
**New Jersey**
**Department of Environmental Protection**

# SOIL REMEDIATION STANDARDS FOR THE INHALATION EXPOSURE PATHWAY

# BASIS AND BACKGROUND

**May 17, 2021**

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## 1. Introduction

As per the *Remediation Standards* (N.J.A.C. 7:26D), the Department has developed human health-based soil remediation standards (SRS) for residential and non-residential exposure scenarios, N.J.S.A. 58:10B-1 et seq. To prevent the unacceptable risk to human health from inhalation of contaminated particulates or vapors, or a combination of particulates and vapors, emanating from contaminated soil, the Department has calculated SRSs for the inhalation exposure pathway using the U.S. Environmental Protection Agency's (USEPA's) risk-based equations. Health-based criteria are developed for carcinogens and non-carcinogens under the residential and non-residential land use scenario. The SRS incorporate default residential and non-residential exposure parameters consistent with those used by USEPA in the Superfund Program (USEPA, 2014 and 2018b). The Legislature determined that standards will not exceed an additional cancer risk of one in one million ($1x10^{-6}$) for carcinogens or a Hazard Quotient of one for noncarcinogens, as mandated by the *Brownfield and Contaminated Site Remediation Act* (N.J.S.A 58:10B-1 et seq.).

Specifically, this document will explain and describe the approach developed by the Department to assess the inhalation exposure pathway. The inhalation exposure pathway is a primary route of human exposure to contamination and is found at residential and non-residential sites. Generally accepted methods, models, and assumptions have already been developed to evaluate this pathway. While the Department employs USEPA's equations (USEPA, 2018b) and default parameters (USEPA, 2014) for the pathway, the procedures and toxicity data used may differ from USEPA due to the Department's preference to be consistent with other Departmental programs. These differences are discussed in this document.

The Inhalation Exposure Pathway SRS are to be used at any site. However, the Department recognizes that the inclusion of site-specific conditions may be appropriate in determining an alternative remediation standard (ARS). If the soil contamination levels at the site are below the appropriate Inhalation Soil Remediation Standards (InhSRS), then no further action is required relative to this exposure pathway. When contaminant levels exceed the InhSRS, one could remediate the contamination levels that exceed the InhSRS to levels below the appropriate standard(s) and no further action would be required relative to this exposure pathway.

Site-specific characteristics may be substituted for default inputs in the algorithm in order to calculate an ARS for the site. The site-specific factors that may be substituted are discussed further within Section 5 of this Basis and Background document. Parameters which are or are not subject to Department approval are further discussed within Section 5. A third approach could be taken to evaluate the specific contamination levels at a site. This approach could involve using alternative models and assumptions. Such an approach is not discussed in Section 5, but may be permissible with Department oversight and acceptance. Please note that the Department also has the right to utilize an ARS for soil when it is appropriate to accurately reflect site conditions.

The remainder of this basis and background document is divided into a discussion of the methodology of InhSRS for contamination including equations, hierarchy, and calculations. Chemical-specific information is also contained within the methodology. The development of the InhSRS contains default parameters including the residential and non-residential default

parameters. Subsequent sections present the methods and information that are needed to develop an ARS for soil or use of an interim soil remediation standard. Finally, sensitivity analyses for contaminants were conducted and are presented.

## 2. Methodology for Developing Standards

### 2.1. Overview

The soil inhalation exposure pathway addresses the potential for contaminants adsorbed to fine soil particles and the inhalation of contaminants that volatilize from fine soil particles. Calculation of remediation standards for the incidental inhalation of soil and dust is based on USEPA's risk assessment methodology. USEPA toxicity data indicates that the risks from exposure to some contaminants in the soil via the inhalation exposure pathway are greater than the risks via other pathways, such as direct ingestion and dermal contact. Therefore, InhSRS were developed by the Department to be protective of the inhalation exposure route. The procedure for calculating residential and non-residential SRS for the inhalation exposure pathway is presented in N.J.A.C. 7:26D Appendix 3, along with this document, and is based on USEPA's *Risk Assessment Guidance for Superfund Human Health Evaluation Manual, Part B* and *Part F* (RAGS HHEM, Part B; USEPA, 1991 and Part F; USEPA, 2009), *Soil Screening Guidance: Technical Background Document* (USEPA, 1996a), *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA, 2002a), and the *Regional Screening Levels Users Guide* (USEPA, 2018b). The input parameters used by the Department are the same as those used by the USEPA Superfund Program, except for those used to model air dispersion and certain soil characteristics (shown in Tables 1 and 2).

The central principle employed in developing the standards was to establish viable methodologies for calculating values and to apply these methodologies to the full range of exposure scenarios and contaminants that need to be assessed. Having established a potential universe of proposed standards, the products of these efforts were evaluated with the goal of selecting the process that was the most technically sound and defensible.

The Regional Screening Tables provide updated equations combining the volatile and particulate equations for both residential and non-residential land use exposure scenarios (RSL 2018b [http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/]). These equations, along with the supporting equations provided in RSL 2018b, are used to generate the InhSRS.

### 2.2. Equations

The risk-based equations and input parameters included in N.J.A.C. 7:26D Appendix 3 and presented below are used in the development of the residential and non-residential health-based criteria for the inhalation exposure pathway. Carcinogenic and non-carcinogenic human health-based criteria are calculated for the listed contaminants under a residential and non-residential land use scenario, when applicable toxicity information is available. Equations 1 and 2 below are derived from the *USEPA RSLs, Users Guide* (USEPA, 2018b). A detailed explanation of the derivation of these equations is contained in N.J.A.C. 7:26D Appendix 12. The supporting equations are provided in Appendix I.

**Equations for Calculating Inhalation Soil Remediation Standards:**

Equation 1- Carcinogenic Inhalation Human Health-Based Criteria

$$Inh_c = \frac{TR*AT*LT}{IUR*1000^{\mu g}/_{mg}*EF*\left(\frac{1}{VF}+\frac{1}{PEF}\right)*ED*ET*\frac{1day}{24hours}}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $Inh_c$ | Inhalation soil remediation standard for carcinogens | mg/kg | Chemical-specific |
| $TR$ | Target cancer risk | Unitless | $1 \times 10^{-6}$ |
| $AT$ | Averaging Time | Days/year | 365 |
| $LT$ | Lifetime | Years | 70 |
| $IUR$ | Inhalation unit risk factor | $(mg/m^3)^{-1}$ | Chemical-specific |
| $EF$ | Exposure frequency | Days/year | 350 (Residential)<br>225 (Nonresidential) |
| $VF$ | Soil-to-air volatilization factor | $m^3/kg$ | Chemical specific |
| $PEF$ | Particulate emission factor | $m^3/kg$ | $1.67 \times 10^9$ (Residential)<br>$1.64 \times 10^9$ (Nonresidential) |
| $ED$ | Exposure duration | Years | 26 (Residential)<br>25 (Nonresidential) |
| $ET$ | Exposure Time | Days/year | 24 (Residential)<br>8 (Nonresidential) |

Equation 2 - Non-carcinogenic Inhalation Human Health-Based Criteria

$$Inh_{nc} = \frac{THQ * AT * ED}{EF * ED * ET * \frac{1day}{24hours} * \frac{1}{RfC} * \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $Inh_{nc}$ | Inhalation soil remediation standard for noncarcinogens | mg/kg | Chemical specific |
| $THQ$ | Target hazard quotient | Unitless | 1 |
| $AT$ | Averaging time | Days/year | 365 |
| $EF$ | Exposure frequency | Days/year | 350 (Residential)<br>225 (Nonresidential |
| $ED$ | Exposure duration | Years | 26 (Residential)<br>25 (Nonresidential) |

| | | | |
|---|---|---|---|
| ***ET*** | Exposure time | Hours/day | 24 (Residential)<br>8 (Nonresidential) |
| ***RfC*** | Reference Concentration | $mg/m^3$ | Chemical specific |
| ***VF*** | Soil-to-air volatilization factor | $m^3/kg$ | Chemical specific |
| ***PEF*** | Particulate emission factor | $m^3/kg$ | 1.67 x 109 (Residential) 1.64 x 109 (Nonresidential) |

## 2.3. Mutagenic Mode of Action

Some contaminants have been determined to have a mutagenic mode of action or early lifetime exposure component. Mutagenicity refers to the capacity to induce or increase the rate of genetic change. For the inhalation exposure pathway, the affected contaminants include 1,2-dibromo-3-chloropropane; methylene chloride; trichloroethene; and vinyl chloride.

While the Department's Site Remediation and Waste Management Program (SRWMP) supports the protection against cancer risks from early-life exposure in the context of the baseline risk assessment and its associated screening levels, as existing policy, the SRWMP does not include the mutagenic mode of action in the development of its soil or indoor air remediation standards. By regulation, the Department's standards are based on a conservative $10^{-6}$ risk level for carcinogenic compounds, which is protective of any additional risks incurred from early life exposure. The SRWMP will continue to review this issue as more information becomes available and may consider it for future amendments to the *Remediation Standards*, N.J.A.C. 7:26D.

1,2-dibromo-3-chloropropane, methylene chloride, trichloroethene (TCE), and vinyl chloride (VC) were not calculated via the mutagenic mode of action as recommended by USEPA, but were rather developed using the standard carcinogenic equations. Specifically, carcinogenic remediation standards for these contaminants were developed using the standard carcinogenic equation with the following toxicity factors: 1,2-dibromo-3-chloropropane utilized the PPRTV IUR of 6E-3 $(\mu g/m^3)^{-1}$; methylene chloride utilized the adult exposure IUR of 1E-8 $(\mu g/m^3)^{-1}$; TCE utilized the adult-based IUR of 4.1E-6 $(\mu g/m^3)^{-1}$; and VC utilized the continuous lifetime exposure during adulthood IUR of 4.4E-6 $(\mu g/m^3)^{-1}$. The use of the standard carcinogenic equation was due to uncertainty in the application of the mutagenic mode of action and varying use by different USEPA programs (Risk Policy Report, December 9, 2014). In addition, NJDEP is required to use a cancer risk of $1x10^{-6}$ (N.J.S.A. 58:10B-1 et seq.), which is at the higher end of the range of the USEPA cancer risk range of $1x10^{-4}$ to $1x10^{-6}$. Therefore, the value derived using the standard carcinogenic equation will likely be within the range of values derived using the mutagenic mode of action with the USEPA's risk range.

