetrachloroethane	79-34-5		14	-	**-**	-	**-**
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	C	14	540	**540**	2,400	**2,400**
Toluene	108-88-3	N	7.5	260,000	**260,000**	1,100,000	**1,100,000**
1,2,4-Trichlorobenzene	120-82-1	N	37	100	**100**	440	**440**
1,1,1-Trichloroethane	71-55-6	N	11	260,000	**260,000**	1,100,000	**1,100,000**
1,1,2-Trichloroethane	79-00-5		11	-	**-**	-	**-**
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	C	11	34	**34**	150	**150**
Trichlorofluoromethane (Freon 11)	75-69-4		11	-	**-**	-	**-**

TABLE A-4

DERIVATION OF THE NJDEP VAPOR INTRUSION SOIL GAS SCREENING LEVELS (SGSL)

Chemical	CAS No.	Cancer/ Noncancer [a]	Method TO-15 Reporting Limits	Residential [b]		Nonresidential [b]	
				Health-Based Soil Gas Screening Values	**Residential Soil Gas Screening Levels**	Health-Based Soil Gas Screening Values	**Nonresidential Soil Gas Screening Levels**
			µg/m³	*µg/m³*	*µg/m³*	*µg/m³*	*µg/m³*
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF)	76-13-1	N	15	260,000	**260,000**	1,100,000	**1,100,000**
1,2,4-Trimethylbenzene	95-63-6	N	9.8	3,100	**3,100**	13,000	**13,000**
Vinyl chloride	75-01-4	C	5.1	32	**32**	140	**140**
Xylenes (total)	1330-20-7	N	8.7	5,200	**5,200**	22,000	**22,000**

NOTES

[a] Value based on cancer (C) or noncancer (N) effects.

[b] The Soil Gas Screening Level is the higher of the health-based soil gas value (determined by dividing the unrounded Indoor Air Remediation Standards human health-based indoor air criteria by 0.02) and the analytical reporting limit.

"-" = Not available

TABLE A-5

DERIVATION OF THE NJDEP VAPOR INTRUSION RAPID ACTION LEVELS

Chemical	CAS No.	Method TO-15 Reporting Limits ($\mu g/m^3$)	Residential [a]			Nonresidential [a]		
			Carcinogenic Indoor Air Human Health-Based Criterion	Noncarcinogenic Indoor Air Human Health-Based Criterion	**Residential Rapid Action Level**	Carcinogenic Indoor Air Human Health-Based Criterion	Noncarcinogenic Indoor Air Human Health-Based Criterion	**Nonresidential Rapid Action Level**
		$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
Acetone (2-Propanone)	67-64-1	12	-	-	**-**	-	-	**-**
Benzene	71-43-2	0.64	0.36	31	**36**	1.6	130	**160**
Bromodichloromethane (Dichlorobromomethane)	75-27-4	1.3	-	-	**-**	-	-	**-**
Bromoform	75-25-2	2.1	-	-	**-**	-	-	**-**
Bromomethane (Methyl bromide)	74-83-9	0.78	-	5.2	**10**	-	22	**44**
2-Butanone (Methyl ethyl ketone) (MEK)	78-93-3	1.5	-	5,200	**10,000**	-	22,000	**44,000**
Carbon disulfide	75-15-0	1.6	-	730	**1,500**	-	3,100	**6,200**
Carbon tetrachloride	56-23-5	1.3	0.47	100	**47**	2.0	440	**200**
Chlorobenzene	108-90-7	0.92	-	52	**100**	-	220	**440**
Chloroethane (Ethyl chloride)	75-00-3	1.3	-	10,000	**20,000**	-	44,000	**88,000**
Chloroform	67-66-3	0.98	-	100	**200**	-	430	**860**
Chloromethane (Methyl chloride)	74-87-3	1.0	-	94	**190**	-	390	**780**
Cyclohexane	110-82-7	0.69	-	6,300	**13,000**	-	26,000	**52,000**
Dibromochloromethane (Chlorodibromomethane)	124-48-1	1.7	-	-	**-**	-	-	**-**
1,2-Dibromoethane (Ethylene dibromide)	106-93-4	1.5	0.0047	9.4	**1.5**	0.020	39	**2.0**
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	1.2	-	210	**420**	-	880	**1,800**
1,4-Dichlorobenzene (p-Dichlorobenzene)	106-46-7	1.2	-	830	**1,700**	-	3,500	**7,000**
Dichlorodifluoromethane (Freon 12)	75-71-8	2.5	-	-	**-**	-	-	**-**
1,1-Dichloroethane	75-34-3	0.81	-	-	**-**	-	-	**-**
1,2-Dichloroethane	107-06-2	0.81	-	7.3	**15**	-	31	**62**
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	0.79	-	21	**42**	-	88	**180**