## 2.4. Hierarchy for Toxicity Source Information

The toxicity information used to develop chemical-specific InhSRS for volatile, semivolatile, and particulate contamination can be found in Appendix B. The inhalation unit risks (IURs) for carcinogens and reference concentrations (RfCs) for noncarcinogens that are used for the evaluation of inhalation toxicity were taken from a number of sources; however, the Department has determined a hierarchy for obtaining toxicity information that is generally applied to all

exposure pathways for the development of SRS. The hierarchy differs from oral exposure pathways in that the A-280 Amendments to the New Jersey Safe Drinking Water Act (P.L. 1983, c. 443) are not considered for the inhalation exposure pathway. Each chemical-specific reference is given in Appendix B. The following describes the hierarchy used specifically for the inhalation exposure pathway. This hierarchy is consistent with the hierarchies established for the other pathways, taking into account the preference for inhalation-based data. The hierarchy follows:

1. USEPA's Integrated Risk Information System (IRIS)
2. Other potential sources including USEPA's National Center for Environmental Assessment's (NCEA) Provisional Peer-Reviewed Toxicity Values (PPRTV), Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs), California Environmental Protection Agency (CalEPA), and USEPA's Health Effects Assessment Summary Table (HEAST)

The Department has used USEPA's IRIS toxicity information as the first source of toxicity information (first tier) for developing soil standards for the inhalation exposure pathway. However, if a second-tier source was more updated and scientifically sound than the IRIS IUR or RfC, then the second-tier source was selected. IRIS provides regularly updated, peer reviewed IURs and RfCs (USEPA, 2018a) and is the source of 21 IURs and 40 RfCs.

For contaminants that do not have IRIS toxicity values, the Department referred to its second-tier of toxicity information, which consists of four databases: the USEPA NCEA, which develops PPRTVs; ATSDR; CalEPA, which is an umbrella agency that includes the Office of Environmental Health Hazard Assessment and the California Air Resources Board; and USEPA's HEAST. 3 IURs and 7 RfCs came from PPRTV, 3 RfCs came from ATSDR, 3 IURs and 4 RfCs came from CalEPA, and 2 RfCs came from HEAST. If toxicity information from multiple second-tier sources existed, then the Department reviewed all available information and selected the most scientifically sound information in order to develop the SRS. With second-tier sources, the source with the most recent toxicity information was considered and reviewed. If the toxicity information was appropriate, the information was used. In several cases, an older IUR or RfC from a second-tier source was not used because a more recent review of the toxicity information by either the first-tier source or another second-tier source indicated that the toxicity information was not adequate to develop an IUR or RfC. In addition, any IURs or RfCs that were based on oral studies were not used unless they were evaluated using the physiologically based pharmacokinetic (PBPK) model or equivalent (see 2.5 Route-to-Route Extrapolation).

## 2.5. Route-to-Route Extrapolation

Inhalation toxicity factors have been developed for some contaminants using studies that relate health effects to oral exposure in the absence of sufficient inhalation-based studies. Historically, the USEPA and the Department implemented route-to-route extrapolation when there was no toxicity information available for the exposure pathway under evaluation. However, subsequent USEPA RAGS Part F states performing route-to-route extrapolation may be inappropriate when data from one route of exposure is substituted for another without consideration of the pharmacokinetic differences between the routes (USEPA, 2009).

Consequently, the Department decided not to do such extrapolation to develop standards without specific contaminant-based justification. As a result, toxicity factors based on route-to-route extrapolation have been evaluated by the Department and their use restricted. Route-to-route extrapolation-based toxicity factors may be used when the values have been developed after a more extensive evaluation of the potential effects of route of exposure (such as through the use of Physiologically Based Pharmacokinetic (PBPK) modeling) in the generation of the toxicity values. The footnotes of Table A-4 of this document and N.J.A.C. 7:26D, Appendix 11, Table 2 provide details for those inhalation toxicity factors in which route-to-route extrapolation was applied and whether its use was supported with PBPK modeling.

## 2.6. Group C Carcinogen Policy

The Department has a policy for the development of remediation standards for contaminants classified as Group C carcinogens, which are defined as possible human carcinogens by the USEPA under the 1986 guidelines, or suggestive carcinogens under the 2005 guidelines (USEPA, 1986 and 2005). Group C carcinogen contaminants are contaminants for which some evidence of human carcinogenicity exists, but for which there is insufficient evidence to classify the contaminants as Known Human Carcinogens (Group A) or Probable Human Carcinogens (Group B). The Department uses this policy to develop Departmental health-based standards including remediation standards, drinking water health-based maximum contaminant levels, ground water quality criteria, and human health-based surface water quality criteria.

Under this Department policy, remediation standards for contaminants classified as Group C carcinogens under the 1986 guidelines or suggestive carcinogens under the 2005 guidelines that have carcinogenic toxicity information (inhalation unit risk for the inhalation exposure pathway) are developed as a carcinogen (Group A or B) using a target cancer risk of one excess human cancer in one million ($1x10^{-6}$ target cancer risk). For those contaminants that do not have available carcinogenic toxicity information, the Department developed a remediation standard using non-carcinogenic toxicity information (RfC for the inhalation exposure pathway), but the Department applied an added uncertainty factor of 10 to account for potential carcinogenic effects not addressed by the non-carcinogenic toxicity information.

There are 3 contaminants classified as Group C carcinogens under the 1986 guidelines or suggestive carcinogens under the 2005 guidelines for which inhalation soil remediation standards were developed. Appendix C of this document and N.J.A.C. 7:26D Appendix 11, Table 2 identify the contaminants which are classified as Group C carcinogens, the toxicity factors in which a 10-fold safety factor adjustment must be applied to the RfC when calculating a standard. These contaminants are 1,1-dichloroethene, methyl tertiary-butyl ether, and naphthalene.

## 2.7. Exposure Parameters

Exposure parameters recommended by the USEPA Superfund program (USEPA 2014) are used as input parameters for the calculation of the residential and non-residential SRS for the inhalation exposure pathway. The input parameters reflect reasonable maximum expose (RME) under the applicable land use scenarios. USEPA defines the RME as the highest exposure that is reasonably expected to occur at a site (USEPA, 1989). The exposure parameters, along with the applicable equations, are presented in Section 2.2 of this document.

## 2.8. Calculations

The equations for the InhSRS of carcinogenic and noncarcinogenic contaminants in soil are provided in Section 2.2, above, for the residential and non-residential land use. The volatile and particulate components of contaminants are calculated in one equation. The target cancer risk of $1x10^{-6}$ and the target hazard quotient of one are used by USEPA and are also mandated by the *Brownfield Contaminated Site Remediation Act* (N.J.S.A. 58:10B-1 et seq.). The Department uses the USEPA RSL methodology for particulate and volatile contaminants for both residential and non-residential exposure.

Carcinogenic and non-carcinogenic human health-based criteria for residential and non-residential land use are calculated for the listed contaminants following the above procedures, where applicable toxicity information is available (Tables A1 and A2). The human health-based criteria for the applicable land use scenarios are determined as the lesser of the carcinogenic or non-carcinogenic based value.

In deriving the SRS for the inhalation exposure pathway, the Department rounded all standards to two digits by applying the rounding rules contained in the American Society for Testing and Materials (ASTM) Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications (ASTM E29-13). For example, in applying ASTM E29-13:

- If the first number beyond the second significant figure is *less than* five, then the second significant figure remains the same, while the remaining numbers are dropped. For example, if 4.438 is rounded to two significant figures, the result is 4.4.
- If the first number beyond the second significant figure is *greater than* five, then the second significant figure increases by one and the remaining numbers are dropped. For example, if 4.668 is rounded to two significant figures, the result is 4.7.
- If the first number beyond the second significant figure is five and there are other non-zero numbers beyond the five, then the second significant increases by one and the remaining numbers are dropped. For example, if 4.6534 is rounded to two significant figures, the result is 4.7
- If the first number beyond the second significant figure is five, and there are no numbers beyond this five (except zeros), then the second significant figure is rounded to the closest even number. For example, if 4.55 is rounded to two significant figures, then the result is 4.6; and when 4.65 is rounded to two significant figures, the result is also 4.6.

The resulting residential and non-residential human health-based criteria are presented in Tables A1 and A2. Results are discussed in Section 4.1.

## 2.9. Chemical-Specific Information

### 2.9.1. Lead

Lead is being evaluated via the lead models developed by *USEPA: Integrated Exposure Uptake Biokinetic Model for Lead for Children (IEUBK);* and *Adult Lead Model (ALM).* These models incorporate inhalation along with the ingestion and dermal components. Therefore, lead will not be evaluated separately within the inhalation exposure pathway.

### 2.9.2. Order of Magnitude

Caprolactam and ethylbenzene are considered to have an order of magnitude decrease from the former rule. While the former rules did not contain residential and nonresidential soil remediation standards criteria for these compounds for the inhalation exposure pathway, the former rules did include residential and nonresidential soil remediation standards for caprolactam and ethylbenzene for the ingestion-dermal exposure pathway. The prior soil remediation standards for caprolactam and ethylbenzene were 31,000 mg/kg residential and 340,000 mg/kg nonresidential and 7,800 mg/kg residential and 110,000 mg/kg nonresidential, respectively. The adopted soil remediation standards for ethylbenzene (inhalation exposure pathway) of 10 mg/kg residential and 48 mg/kg nonresidential are more than an order of magnitude lower than the existing prior soil remediation standards. The adopted soil remediation standards for caprolactam (inhalation exposure pathway) of 290 mg/kg residential and 1,300 mg/kg nonresidential are more than an order of magnitude lower than the prior soil remediation standards.

### 2.9.3. Volatile and Semivolatile Designation

The Department proposes a more stringent standard for phenol for the inhalation exposure pathway for only the residential exposure scenario, as the Department treats this compound as a volatile organic compound (VOC) and the USEPA does not. In the development of a health-based remediation standard for the soil inhalation exposure pathway, the Department evaluates the effect of the inhalation of contaminants adsorbed to fine soil particles and the inhalation of contaminants that volatilize from fine soil particles. The Department applies the volatilization factor to only those contaminants where the parameters are available. Because of this, contaminants that are considered volatiles tend to pose a greater health risk compared to non-volatiles and have remediation standards that are more stringent.

Phenol is not considered to be a VOC by the USEPA, nor has the USEPA developed an inhalation RfC for phenol. The Department has made the determination that it should be evaluated as a VOC for the inhalation exposure pathway and used the CalEPA's derived noncarcinogenic reference concentration (RfC) to calculate the soil remediation standard.

The proposed standard for caprolactam for the inhalation exposure pathway is also more stringent for the residential and nonresidential exposure scenarios, as the Department treats this compound as a VOC while the USEPA does not.

## 3. The Development of Inhalation Exposure Pathway Standards

### 3.1. Standards Determination

The residential and non-residential SRS for the inhalation exposure pathway are determined as the higher of the calculated human health-based criteria and the contaminant's analytical reporting limit (RL) or natural background level in soil. The human health-based criteria default to the analytical RL when higher, since a contaminant's analytical RL is the lowest concentration reliably able to be detected by a laboratory using the applicable analytical method. The health-based criteria default to soil background levels since the *Brownfield and Contaminated Site Remediation Act* (N.J.S.A. 58:10B-12(4)) requires that SRS are health-based, but not lower than frequently detected regional natural background levels in New Jersey. In addition, the inhalation

exposure pathway uses the soil saturation limit as a ceiling limit for VOCs. If the health-based standard for the VOC portion of the equation is above the soil saturation limit, then no standards are developed for the VOC portion for that contaminant; however, standards may be developed based on the particulate portion of the equation (see Section 3.3 for further details). The residential and non-residential SRS, along with whether the standard is based on the analytical RL or soil background level are presented in Appendix A, Tables A1 and A2.

For the generation of RLs associated with soils, USEPA Statements of Work were used. The specific methods were:

> USEPA Contract Laboratory Program Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, SOMO1.1, May 2005; and
>
> USEPA Contract Laboratory Program Statement of Work for Inorganic Superfund Methods, (Multi-Media, Multi-Concentration), ISMO1.2, January 2010.

These methods have method-defined Contract Required Quantitation Limits (CRQLs). Laboratories receiving contracts from the USEPA for these Statements of Work must demonstrate they can attain, at a minimum, the concentrations listed as CRQLs, thereby demonstrating the ability to routinely achieve the analytical sensitivity required. Additionally, these Statements of Work methods are similar in technique and sensitivity to other methods commonly used in the field of environmental analytical chemistry. As such, it was decided that the CRQL concentrations would be used to generate the RLs for the tables. For volatile and semivolatile organic contaminants, values under their respective "Low Soil" columns were used. For pesticides and Aroclors, values under their respective "soil" columns were used. For inorganics, the values under the "ICP-MS CRQL for Soil" column were used. For Mercury and Arsenic, values under their respective "CRQL for Soil" columns were used.

New Statement of Works have been issued in 2013: USEPA Contract Laboratory Program Statement of Work for Organic Superfund Methods, Multi-Media, Multi-Concentration, SOMO2.1, September 2013; and USEPA Contract Laboratory Program Statement of Work for Inorganic Superfund Methods, Multi-Media, Multi-Concentration, ISMO2.1, September 2013. In these Statements of Work, there are compounds whose associated CRQLs have changed. Those compounds are:

- Acetophenone
- Atrazine
- Benzaldehyde
- Bis(2-chloroethoxy)methane
- Bis(2-chloroethyl)ether
- Caprolactam
- 3,3'-Dichlorobenzidine
- Di-n-octyl phthalate
- 1,4-Dioxane
- Fluoranthene
- Hexachlorocyclopentadiene
- 2-Methylphenol

- 4-Methylphenol
- 2,2'-oxybis(1-chloropropane) and
- Phenol

There are five exceptions where the RLs were not obtained from the Statements of Work: 1,2,4-Trimethybenzene; Extractable Petroleum Hydrocarbons (No. 2 Fuel Oil and Diesel); Extractable Petroleum Hydrocarbons (Other); Tertiary butyl alcohol; and 2,3,7,8-Tetrachlorodibenzo-p-dioxin; however, none of these are relevant to the inhalation exposure pathway as standards were not developed for these contaminants.

The 1,2,4-Trimethylbenzene RL was derived from USEPA SW-846 Method 8270D, calculating the reporting limit by multiplying the MDL by 10, then converting from aqueous to solid using the method described volumes and weights for a routine analysis.

Extractable Petroleum Hydrocarbons (No. 2 Fuel Oil and Diesel) and Extractable Petroleum Hydrocarbons (Other) RLs were obtained from the method-defined low limit noted in the dynamic range of the NJDEP method, "Analysis of Extractable Petroleum Hydrocarbon Compounds (EPH) in Aqueous and Soil/Sediment Matrices, August 2010, Revision 3".

The Tertiary Butyl Alcohol RL was derived from the information received after a request was made to the Environmental Laboratory Advisory Committee (ELAC) to give the program a concentration value based on their familiarity and knowledge with regard to analyzing for the compound.

The 2,3,7,8-Tetrachlorodibenzo-p-dioxin RL was obtained from USEPA Method 1613, Revision B, Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS, October 1994. The method-defined "Minimum level for Solid" was used for the RL.

## 3.2. Default Input Parameters

The methodology for calculating InhSRS for volatile contaminants is taken from USEPA's *Soil Screening Guidance: Technical Background Document* (USEPA 1996a). The input parameters used by the Department were the same as those used by USEPA (1996a, 2001); except for air dispersion and certain soil characteristics. These exceptions are noted in Tables 1 and 2, below. For the volatile component of the inhalation exposure pathway, the difference between the residential and non-residential scenarios is exposure time, including averaging time (AT), exposure frequency (EF), exposure duration (ED), and exposure interval (T).

A sensitivity analysis of the inhalation model for volatile contaminants is presented in Appendix D. Some of these analyses are discussed further below.

The Q/C value gives an estimate of dispersion based on meteorological conditions. It was changed from USEPA's default value based on meteorological modeling for New Jersey.

Soil texture may significantly affect the soil moisture content, which in turn has a substantial effect on the volatilization rate of VOCs. Heavier soils such as loam soils, or those with significant clay content, tend to have higher moisture contents that can significantly reduce

volatilization. Based on nationwide data, the USEPA uses loam as the default soil texture. However, due to the southern half of New Jersey being primarily composed of sandy loam, loamy sand, and sand soils (Tedrow, 1986), it was determined that a loam soil texture would not be protective of many areas of the state. Sand is adequately protective for all soil types; however it was not used as the default soil texture because sand is too porous to be representative of northern New Jersey, which consists largely of sandy loam, loam and silt loam soils. To represent the state as a whole, sandy loam soil was selected as a mid-range soil texture to represent the state when calculating default remediation standards.

The USEPA default characteristics were altered slightly to generate default values for New Jersey. These values are representative of a sandy loam soil: total soil porosity (n); water-filled soil porosity ($\theta_w$); air-filled soil porosity ($\theta_a$); and organic carbon content of soil ($f_{oc}$). Comparison of USEPA's and the Department's default parameters are given in Table 1 below.

**Table 1**
**Comparison of Input Parameters**

| Parameters | | NJDEP Default | USEPA Default |
|---|---|---|---|
| $\theta_w$ | water-filled soil porosity | 0.23 $L_{water}/L_{soil}$ | 0.15 $L_{water}/L_{soil}$ |
| **n** | total soil porosity | 0.41 $L_{pore}/L_{soil}$ | 0.43 $L_{pore}/L_{soil}$ |
| $\theta_a$ | air-filled soil porosity | 0.18 $L_{air}/L_{soil}$ | 0.28 $L_{air}/L_{soil}$ |
| $f_{oc}$ | organic carbon content of soil | 0.002 g/g | 0.006 g/g surface |

| Table 2<br>Volatile Exposure Input Parameters for the Inhalation Exposure Pathway | | | | |
|---|---|---|---|---|
| **Parameters** | | **Default** | **Units** | **Source** |
| **THQ** | target hazard quotient | 1 | unitless | N.J.S.A. 58:10B-12 |
| **TR** | target cancer risk | $1x10^{-6}$ | unitless | N.J.S.A. 58:10B-12 |
| **LT** | lifetime | 70 | years | USEPA (2014a) |
| **AT** | averaging time | 365 | days | USEPA (2014a) |
| **ET** | exposure time | Residential: 24 | hours | USEPA (2014a) |
| | | Non-residential: 8 | hours | USEPA (2014a) |
| **EF** | exposure frequency | Residential: 350 | days/year | USEPA (2014a) |
| | | Non-residential: 225 | days/year | USEPA (2014a) |
| **ED** | exposure duration | Residential: 26<br>(child: 6, adult: 20) | years | USEPA (2014a) |
| | | Non-residential: 25 | years | USEPA (2014a) |
| **Q/C** | inverse concentration at center of source | Residential: 86.6<br>Non-residential: 85 | $(g/m^2\text{-}s)/(kg/m^3)$ | NJDEP (2021b) |
| **T** | exposure interval | $8.2 \times 10^8$ | seconds | USEPA (2014a) |
| $\rho_b$ | dry soil bulk density | 1.5 | $g/cm^3$ | USEPA (1996a) |
| $\theta_a$ | air -filled soil porosity | 0.18 | $L_{air}/L_{soil}$ | NJDEP (2021b) |
| $\theta_w$ | water-filled soil porosity | 0.23 | $L_{water}/L_{soil}$ | |
| **n** | total soil porosity | 0.41 | $L_{pore}/L_{soil}$ | Carsel et al. (1988) |
| $f_{oc}$ | organic carbon content of soil | 0.002 | g/g | NJDEP (2021b) |

### 3.2.1. Air-Filled Soil Porosity ($\theta_a$)

Air-filled soil porosity is the most significant soil parameter affecting the final steady-state flux of volatile contaminants from soil. The higher the air-filled soil porosity, the greater the emission flux of volatile constituents (USEPA, 1996a). USEPA used an air-filled porosity of 0.28 (v/v) for loam soil, its default soil texture. The Department default soil texture is sandy loam, and a default air-filled soil porosity of 0.18 (v/v) was determined as the difference between the total porosity (0.41 (v/v)) and the soil moisture content (0.23 (v/v)). The appropriate values for these two latter parameters were determined as follows:

### 3.2.2. Total Soil Porosity (n)

The Department obtained the value of 0.41(v/v) for total soil porosity for sandy loam soil, from Carsel and Parrish (1988), which is one of the data sources cited by the USEPA in the soil screening guidance.

### 3.2.3. Soil Moisture Content

Soil moisture content is highly specific to soil type and climate (Sanders and Talimcioglu, 1997) and will vary according to season and short-term weather. In New Jersey, this variation for a sandy loam soil has been estimated to lie within the range of 0.18 to 0.26 (v/v) (Sanders and Talimcioglu, 1997). For purposes of the New Jersey default remediation standard calculation, it is best to use local climate data to determine average water content for a targeted soil. USEPA's soil moisture value corresponds to a moisture level in between the field capacity of sandy loam soils and the saturation volume for loam soils, and is higher than the actual average moisture level for sandy loam soil in New Jersey (Sanders and Talimcioglu, 1997). For New Jersey, an average soil moisture content specific to sandy loam soil and New Jersey climate and weather conditions was calculated to be 0.23 (v/v), using a simple relationship described in the USEPA SSG User's Guide (USEPA, 1996b). Appendix E contains additional information regarding determination of the default soil moisture level.

### 3.2.4. Soil pH

Although soil pH is not a direct input parameter used in the inhalation exposure pathway, it may affect the $K_{oc}$ value for ionizable organic contaminants and the $K_d$ value for inorganic contaminants. The default pH of 6.8 used in the USEPA SSL guidance document is an overall average pH for United States soils. However, it is well known that soils in the eastern United States are more acidic than those in the western part of the country (Foth,1984), thus, it is appropriate to use New Jersey-specific information regarding soil pH. The pH of New Jersey soils typically ranges from about pH 4 to pH 6.5 (Lee et al. 1996, Yin et al. 1996), therefore, a pH value of 5.3 is appropriate for New Jersey use.

### 3.2.5. Organic Carbon Content of Soil ($f_{oc}$)

NJDEP deviates from USEPA's organic carbon content of soil ($f_{oc}$) default value of 0.006. The reason for this is that the Jury model calculates contaminant transport for the entire soil column, using a single value for $f_{oc}$. Using a surface default value of 0.006 in the model may be appropriate for the surface layer of the soil column, but may underestimate volatile migration in the subsurface portion of the soil column. Therefore, to provide a better estimate of contaminant volatilization, the USEPA subsurface default value for $f_{oc}$ (0.002) was used instead of the surface default value (0.006). This latter value does not represent typical soil organic carbon values in the subsurface, and would reduce the extent of contaminant volatilization.