TABLE A-5

DERIVATION OF THE NJDEP VAPOR INTRUSION RAPID ACTION LEVELS

Chemical	CAS No.	Method TO-15 Reporting Limits ($\mu g/m^3$)	Residential [a]			Nonresidential [a]		
			Carcinogenic Indoor Air Human Health-Based Criterion	Noncarcinogenic Indoor Air Human Health-Based Criterion	**Residential Rapid Action Level**	Carcinogenic Indoor Air Human Health-Based Criterion	Noncarcinogenic Indoor Air Human Health-Based Criterion	**Nonresidential Rapid Action Level**
		$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene)	159-59-2	0.79	-	-	**-**	-	-	**-**
1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene)	156-60-5	0.79	-	-	**-**	-	-	**-**
1,2-Dichloropropane	78-87-5	0.92	0.76	4.2	**8.4**	3.3	18	**36**
1,3-Dichloropropene (total)	542-75-6	0.91	0.70	21	**42**	3.1	88	**180**
1,4-Dioxane	123-91-1	0.72	0.56	31	**56**	2.5	130	**250**
Ethylbenzene	100-41-4	0.87	1.1	1,000	**110**	4.9	4,400	**490**
Hexachloro-1,3-butadiene	87-68-3	2.1	-	-	**-**	-	-	**-**
n-Hexane	110-54-3	0.70	-	730	**1,500**	-	3,100	**6,200**
Mercury (elemental)[b]	7439-97-6	1.0	-	0.31	**1.0**	-	1.3	**2.6**
Methylene chloride (Dichloromethane)	75-09-2	1.7	280	630	**1,300**	1,200	2,600	**5,200**
4-Methyl-2-pentanone (MIBK)	108-10-1	2.0	-	3,100	**6,200**	-	13,000	**26,000**
Methyl tert-butyl ether (MTBE)	1634-04-4	0.72	11	3,100	**1,100**	47	13,000	**4,700**
Naphthalene	91-20-3	2.6	0.083	3.1	**6.2**	0.36	13	**26**
Styrene	100-42-5	0.85	-	1,000	**2,000**	-	4,400	**8,800**
1,1,2,2-Tetrachloroethane	79-34-5	1.4	-	-	**-**	-	-	**-**
Tetrachloroethene (PCE) (Tetrachloroethylene)	127-18-4	1.4	11	42	**84**	47	180	**360**
Toluene	108-88-3	0.75	-	5,200	**10,000**	-	22,000	**44,000**
1,2,4-Trichlorobenzene	120-82-1	3.7	-	2.1	**4.2**	-	8.8	**18**
1,1,1-Trichloroethane	71-55-6	1.1	-	5,200	**10,000**	-	22,000	**44,000**
1,1,2-Trichloroethane	79-00-5	1.1	-	-	**-**	-	-	**-**
Trichloroethene (TCE) (Trichloroethylene)	79-01-6	1.1	0.68	2.1	**4.2**	3.0	8.8	**18**
Trichlorofluoromethane (Freon 11)	75-69-4	1.1	-	-	**-**	-	-	**-**

TABLE A-5

DERIVATION OF THE NJDEP VAPOR INTRUSION RAPID ACTION LEVELS

Chemical	CAS No.	Method TO-15 Reporting Limits ($\mu g/m^3$)	Residential [a]			Nonresidential [a]		
			Carcinogenic Indoor Air Human Health-Based Criterion	Noncarcinogenic Indoor Air Human Health-Based Criterion	**Residential Rapid Action Level**	Carcinogenic Indoor Air Human Health-Based Criterion	Noncarcinogenic Indoor Air Human Health-Based Criterion	**Nonresidential Rapid Action Level**
		$\mu g/m^3$	*$\mu g/m^3$*	*$\mu g/m^3$*	*$\mu g/m^3$*	*$\mu g/m^3$*	*$\mu g/m^3$*	*$\mu g/m^3$*
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF)	76-13-1	1.5	-	5,200	**10,000**	-	22,000	**44,000**
1,2,4-Trimethylbenzene	95-63-6	0.98	-	63	**130**		260	**520**
Vinyl chloride	75-01-4	0.51	0.64	100	**64**	2.8	440	**280**
Xylenes (total)	1330-20-7	0.87	-	100	**200**	-	440	**880**

NOTES

[a] The Rapid Action Level is the higher of the health-based criterion (determined as the lower of 100X the indoor air cancer value or 2X the indoor air noncancer value) and the analytical reporting limit.

[b] The analytical reporting limit for elemental mercury is based on NIOSH Method 6009.