The subsurface default $f_{oc}$ value was determined after review of data published by Carsel et al. (1988). Organic carbon content can vary from near zero (beach sands and other sandy soils at subsurface depths) to several percent (surface soils in forests). The USEPA determined that a fraction organic carbon content of 0.002 was appropriate for subsurface soils. The organic carbon content of soil has not been well documented below 1-2 m depth, but Carsel et al. (1988)

performed statistical analysis of a large soil dataset and reported distributions of soil organic matter contents at various depth intervals up to 1.2 m depth. The average fraction organic carbon content of the three mean subsurface values for Class B and Class C soils was 0.002. These hydrologic soil groups include sandy loam soils. Therefore, the NJDEP has decided that a default fraction organic carbon content of 0.002 is appropriate.

### 3.2.6. Chemical Properties of Contaminants

Chemical properties for all regulated contaminants are listed in Appendix F. When possible, chemical properties were taken from values in USEPA's Regional Screening Table (May 2018) (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/). For contaminants not listed in the USEPA Regional Screening Table, properties were generally obtained from the same data sources that USEPA used in its user's guide.

Water solubilities and Henry's law constants for contaminants not listed in the guidance document were usually taken from the Superfund Chemical Data Matrix (USEPA, 1996c). The few exceptions are noted in Appendix F.

$K_{oc}$ values for contaminants not listed in the user's guide were calculated from octanol-water partition coefficients using Equations 70 or 71 provided in the USEPA SSL document. Octanol-water partition coefficients were obtained from the Superfund Chemical Data Matrix in most cases. For ionizable organic contaminants, Attachment C of the USEPA SSL User's Guide lists $K_{oc}$ values for any environmental pH value (USEPA, 1996b). The pH selected for New Jersey remediation standard calculations was 5.3 (see below). $K_d$ (soil-water partition coefficients) values for organic compounds were calculated by multiplying the $K_{oc}$ value by the default fraction organic content of 0.002 (Equation 5). For inorganic contaminants, $K_d$ was determined directly. $K_d$ values were taken at pH 5.3 for those inorganic contaminants with pH dependent values reported in USEPA (1996b). For inorganic contaminants without $K_d$ values in USEPA (1996a) or (1996b), values from USEPA (1996c) were used.

Diffusion coefficients for contaminants not reported in USEPA (1996a) were either taken from or calculated using CHEMDAT8 or WATER8 (see USEPA (1994a) and USEPA (1994b)). The few exceptions to the above data sources are footnoted in the chemical property table (Appendix F).

### 3.2.7. Volatilization Factor (VF)

The soil-to-air volatilization factor (VF) defines the relationship between the concentration of the contaminant in soil and the flux of the volatilized contaminant to air, taking into consideration chemical-specific properties and soil characteristics. The equation for VF is based on the volatilization model developed by Jury et al. (1984) for infinite sources.

### 3.2.8. Inverse Concentration at Center of Source (Q/C)

Dispersion of a contaminant in the air was determined by modeling a square area source of one-half-acre (residential) and two-acre (nonresidential) with a unit emission rate of one gram per second. The normalized concentration at or near the center of the square area was found to represent the maximum annual average concentration. However, when using this technique,

there is an exponential relationship in which the emission flux decreases as the site size increases. Therefore, rather than directly using the normalized concentration as a dispersion coefficient, the inverse concentration, or Q/C, was developed to be equally protective, regardless of the size of the site. The Q/C is simply the average rate of contaminant flux ($g/cm^2$-s) based on an overall site emission rate of one gram per second divided by the maximum normalized air concentration in $kg/m^3$.

Meteorological conditions (i.e., the intensity and frequency of wind) affect both the dispersion and emissions of particulate matter. Since the Q/C accounts for the average concentration from wind erosion over an entire year, it should be used only to develop chronic health criteria. The ratio of emissions to maximum concentration is not appropriate to evaluate the potential for acute health criteria. In developing the InhSRS for a half-acre and two-acre site, dispersion modeling was done with Newark International Airport meteorological observations which resulted in a Q/C value of 86.6 $(g/m^2- s)/(kg/m^3)$ (residential) and 85 $(g/m^2- s)/(kg/m^3)$ (nonresidential). This is the least conservative value of three locations with meteorological data representative of New Jersey (Newark, Philadelphia, and Atlantic City). See Tables 6 and 6 for the Q/C value used as well as other default exposure parameters.

### 3.2.9. Soil Saturation Limit ($C_{sat}$)

The soil saturation limit ($C_{sat}$) corresponds to the contaminant concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil pore air have been reached. Above this concentration, the soil contaminant may be present in free phase (i.e., nonaqueous phase liquids (NAPLs)) for contaminants that are liquid at ambient soil temperatures and pure solid phases for compounds that are solid at ambient soil temperatures (USEPA, 1996a).

To determine the soil saturation limit for each contaminant, the Department used Equation 11 (see Appendix I). For chemical-specific values for solubility in water (S), see the chemical properties table in Appendix F. The soil characteristics are the same as those used above to calculate risk-based soil remediation standards.

USEPA recommends that when the risk-based inhalation soil screening level is calculated using Equations 1 or 2, and that value exceeds $C_{sat}$ for liquid compounds; the soil screening level should be set at $C_{sat}$. For chemicals that are solid at ambient soil temperatures and InhSRS are above $C_{sat}$, USEPA recommends that the soil cleanup decisions should be based on another pathway of concern (USEPA, 1996a).

The USEPA recommends the regulation of contaminants at the $C_{sat}$ level because of concerns about the presence of liquid, free product. The Department also has similar concerns, but liquid, free product remediation is addressed within the context of other rules and regulations, such as the *Technical Requirements for Site Remediation* (N.J.A.C. 7:26E) and the *Ground Water Quality Standards* (N.J.A.C. 7:9C).

When $C_{sat}$ is exceeded by a calculated standard for a liquid contaminant, the calculated values cannot be achieved. Ultimately the compound cannot be regulated via this exposure pathway and the $C_{sat}$ number will not be specified as the InhSRS; however, this is not the case for the

evaluation of those liquid chemicals acting as particulates (i.e., where the chemical is adsorbed to airborne dust particles or is a condensate). Consequently, the particulate standard values may be above $C_{sat}$, but as long as they do not exceed $1x10^6$ parts per million, the calculated values will be used as the standard for the inhalation exposure pathway.

**Table 3**
**Soil Saturation Input Parameters**

| Parameter | | Value | Source |
|---|---|---|---|
| $\rho_b$ | Dry soil bulk density | 1.5 g/cm$^3$ | USEPA (1996a) |
| $\theta_a$ | Air-filled soil porosity | 0.18 $L_{water}/L_{soil}$ | This document Section 3.2.1 |
| $\theta_w$ | Water-filled soil porosity | 0.23 $L_{water}/L_{soil}$ | This document Section 3.2.1 |

### 3.2.10. Particulate Default Input Parameters

The emissions in the Particulate Emission Factor (PEF) equation in Appendix I are based on the "unlimited reservoir" model from Cowherd et al. (1985), which was developed to estimate particulate emissions due to wind erosion. The unlimited reservoir model is sensitive to the threshold friction velocity, which is a function of particle size distribution and has the greatest effect on emissions and resulting concentration. For this reason, a conservative soil aggregate size of 500 μm was selected as the default value for calculating particulate portion of the InhSRS. The soil size aggregate is related to how much wind is needed before dust is generated at a site. A soil aggregate size of 500 μm yields a threshold friction velocity of 0.5 m/s. This means that the wind speed must be at least 0.5 m/s before any fugitive dust is generated (Cowherd et al., 1985). However, the threshold friction velocity should be corrected to account for the presence of nonerodible elements such as clumps of grass or stones larger than 1 cm in diameter that can deflect a wind which otherwise would impact erodible soil (Cowherd et al., 1985). The amount of vegetative cover assumed for wind erosion was 50%, as a reasonable compromise between no vegetation and complete cover. This is not a conservative value since a significant number of sites have less than 50 percent vegetative cover. Please note that an assessment of the potential impact of some of these parameters is in the sensitivity analysis, Appendix G.

| Table 4<br>Inhalation Exposure Pathway Parameters - Particulates | | | |
|---|---|---|---|
| **Parameters** | | **Input Value** | **Source** |
| **V** | Fraction of vegetative cover | 50 % | USEPA (1996a) |
| **$U_m$** | Mean annual wind speed | 4.56 m/s | NOAA (2002b) |
| **$U_t$** | Equivalent threshold wind speed at 7 m | 11.32 m/s | USEPA (1996a) |
| **F(x)** | Function of wind speed over threshold wind speed | 0.159 | Function dependent on $U_m/U_t$ derived using Cowherd et al. (1985) (unitless) |
| **AT** | Averaging time | Carcinogen: 70 years | USEPA (1996a) |
| | | Noncarcinogen: 26 years | |

### 3.3. Residential Default Input Parameters

The inputs used by the Department in the equations in Section 2.2, above, and are either USEPA default inputs or New Jersey-specific values developed by the Department. Table 4 shows the input values and sources used to calculate the residential InhSRS. Sensitivity analyses for a number of the inputs were conducted; Appendices D and G detail the findings.

| Table 5<br>Residential Exposure Parameters | | | |
|---|---|---|---|
| **Parameters** | | **Input Value** | **Source** |
| **$A_s$** | Site size | 0.5 acres | This document Appendix G |
| **Q/C** | Inverse concentration at center of source | 86.6 $(g/m^2\text{-}s)/(kg/m^3)$ | This document Section 3.2.8 |
| **V** | Fraction of vegetative cover | 50 % | USEPA (1996a) |
| **$U_m$** | Mean annual wind speed | 4.56 m/s | NOAA (2002b) |
| **$U_t$** | Equivalent threshold wind speed at 7 m | 11.32 m/s | USEPA (1996a) |
| **F(x)** | Function of wind speed over threshold wind speed | 0.159 | Function dependent on $U_m/U_t$ derived using Cowherd et al. (1985) (unitless) |

| Table 5<br>Residential Exposure Parameters | | | |
|---|---|---|---|
| **Parameters** | | **Input Value** | **Source** |
| **IR** | Inhalation rate | 20 $m^3$/day | USEPA (1997b) |
| **AT** | Averaging time | Carcinogen: 70 years | USEPA (1996a) |
| | | Noncarcinogen: 26 years | |
| **EF** | Exposure frequency | 350 days | USEPA (1996a) |
| **ED** | Exposure duration | 26 years | USEPA (1996a) |

### 3.4. Non-residential Default Input Parameters

The inputs used by the Department in the equations in Section 2.2, above, and are either USEPA default inputs or New Jersey-specific values developed by the Department. Table 5 shows the input values and sources used to calculate the nonresidential InhSRS. Sensitivity analyses for a number of the inputs were conducted; Appendices D and G detail the findings.

| Table 6<br>Non-residential Exposure Parameters | | | |
|---|---|---|---|
| **Parameters** | | **Input Value** | **Source** |
| **$A_s$** | Site size | 2 acres | This document Appendix G |
| **Q/C** | Inverse concentration at center of source | 85 $(g/m^2\text{-}s)/(kg/m^3)$ | This document Section 3.2.8 |
| **V** | Fraction of vegetative cover | 50 % | USEPA (1996a) |
| **$U_m$** | Mean annual wind speed | 4.56 m/s | NOAA (2002b) |
| **$U_t$** | Equivalent threshold wind speed at 7 m | 11.32 m/s | USEPA (1996a) |
| **F(x)** | Function of wind speed over threshold wind speed | 0.159 | Function dependent on $U_m/U_t$ derived using Cowherd et al. (1985) (unitless) |
| **IR** | Inhalation rate | 20 $m^3$/day | USEPA (1997b) |
| **EF** | Exposure frequency | 225 days | USEPA (2014) |
| **ED** | Exposure duration | 25 years | USEPA (2014) |
| **BW** | Body weight | 80 kg | USEPA (2014) |
| **AT** | Averaging time | Carcinogen: 70 years | USEPA (2014) |
| | | Noncarcinogen: 25 years | |

Site size is a major factor affecting the dispersion modeling results. Currently, the Department considers a site size of two acres for nonresidential exposure. The larger the site, the less stringent the particulate portion of the InhSRS will be. In other words, when a source of emissions is dispersed over a larger area, the average concentration of contaminated dust in the air is smaller.

# 4. Inhalation Soil Remediation Standards

## 4.1. Calculation Results

For residential and nonresidential exposure scenarios, InhSRS were calculated for each contaminant for combined particulate and volatile phases using existing carcinogenic and noncarcinogenic health endpoint toxicity data where applicable. Inorganic contaminants with negligible vapor pressure have no Henry's law constant and exhibit no vapor phase behavior. For these contaminants, only the particulate portion of the equation calculated a value. The volatile portion of the equation utilized Equations 3 through 7, and the particulate portion of the equation utilized Equations 8 through 10 (see Appendix I).

The particulate portion of the equation applies mainly to metals (except for mercury) and other solid contaminants; however, because conceptually volatile contaminants could adhere to the surface of existing nuclei, the particulate approach is relevant, as well. Specific to volatile contaminants, smaller particles, called fines, can be formed from gases. The smallest particles, less than 0.1 μm, can be formed from nucleation, which is the condensation of low vapor pressure substances at high-temperature vaporization. Particles formed by nucleation can then grow by either coagulation, which is the combination of two or more particles to form a larger particle, or by the condensation of gas or vapor molecules on the surface of existing particles. Similarly, because semivolatile contaminants could also adhere to the surface of existing nuclei, this same concept applies to semivolatile contaminants.

The results of these calculations are provided in Table 7. The lowest calculated standard for each given contaminant for the carcinogenic and non-carcinogenic equations are provided in these tables. Two different exposure scenarios are represented in the tables. One is the residential exposure scenario; the other is the nonresidential exposure scenario. For ease-of-use, Table 7 summarizes the values by presenting the proposed standard for each inhalation exposure scenario. These values are the lowest and therefore most protective of the calculated standards within a given exposure scenario and are irrespective of the relevant phase of investigation (i.e., site investigation, remedial investigation) or health endpoint type. The values in Table 7 have been rounded and are to the appropriate number of significant figures.

## 4.2. Calculated Values

Within the inhalation exposure pathway and for all the chemicals considered, the standards for the volatile organic compounds typically are more likely to be lower than the standards developed for particulate contamination. For the residential exposure scenario, of the total 138 chemicals for which standards were derived, 25 standards were volatile based and 15 standards were particulate based. The remaining 98 were not regulated, had no available toxicity data to derive an appropriate InhSRS, or consisted of lead, which is being evaluated via the lead models developed by *USEPA: Integrated Exposure Uptake Biokinetic Model for Lead for Children*

*(IEUBK);* and *Adult Lead Model (ALM)* (see Section 2.9 A.). For the non-residential exposure scenario, 18 standards were volatile based and 12 standards were particulate based. The remaining 108 were not regulated, had no available toxicity data to derive an appropriate InhSRS, or consisted of lead as stated above.

The calculated values derived for a carcinogenic health endpoint are similarly more critical to a remedial investigation than the corresponding noncarcinogenic health endpoint values. For the residential exposure scenario, of the 40 regulated chemicals, 25 were associated with a carcinogenic health endpoint; none of these are determined to be carcinogenic under the Departments Group C Carcinogen policy. For the 30 regulated chemicals under the non-residential exposure scenario, 22 were associated with a carcinogenic health endpoint; none of these are determined to be carcinogenic under the Departments Group Carcinogen policy.

## 4.3. Soil Remediation Standards for the Inhalation Exposure Pathway

Listed in Table 7 are the InhSRS below which the Department has no regulatory concern relative to the inhalation exposure pathway for the respective residential and non-residential exposure scenarios. Notes are provided to identify if the standard is derived from a carcinogenic or noncarcinogenic health endpoint. The values listed in Table 7 have been rounded using currently accepted rounding rules.

| Table 7: Inhalation Soil Remediation Standards (mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Contaminant** | **CAS No.** | **Soil Saturation Concentration** | **Soil RL** | **Residential Carcinogenic Inhalation Human Health-based Criterion** | **Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Residential Inhalation Soil Remediation Standard** | **Non-Residential Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Inhalation Soil Remediation Standard** |
| Acenaphthene | 83-32-9 | 40 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Acetone (2-Propanone) | 67-64-1 | 160,000 | 0.01 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Acetophenone | 98-86-2 | 1,600 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Aldrin | 309-00-2 | 2.8 | 0.0017 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Aluminum (total) | 7429-90-5 | NA | 20 | NA[1] | NA[2] | NA[1,2] | NA[1] | NA[2] | NA[1,2] |
| Anthracene | 120-12-7 | 1.4 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Antimony (total) | 7440-36-0 | NA | 1.0 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Arsenic (total) | 7440-38-2 | NA | 0.50 | 1,100 | NA[1] | 1,100 | 5,200 | NA[1] | 5,200 |
| Atrazine | 1912-24-9 | 21 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Barium (total) | 7440-39-3 | NA | 5.0 | NA[1] | 870,000 | 870,000 | NA[1] | NA[2] | NA[2] |
| Benzaldehyde | 100-52-7 | 1,200 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Benzene | 71-43-2 | 850 | 0.0050 | 2.2 | 190 | 2.2 | 11 | NA[2,3] | 11 |
| Benzo(a)anthracene (1,2-Benzanthracene) | 56-55-3 | 3.3 | 0.17 | 78,000[4] | NA[1] | 78,000[4] | 370,000[4] | NA[1] | 370,000[4] |
| Benzo(a)pyrene | 50-32-8 | 1.9 | 0.17 | 7,800[4] | NA[1] | 7,800[4] | 37,000[4] | NA[1] | 37,000[4] |
| Benzo(b)fluoranthene (3,4-Benzofluoranthene) | 205-99-2 | 1.8 | 0.17 | 78,000[4] | NA[1] | 78,000[4] | 370,000[4] | NA[1] | 370,000[4] |
| Benzo(k)fluoranthene | 207-08-9 | 0.94 | 0.17 | 78,000[4] | NA[1] | 78,000[4] | NA[2,3] | NA[1] | NA[2,3] |
| Beryllium | 7440-41-7 | NA | 0.50 | 2,000 | 35,000 | 2,000 | 9,300 | 160,000 | 9,300 |
| 1,1'-Biphenyl | 92-52-4 | 78 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Bis(2-chloroethoxy)methane | 111-91-1 | 1,400 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Bis(2-chloroethyl)ether | 111-44-4 | 3,700 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | 65 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |

| Table 7: Inhalation Soil Remediation Standards (mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Contaminant** | **CAS No.** | **Soil Saturation Concentration** | **Soil RL** | **Residential Carcinogenic Inhalation Human Health-based Criterion** | **Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Residential Inhalation Soil Remediation Standard** | **Non-Residential Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Inhalation Soil Remediation Standard** |
| Bromodichloromethane (Dichlorobromomethane) | 75-27-4 | 690 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Bromoform | 75-25-2 | 680 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Bromomethane (Methyl bromide) | 74-83-9 | 3,300 | 0.0050 | NA[1] | 18 | 18 | NA[1] | 82 | 82 |
| 2-Butanone (Methyl ethyl ketone) (MEK) | 78-93-3 | 36,000 | 0.010 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Butylbenzyl phthalate | 85-68-7 | 39 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Cadmium | 7440-43-9 | NA | 0.50 | 2,600 | 17,000 | 2,600 | 12,000 | 80,000 | 12,000 |
| Caprolactam | 105-60-2 | 160,000 | 0.33 | NA[1] | 290 | 290 | NA[1] | 1,300 | 1,300 |
| Carbon disulfide | 75-15-0 | 580 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Carbon tetrachloride | 56-23-5 | 300 | 0.0050 | 1.4 | NA[2,3] | 1.4 | 6.9 | NA[2,3] | 6.9 |
| Chlordane (alpha and gamma forms summed) | 57-74-9 | 7.6 | 0.0017 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| 4-Chloroaniline | 106-47-8 | 1,500 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Chlorobenzene | 108-90-7 | 320 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Chloroethane (Ethyl chloride) | 75-00-3 | 1,700 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Chloroform | 67-66-3 | 1,900 | 0.0050 | NA[1] | 590 | 590 | NA[1] | NA[2,3] | NA[2,3] |
| Chloromethane (Methyl chloride) | 74-87-3 | 1,200 | 0.0050 | NA[1] | 270 | 270 | NA[1] | 1,200 | 1,200 |
| 2-Chloronaphthalene | 91-58-7 | 60 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 2-Chlorophenol (o-Chlorophenol) | 95-57-8 | 11,000 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Chrysene | 218-01-9 | 0.72 | 0.17 | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] |
| Cobalt (total) | 7440-48-4 | NA | 0.50 | 520 | 10,000 | 520 | 2,500 | 48,000 | 2,500 |

| Table 7: Inhalation Soil Remediation Standards (mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Contaminant** | **CAS No.** | **Soil Saturation Concentration** | **Soil RL** | **Residential Carcinogenic Inhalation Human Health-based Criterion** | **Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Residential Inhalation Soil Remediation Standard** | **Non-Residential Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Inhalation Soil Remediation Standard** |
| Copper (total) | 7440-50-8 | NA | 1.0 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Cyanide | 57-12-5 | NA | 0.50 | NA[1] | NA[2] | NA[1,2] | NA[1] | NA[2] | NA[2] |
| Cyclohexane | 110-82-7 | 65 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| 4,4'-DDD (p,p'-TDE) | 72-54-8 | 21 | 0.0033 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 4,4'-DDE (p,p'-DDX) | 72-55-9 | 9.4 | 0.0033 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 4,4'-DDT | 50-29-3 | 1.9 | 0.0033 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Dibenz(a,h)anthracene | 53-70-3 | 9.5 | 0.17 | 7,800[4] | NA[1] | 7,800[4] | 37,000[4] | NA[1] | 37,000[4] |
| Dibromochloromethane (Chlorodibromomethane) | 124-48-1 | 600 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 470 | 0.0050 | 0.026 | 11 | 0.026 | 0.12 | 52 | 0.12 |
| 1,2-Dibromoethane (Ethylene dibromide) | 106-93-4 | 920 | 0.0050 | 0.085 | 170 | 0.085 | 0.41 | 780 | 0.41 |
| 1,2-Dichlorobenzene (o-Dichlorobenzene) | 95-50-1 | 140 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| 1,3-Dichlorobenzene (m-Dichlorobenzene) | 541-73-1 | 110 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,4-Dichlorobenzene (p-Dichlorobenzene) | 106-46-7 | 74 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| 3,3'-Dichlorobenzidine | 91-94-1 | 20 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Dichlorodifluoromethane (Freon 12) | 75-71-8 | 540 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,1-Dichloroethane | 75-34-3 | 1,200 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,2-Dichloroethane | 107-06-2 | 2,000 | 0.0050 | NA[1] | 71 | 71 | NA[1] | 320 | 320 |
| 1,1-Dichloroethene (1,1-Dichloroethylene) | 75-35-4 | 830 | 0.0050 | NA[1] | 52 | 52 | NA[1] | 240 | 240 |
| 1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene) | 156-59-2 | 1,600 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |