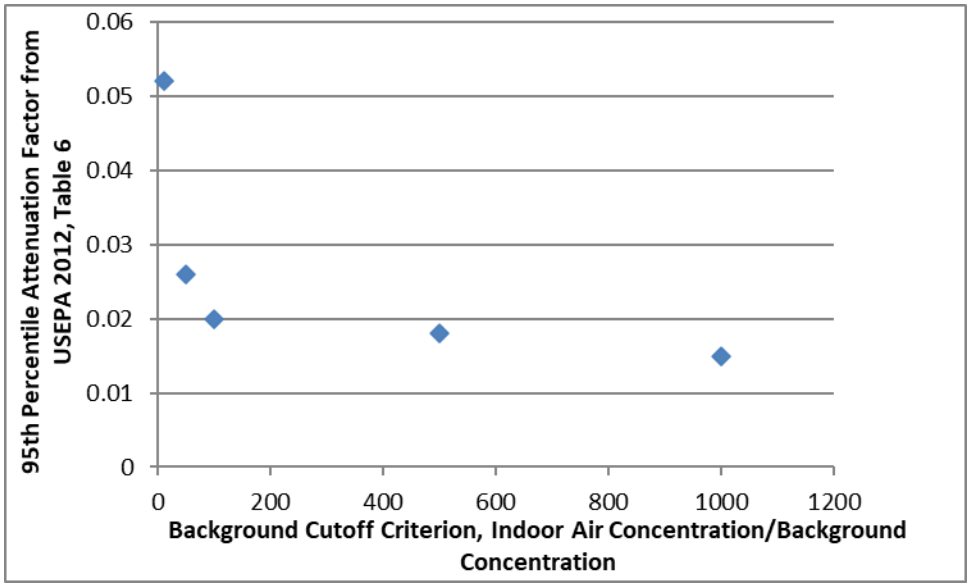
"-" = Not available

APPENDIX B

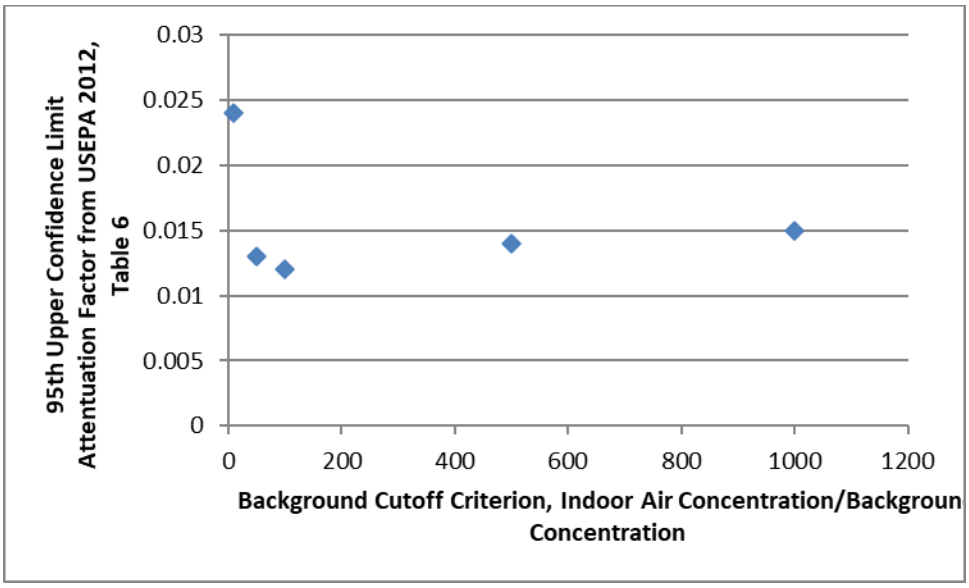
NEW JERSEY EVALUATION OF THE SOIL GAS ATTENUATION FACTOR

The USEPA, in its current vapor intrusion guidance (USEPA 2015), recommends a subslab soil gas attenuation factor of 0.03, which is drawn from a report on the EPA Vapor Intrusion Database (USEPA 2012). The Department has evaluated the 2012 and 2015 reports and feels that the current New Jersey value of 0.02 continues to be satisfactory, as explained below.

When evaluating attenuation factors, the USEPA eliminated data where indoor concentrations were less than 50 times background concentrations, stating in Section 4 of the 2012 report that this "most effectively" reduced the influence of background data while still keeping as much data as possible. This led to an attenuation factor of 0.026 (95th percentile value in Table 6 of the 2012 EPA report), which was rounded to 0.03. (Note that a slightly lower value of 0.025 would have rounded down to 0.02). Looking at the remaining 95th percentile values in Table 6, it can be observed that if the background cutoff criterion is raised to 100, 500 or even 1000 times background, there are still abundant attenuation factor data remaining, and the attenuation factor levels off between 0.01 and 0.02 (see figure below). This suggests that an attenuation factor of 0.02 is suitable.



If instead the 95th upper confidence limit attenuation factors from Table 6 are plotted, all values are between 0.01 and 0.02 except for the cutoff criterion of ten times the background (see figure below).



Finally, on page 50 of the 2012 USEPA report, conservative values (10th percentile values) of building volumes, air exchange rates and soil gas entry rates are used to calculate a theoretical upper end value of 0.02 for the subslab soil gas attenuation factor.

Considering the above assessments, the NJDEP has decided to continue the use of a soil gas attenuation factor of 0.02.