| Table 7: Inhalation Soil Remediation Standards (mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Contaminant** | **CAS No.** | **Soil Saturation Concentration** | **Soil RL** | **Residential Carcinogenic Inhalation Human Health-based Criterion** | **Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Residential Inhalation Soil Remediation Standard** | **Non-Residential Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Inhalation Soil Remediation Standard** |
| 1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene) | 156-60-5 | 1,300 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 2,4-Dichlorophenol | 120-83-2 | 2,600 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,2-Dichloropropane | 78-87-5 | 810 | 0.0050 | 5.7 | 31 | 5.7 | 27 | 140 | 27 |
| 1,3-Dichloropropene (total) | 542-75-6 | 880 | 0.0050 | 4.8 | 140 | 4.8 | 23 | 650 | 23 |
| Dieldrin | 60-57-1 | 7.9 | 0.0033 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Diethylphthalate | 84-66-2 | 390 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 2,4-Dimethylphenol | 105-67-9 | 8,900 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Di-n-butyl phthalate | 84-74-2 | 28 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 2,4-Dinitrophenol | 51-28-5 | 430 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 2,4-Dinitrotoluene/2,6-Dinitrotoluene (mixture) | 25321-14-6 | 360 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Di-n-octyl phthalate | 117-84-0 | 6.2 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,4-Dioxane | 123-91-1 | 160,000 | 0.067 | 45 | 2,500 | 45 | 210 | 11,000 | 210 |
| Endosulfan I and Endosulfan II (alpha and beta) (summed) | 115-29-7 | 4.4 | 0.0033 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Endrin | 72-20-8 | 10 | 0.0033 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Ethylbenzene | 100-41-4 | 180 | 0.0050 | 10 | NA[2,3] | 10 | 48 | NA[2,3] | 48 |
| Extractable Petroleum Hydrocarbons (No. 2 Fuel Oil and Diesel) | various | NA | 80 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Extractable Petroleum Hydrocarbons (Other) | various | NA | 80 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Fluoranthene | 206-44-0 | 29 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Fluorene | 86-73-7 | 31 | 0.17 | NA[1] | NA[1] | NA | NA[1] | NA[1] | NA[1] |

| Table 7: Inhalation Soil Remediation Standards (mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Contaminant** | **CAS No.** | **Soil Saturation Concentration** | **Soil RL** | **Residential Carcinogenic Inhalation Human Health-based Criterion** | **Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Residential Inhalation Soil Remediation Standard** | **Non-Residential Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Inhalation Soil Remediation Standard** |
| alpha-HCH (alpha-BHC) | 319-84-6 | 12 | 0.0017 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| beta-HCH (beta-BHC) | 319-85-7 | 1.4 | 0.0017 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Heptachlor | 76-44-8 | 15 | 0.0017 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Heptachlor epoxide | 1024-57-3 | 4.1 | 0.0017 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Hexachlorobenzene | 118-74-1 | 0.078 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Hexachloro-1,3-butadiene | 87-68-3 | 6.1 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Hexachlorocyclopentadiene | 77-47-4 | 5.6 | 0.33 | NA[1] | 2.7 | 2.7 | NA[1] | NA[2,3] | NA[2,3] |
| Hexachloroethane | 67-72-1 | 28 | 0.17 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| n-Hexane | 110-54-3 | 88 | NA | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| 2-Hexanone | 591-78-6 | 3,200 | 0.010 | NA[1] | 1,000 | 1,000 | NA[1] | NA[2,3] | NA[2,3] |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 0.74 | 0.17 | 78,000[4] | NA[1] | 78,000[4] | 370,000[4] | NA[1] | 370,000[4] |
| Isophorone | 78-59-1 | 3,400 | 0.17 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Isopropylbenzene | 98-82-8 | 98 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Lead (total) | 7439-92-1 | NA | 0.50 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Lindane (gamma-HCH)(gamma-BHC) | 58-89-9 | 42 | 0.0017 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Manganese (total) | 7439-96-5 | NA | 0.50 | NA[1] | 87,000 | 87,000 | NA[1] | 400,000 | 400,000 |
| Mercury (total) | 7439-97-6 | 3.1[6] | 0.10 | NA[1] | 520,000[5] | 520,000[5] | NA[1] | NA[2,3] | NA[2,3] |
| Methoxychlor | 72-43-5 | 5.4 | 0.017 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Methyl acetate | 79-20-9 | 39,000 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Methylene chloride (Dichloromethane) | 75-09-2 | 2,800 | 0.0050 | 1,400 | NA[2,3] | 1,400 | NA[2,3] | NA[2,3] | NA[2,3] |
| 2-Methylnaphthalene | 91-57-6 | 130 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |

| Table 7: Inhalation Soil Remediation Standards (mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Contaminant** | **CAS No.** | **Soil Saturation Concentration** | **Soil RL** | **Residential Carcinogenic Inhalation Human Health-based Criterion** | **Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Residential Inhalation Soil Remediation Standard** | **Non-Residential Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Inhalation Soil Remediation Standard** |
| 4-Methyl-2-pentanone (MIBK) | 108-10-1 | 3,400 | 0.010 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| 2-Methylphenol (o-cresol) | 95-48-7 | 20,000 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 4-Methylphenol (p-cresol) | 106-44-5 | 16,000 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Methyl tert-butyl ether (MTBE) | 1634-04-4 | 9,100 | 0.0050 | 140 | NA[2,3] | 140 | 650 | NA[2,3] | 650 |
| Naphthalene | 91-20-3 | 100 | 0.17 | 5.7 | NA[2,3] | 5.7 | 27 | NA[2,3] | 27 |
| Nickel (total) | 7440-02-0 | NA | 0.50 | 20,000 | 24,000 | 20,000 | 93,000 | 110,000 | 93,000 |
| 4-Nitroaniline | 100-01-6 | 270 | 0.33 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Nitrobenzene | 98-95-3 | 1,300 | 0.17 | 7.5 | 1,000 | 7.5 | 36 | NA[2,3] | 36 |
| N-Nitrosodi-n-propylamine | 621-64-7 | 9,200 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| N-Nitrosodiphenylamine | 86-30-6 | 190 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 2,2'-oxybis(1-chloropropane) | 108-60-1 | 540 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Pentachlorophenol | 87-86-5 | 140 | 0.33 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Phenol | 108-95-2 | 44,000 | 0.33 | NA[1] | 39,000 | 39,000 | NA[1] | NA[2,3] | NA[2,3] |
| Polychlorinated biphenyls (PCBs) | 1336-36-3 | 110 | 0.033 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Pyrene | 129-00-0 | 15 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Selenium (total) | 7782-49-2 | NA | 2.5 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Silver (total) | 7440-22-4 | NA | 0.50 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Styrene | 100-42-5 | 330 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Tertiary butyl alcohol (TBA) | 75-65-0 | 160,000 | 0.10 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | 2.7 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |

| Table 7: Inhalation Soil Remediation Standards (mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Contaminant** | **CAS No.** | **Soil Saturation Concentration** | **Soil RL** | **Residential Carcinogenic Inhalation Human Health-based Criterion** | **Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Residential Inhalation Soil Remediation Standard** | **Non-Residential Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Non-Carcinogenic Inhalation Human Health-based Criterion** | **Non-Residential Inhalation Soil Remediation Standard** |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 1746-01-6 | 0.10 | 0.0000010 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | 980 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Tetrachloroethene (PCE) (Tetrachloroethylene) | 127-18-4 | 89 | 0.0050 | 47 | NA[2,3] | 47 | NA[2,3] | NA[2,3] | NA[2,3] |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | 150 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Toluene | 108-88-3 | 340 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Toxaphene | 8001-35-2 | 85 | 0.17 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,2,4-Trichlorobenzene | 120-82-1 | 140 | 0.0050 | NA[1] | 94 | 94 | NA[1] | NA[2,3] | NA[2,3] |
| 1,1,1-Trichloroethane | 71-55-6 | 420 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| 1,1,2-Trichloroethane | 79-00-5 | 1,300 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Trichloroethene (TCE) (Trichloroethylene) | 79-01-6 | 410 | 0.0050 | 3.0 | 9.1 | 3.0 | 14 | 42 | 14 |
| Trichlorofluoromethane (Freon 11) | 75-69-4 | 790 | 0.0050 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 2,4,5-Trichlorophenol | 95-95-4 | 5,800 | 0.20 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 2,4,6-Trichlorophenol | 88-06-2 | 1,700 | 0.20 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF) | 76-13-1 | 530 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| 1,2,4-Trimethylbenzene | 95-63-6 | 80 | 0.076 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Vanadium (total) | 7440-62-2 | NA | 2.5 | NA[1] | 170,000 | 170,000 | NA[1] | 800,000 | 800,000 |
| Vinyl chloride | 75-01-4 | 2,900 | 0.0050 | 1.4 | 220 | 1.4 | 6.4 | 1,000 | 6.4 |
| Xylenes (total) | 1330-20-7 | 100 | 0.0050 | NA[1] | NA[2,3] | NA[2,3] | NA[1] | NA[2,3] | NA[2,3] |
| Zinc (total) | 7440-66-6 | NA | 1.0 | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |

NA = Not available/applicable

1 – Appropriate toxicological information not available
2 – Health-based criterion exceeds one million parts per million
3 – Exceeds soil saturation limit
4 – Exceeds soil saturation limit; however, human health-based criterion based on particulate portion of the equation
5 –Value is for elemental mercury

# 5. Methodology for Developing Alternative Remediation Standards for Soil

## 5.1. Overview

The *Brownfield and Contaminated Site Remediation Act* (N.J.S.A. 58:10B-1 et seq.) requires the Department to consider site-specific factors in determining alternative remediation standards (ARS) for soil and will review proposals on a site-by-site basis and render a decision on the acceptability of the proposal for the site. These site-specific factors may vary from those used by the Department in the development of the adopted soil remediation standards pursuant to this section. The *Alternative Remediation Standards Technical Guidance for Soil for the Ingestion-Dermal and Inhalation Exposure Pathways* (https://www.nj.gov/dep/srp/guidance/) provides technical guidance to support the development of an ARS for the inhalation exposure and ingestion-dermal pathways. Guidance is provided to identify when and how to calculate a site-specific ARS for soil and supplements N.J.A.C 7:26D-8 and Appendix 7. The document does not cover interim SRS or updated SRS based on new toxicity data (N.J.A.C. 7:26D-6 and 7). USEPA references and other sources that may be helpful to investigators for developing an ARS for soil and supporting assumptions used in ARS calculations are also provided in the technical guidance.

In addition, the Department has developed a calculator that will allow the input of site-specific conditions that will calculate an appropriate ARS for soil. This Inhalation Exposure Pathway Alternative Remediation Standard Calculator may be found at http://www.nj.gov/dep/srp/guidance/rs.

The Department will also review other proposed approaches incorporating different models, assumptions, and information on a case-by-case basis. If the Department approves of their use, these approaches may then be used to develop an acceptable ARS for soil; however, the Department reserves the right to unilaterally determine the acceptability of these proposals.

Be advised that the Department will continue to evaluate other factors for potential use in the ARS for soil process. The Department will also monitor those variables it currently allows to be used to develop an ARS and will, if appropriate, preclude their future use.

An acceptable ARS for soil will effectively function as the InhSRS that it replaces for that particular site or AOC. Specifically, such an ARS would be used in determining whether an area is contaminated. The ARS would be used in the compliance process just as an InhSRS would be. In particular, the *Alternative Remediation Standards Technical Guidance for Soil for the Ingestion-Dermal and Inhalation Exposure Pathways* (https://www.nj.gov/dep/srp/guidance/) provides:

- Background on the default SRS for the ingestion-dermal and inhalation exposure pathways to help investigators identify when development of an ARS for soil may or may not be appropriate to support site remedial decisions;

- ARS for soil options that require prior approval by the Department before being implemented, including guidance and examples of appropriate exposure factors for deriving an ARS for soil for exposure assumptions relevant to an alternative land use scenarios (i.e., active recreational land use, passive recreational land use, restricted access areas, and infrequent access areas);

- ARS for soil options for the inhalation exposure pathway that do not require prior approval from the Department before being implemented, including contaminated soil depth range, organic carbon content of soil, and fraction of vegetative cover;

- Information regarding the Department's calculator used for developing and submitting an ARS for soil; and

- Information on the application, documentation, and review process (where prior approval is required before implementation) of an ARS for soil request.

The above *Alternative Remediation Standards Technical Guidance for Soil for the Ingestion-Dermal and Inhalation Exposure Pathways* may be accessed at https://www.nj.gov/dep/srp/guidance/.

## 5.2. Methods to Develop an ARS for Soil for the Inhalation Exposure Pathway - Variables Which Can Be Changed

Only a limited number of variables are allowed to be changed to accommodate site-specific conditions. When submitting an ARS for soil the following information is required to be submitted to the department:

- A printout of the Department's calculator showing the modified input parameters and resultant ARS;
- A description of how the input parameters were selected (i.e., vertical contaminant delineation, average or lowest soil organic concentration, and figures, photos, etc.), including all related laboratory results or measurements and calculations; and
- A description of how the standards were used in the remediation of the site or AOC, including institutional controls, if appropriate.

The ARS for soil developed using these methods may be used to remediate a site without prior Department approval; however, pursuant to N.J.A.C. 7:26D-8.5 and N.J.S.A. 58:10C-21, the supporting documentation must be submitted to the Department for review. These variables which can be changed are described below.

1. Depth Range of Contamination – The depth range of the contaminant may be used to develop an ARS for soil only for the inhalation exposure pathway. This parameter will only have an effect on volatile contaminants. The inhalation exposure pathway assumes the contamination starts at the ground surface and has an infinite depth (USEPA, 1996a). If the contamination is delineated in accordance with the *Technical Requirements for Site Remediation* N.J.A.C. 7:26E-4.2(b), then the shallowest point (d1) and deepest point (d2) of contamination that exceeds the default inhalation exposure pathway SRS may be used to define the depth range of contamination. These values (d1 and d2), measured in centimeters below ground surface, may be entered into the Department's Soil Remediation Standards for the Inhalation Exposure Pathway Calculator, (https://www.nj.gov/dep/srp/guidance/rs/index.html), to develop an ARS for soil. An assumption of finite depth range will reduce the mass of contaminant in the soil, which will reduce the average volatilization flux resulting in a greater remediation standard.

The Department shall require the use of an institutional control and soil remedial action permit, pursuant to N.J.A.C. 7:26C-7, for an ARS based on a site-specific depth range of contamination that begins at a depth greater than zero centimeters below ground surface to ensure that the continued use of the ARS for soil remains valid. These institutional controls and permits are necessary to prevent excavation of the uncontaminated material above the contaminated soil, which would affect contaminant flux and thus the ARS. The Department shall not require the use of an institutional control or soil remedial action permit, pursuant to N.J.A.C. 7:26C-7, for an ARS based on a site-specific depth range of contamination that begins at a depth of zero centimeters below ground surface.

2. Organic Carbon Content of Soil ($f_{oc}$) - The $f_{oc}$ may be used to develop an ARS for soil and will only have an effect on volatile contaminants. The inhalation exposure pathway assumes 0.002 $g_{(oc)}/g_{(soil)}$ based on USEPA (1996a) and Carsel et al. (1988). If the $f_{oc}$ is measured in accordance with the *Alternative Remediation Standards Technical Guidance for Soil and Soil Leachate for the Migration to Ground Water Exposure Pathway* (NJDEP 2021c), Section VII(A), the $f_{oc}$ value may be entered into the Department's Alternative Soil Remediation Standards Inhalation Exposure Pathway Calculator (http://www.nj.gov/dep/srp/guidance/rs/index.html), to develop an ARS for soil. The organic carbon content of the soil is used with a contaminant's soil organic-carbon water partitioning coefficient ($K_{oc}$) value to determine the extent the contaminant is adsorbed to soil. In general, the organic carbon content of soil generally ranges from about 0.002 to 0.05 and the variation has a relatively small effect on calculated remediation standards. See sensitivity analysis in Appendix D.

   The Department shall not require the use of an institutional control, or soil remedial action permit, pursuant to N.J.A.C. 7:26C-7 for an ARS for soil based on a site-specific $f_{oc}$.

3. Fraction of Vegetative Cover (V) - The V may be used to develop an ARS for soil only for the inhalation exposure pathway and only has an effect on non-volatile contaminants. The default assumption for developing soil remediation standards for the inhalation exposure pathway is 50% vegetative cover for the site or AOC because it represents a reasonable compromise between no cover and a totally vegetated site (USEPA, 1996a). This parameter can be varied to reflect a site-specific condition and an appropriate ARS subsequently calculated. The Department does not consider any portion of the site consisting of a gravel path, sidewalk, parking lot, building, or other non-vegetated area to be an area of vegetative cover and these areas may not be included in any fraction of vegetation determination. Likewise, the Department does not consider areas of barren soil to be vegetative cover, but these areas should be factored into a percent vegetative cover calculation. The percent of vegetative cover is the amount of soil covered by vegetation using standard ecological techniques (e.g., grid or plot sampling). Although professional judgement will need to be employed, this does not necessarily mean that half of an area has vegetation while the other half does not (barren soil). Rather, the entire area may appear to be covered with vegetation, but upon closer examination the vegetation may not fully cover all of the soil. Therefore, this vegetative area would have less than 100 percent cover and must be factored into any calculation. The calculated

percentage of vegetation (versus soil) must be maintained and monitored to be an effective engineering control. This parameter can be varied to reflect a site-specific condition and to allow for an appropriate ARS for soil to be calculated.

If the area of vegetative cover is measured at the site or AOC using an appropriate technique, then V can be determined for the site or AOC as appropriate. V would be calculated for the covered area, and other barren soil areas would be factored in. An example of an acceptable vegetative cover would be areas of continuous grass where there is no bare ground for consideration as an area greater than fifty percent. The value for V (as a decimal) may be entered into the Department's Inhalation Exposure Pathway Calculator (http://www.nj.gov/dep/srp/guidance/rs/index.html), to develop an ARS for soil.

The Department shall require the use of an institutional control and a soil remedial action permit, pursuant to N.J.A.C. 7:26C-7, for an ARS based on a site-specific V to ensure that the continued use of the ARS remains valid.

## 5.3. Methods to Develop an ARS for Soil for the Inhalation Exposure Pathway - Variables Which Cannot Be Changed

The following variables cannot be changed to develop an ARS for soil:

1. Total Soil Porosity (n) – The Department uses 0.41 because it is the value for sandy loam soil, which is the default soil texture for New Jersey. The USEPA uses a default of 0.43 for loam soil. Site-specific porosity values are difficult to obtain in the field, and laboratory measurements of this parameter are not advised since the integrity of the soil structure is lost during sampling unless special techniques are used.

2. Water-filled & Air-filled Soil Porosity (Volumetric soil water content) ($\theta_w$ & $\theta_a$) – Due to long-term and short-term variations in soil moisture, experimentally determining site-specific air and water contents of a soil at a particular site is difficult. Long-term variations occur due to seasonal changes and short-term variations occur due to weather events. As a result, the SSG User's guide does not recommend using field results to adjust these parameters. Therefore, adjustment of these parameters will not be allowed without consultation with and approval by the Department. The value for air-filled porosity ($\theta_a$) is 0.18 $L_{air}/L_{soil}$, and the value for water-filled porosity ($\theta_w$) is 0.23 $L_{water}/L_{soil}$.

3. Dry Soil Bulk Density ($\rho_b$) - Dry soil bulk densities vary over a relatively small range, from about 1.3 to 1.8 g/cm$^3$ (Carsel et al., 1988). The USEPA default value of 1.5 g/cm$^3$ was used because it agrees with the value listed for a sandy loam soil texture. Soil remediation standards are only slightly affected by the value for this parameter.

## 5.4. Exposure Parameters

### 5.4.1. Residential Scenario – Variables Cannot Be Changed

1. Averaging time - The averaging time for contaminants that are known carcinogens is 70 years, and the averaging time for non-carcinogenic contaminants is 26 years. Both of these values are USEPA default values (2018a).

2. Exposure frequency - The exposure frequency of 350 days assumes year-round exposure and is a USEPA default value (2018a).

3. Exposure duration - The exposure duration for residential sites is 26 years and is a USEPA default value (2018a).

### 5.4.2. Non-Residential Scenario – Variables Cannot Be Changed

1. Averaging time - The averaging time for contaminants that are known carcinogens is 70 years, and the averaging time for non-carcinogenic contaminants is 25 years. Both of these values are USEPA default values (2018a).

2. Exposure frequency - The exposure frequency also assumes 225 days per year. A value of 225 days assumes a five-day work week for 50 weeks per year. Furthermore, exposure is assumed not to occur during holidays, vacation, and sick time, accounting for another 25 days during the year. These are USEPA default values (2018a).

3. Exposure duration - The exposure duration for non-residential sites is 25 years. This is a USEPA default value (2018a).

### 5.4.3. Alternative Remediation Standards for Soil Based on Alternative Land Use – Variables May Be Changed

An ARS for soil may be based on use of the site for alternative land use scenarios or based on site-specific land use scenarios that affect the amount of time that people are likely to spend at a site designated for an alternative use. Approval by the Department is required for an ARS for soil developed in accordance with N.J.A.C. 7:26D-8.4 prior to implementation of a site or AOC-specific ARS. These scenarios consist of land use that cannot be defined as either residential or non-residential in accordance with N.J.A.C. 7:26D-1.5 (e.g., park lands, conservation areas). Examples of alternative land use scenarios include:

- Active Recreational Land Use (sports playing fields, playgrounds, and motorcycle and ATV use areas)
- Passive Recreational Land Use (trails used for walking, cycling, and hunting)
- Restricted Access Areas (right-of-way areas accessed for the inspection and repair of utilities, transportation corridors and similar uses)
- Infrequent Access Areas (ecological preservation and conservation areas).

The approval of an alternative remediation standard for alternative land use will be contingent on the use of proper institutional and appropriate engineering controls, if necessary, to ensure the

continued use of the site for the proposed alternative use. Refer to The *Alternative Remediation Standards Technical Guidance for Soil for the Ingestion-Dermal and Inhalation Exposure Pathways for Soil* (NJDEP 2021) (https://www.nj.gov/dep/srp/guidance/) for details regarding ARS development.

## 5.5. Interim Soil Remediation Standards

Interim soil remediation standards may be developed in the absence of available SRS for contaminants of concern at a site. The procedures set forth at N.J.A.C. 7:26D Appendix 3 and outlined in this document, as applicable, are used to develop interim SRS for the inhalation exposure pathway provided appropriate toxicity information is available for the contaminants. Consistent with N.J.A.C.7:26D-6, the person responsible for conducting the remediation may request that the Department develop an interim soil remediation standard and shall use only a Department developed interim soil remediation standard. Contacts for technical questions regarding the development of interim SRS can be found at http://www.nj.gov/dep/srp/srra/srra_contacts.htm.

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# APPENDICES

# Appendix A

# Tables

Table A1
Soil Remediation Standards for the Inhalation Exposure Pathway – Residential (mg/kg)

| Contaminant | CAS No. | Carcinogenic Inhalation Human Health-based Criterion | Noncarcinogenic Inhalation Human Health-based Criterion | Soil Saturation Limit | Reporting Limit | Soil Remediation Standard Inhalation Residential |
|---|---|---|---|---|---|---|
| Acenaphthene | 83-32-9 | NA[1] | NA[1] | 40 | 0.17 | NA[1] |
| Acetone (2-Propanone) | 67-64-1 | NA[1] | NA[1] | 160,000 | 0.010 | NA[1] |
| Acetophenone | 98-86-2 | NA[1] | NA[1] | 1,600 | 0.33 | NA[1] |
| Aldrin | 309-00-2 | NA[1] | NA[1] | 2.8 | 0.0017 | NA[1] |
| Aluminum (total) | 7429-90-5 | NA[1] | NA[2] | NA | 20 | NA[2] |
| Anthracene | 120-12-7 | NA[1] | NA[1] | 1.4 | 0.17 | NA[1] |
| Antimony (total) | 7440-36-0 | NA[1] | NA[1] | NA | 1.0 | NA[1] |
| Arsenic (total) | 7440-38-2 | 1,100 | NA[1] | NA | 0.50 | 1,100 |
| Atrazine | 1912-24-9 | NA[1] | NA[1] | 21 | 0.33 | NA[1] |
| Barium (total) | 7440-39-3 | NA[1] | 870,000 | NA | 5.0 | 870,000 |
| Benzaldehyde | 100-52-7 | NA[1] | NA[1] | 1,200 | 0.33 | NA[1] |
| Benzene | 71-43-2 | 2.2 | 190 | 850 | 0.0050 | 2.2 |
| Benzo(a)anthracene (1,2-Benzanthracene) | 56-55-3 | 78,000[4] | NA[1] | 3.3 | 0.17 | 78,000[4] |
| Benzo(a)pyrene | 50-32-8 | 7,800[4] | 3,500[4] | 1.9 | 0.17 | 3,500[4] |
| Benzo(b)fluoranthene (3,4-Benzofluoranthene) | 205-99-2 | 78,000[4] | NA[1] | 1.8 | 0.17 | 78,000[4] |
| Benzo(k)fluoranthene | 207-08-9 | 780,000[4] | NA[1] | 0.94 | 0.17 | 780,000[4] |
| Beryllium | 7440-41-7 | 2,000 | 35,000 | NA | 0.50 | 2,000 |
| 1,1'-Biphenyl | 92-52-4 | NA[1] | NA[1] | 78 | 0.17 | NA[1] |
| Bis(2-chloroethoxy)methane | 111-91-1 | NA[1] | NA[1] | 1,400 | 0.17 | NA[1] |
| Bis(2-chloroethyl)ether | 111-44-4 | NA[1] | NA[1] | 3,700 | 0.33 | NA[1] |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | NA[1] | NA[1] | 65 | 0.17 | NA[1] |
| Bromodichloromethane (Dichlorobromomethane) | 75-27-4 | NA[1] | NA[1] | 690 | 0.0050 | NA[1] |
| Bromoform | 75-25-2 | NA[1] | NA[1] | 680 | 0.0050 | NA[1] |
| Bromomethane (Methyl bromide) | 74-83-9 | NA[1] | 18 | 3,300 | 0.0050 | 18 |
| 2-Butanone (Methyl ethyl ketone) (MEK) | 78-93-3 | NA[1] | NA[2,3] | 36,000 | 0.010 | NA[2,3] |
| Butylbenzyl phthalate | 85-68-7 | NA[1] | NA[1] | 39 | 0.17 | NA[1] |
| Cadmium | 7440-43-9 | 2,600 | 17,000 | NA | 0.50 | 2,600 |
| Caprolactam | 105-60-2 | NA[1] | 290 | 160,000 | 0.33 | 290 |
| Carbon disulfide | 75-15-0 | NA[1] | NA[2,3] | 580 | 0.0050 | NA[2,3] |
| Carbon tetrachloride | 56-23-5 | 1.4 | NA[2,3] | 300 | 0.0050 | 1.4 |
| Chlordane (alpha and gamma forms summed) | 57-74-9 | NA[1] | NA[2,3] | 7.6 | 0.0017 | NA[2,3] |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4-Chloroaniline | 106-47-8 | NA[1] | NA[1] | 1,500 | 0.17 | NA[1] |
| Chlorobenzene | 108-90-7 | NA[1] | NA[2,3] | 320 | 0.0050 | NA[2,3] |
| Chloroethane (Ethyl chloride) | 75-00-3 | NA[1] | NA[2,3] | 1,700 | 0.0050 | NA[2,3] |
| Chloroform | 67-66-3 | NA[1] | 590 | 1,900 | 0.0050 | 590 |
| Chloromethane (Methyl chloride) | 74-87-3 | NA[1] | 270 | 1,200 | 0.0050 | 270 |
| 2-Chloronaphthalene | 91-58-7 | NA[1] | NA[1] | 60 | 0.17 | NA[1] |
| 2-Chlorophenol (o-Chlorophenol) | 95-57-8 | NA[1] | NA[1] | 11,000 | 0.17 | NA[1] |
| Chrysene | 218-01-9 | NA[2,3] | NA[1] | 0.72 | 0.17 | NA[2,3] |
| Cobalt (total) | 7440-48-4 | 520 | 10,000 | NA | 0.50 | 520 |
| Copper (total) | 7440-50-8 | NA[1] | NA[1] | NA | 1.0 | NA[1] |
| Cyanide | 57-12-5 | NA[1] | NA[2] | NA | 0.50 | NA[2] |
| Cyclohexane | 110-82-7 | NA[1] | NA[2,3] | 65 | 0.0050 | NA[2,3] |
| 4,4'-DDD (p,p'-TDE) | 72-54-8 | NA[1] | NA[1] | 21 | 0.0033 | NA[1] |
| 4,4'-DDE (p,p'-DDX) | 72-55-9 | NA[1] | NA[1] | 9.4 | 0.0033 | NA[1] |
| 4,4'-DDT | 50-29-3 | NA[1] | NA[1] | 1.9 | 0.0033 | NA[1] |
| Dibenz(a,h)anthracene | 53-70-3 | 7,800[4] | NA[1] | 9.5 | 0.17 | 7,800[4] |
| Dibromochloromethane (Chlorodibromomethane) | 124-48-1 | NA[1] | NA[1] | 600 | 0.0050 | NA[1] |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 0.026 | 11 | 470 | 0.0050 | 0.026 |
| 1,2-Dibromoethane (Ethylene dibromide) | 106-93-4 | 0.085 | 170 | 920 | 0.0050 | 0.085 |
| 1,2-Dichlorobenzene (o-Dichlorobenzene) | 95-50-1 | NA[1] | NA[2,3] | 140 | 0.0050 | NA[2,3] |
| 1,3-Dichlorobenzene (m-Dichlorobenzene) | 541-73-1 | NA[1] | NA[1] | 110 | 0.0050 | NA[1] |
| 1,4-Dichlorobenzene (p-Dichlorobenzene) | 106-46-7 | NA[1] | NA[2,3] | 74 | 0.0050 | NA[2,3] |
| 3,3'-Dichlorobenzidine | 91-94-1 | NA[1] | NA[1] | 20 | 0.33 | NA[1] |
| Dichlorodifluoromethane (Freon 12) | 75-71-8 | NA[1] | NA[1] | 540 | 0.0050 | NA[1] |
| 1,1-Dichloroethane | 75-34-3 | NA[1] | NA[1] | 1,200 | 0.0050 | NA[1] |
| 1,2-Dichloroethane | 107-06-2 | NA[1] | 71 | 2,000 | 0.0050 | 71 |
| 1,1-Dichloroethene (1,1-Dichloroethylene) | 75-35-4 | NA[1] | 52 | 830 | 0.0050 | 52 |
| 1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene) | 156-59-2 | NA[1] | NA[1] | 1,600 | 0.0050 | NA[1] |
| 1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene) | 156-60-5 | NA[1] | NA[1] | 1,300 | 0.0050 | NA[1] |
| 2,4-Dichlorophenol | 120-83-2 | NA[1] | NA[1] | 2,600 | 0.17 | NA[1] |
| 1,2-Dichloropropane | 78-87-5 | 5.7 | 31 | 810 | 0.0050 | 5.7 |
| 1,3-Dichloropropene (total) | 542-75-6 | 4.8 | 140 | 880 | 0.0050 | 4.8 |
| Dieldrin | 60-57-1 | NA[1] | NA[1] | 7.9 | 0.0033 | NA[1] |

| | | | | | | |
|---|---|---|---|---|---|---|
| Diethylphthalate | 84-66-2 | NA[1] | NA[1] | 390 | 0.17 | NA[1] |
| 2,4-Dimethylphenol | 105-67-9 | NA[1] | NA[1] | 8,900 | 0.17 | NA[1] |
| Di-n-butyl phthalate | 84-74-2 | NA[1] | NA[1] | 28 | 0.17 | NA[1] |
| 2,4-Dinitrophenol | 51-28-5 | NA[1] | NA[1] | 430 | 0.33 | NA[1] |
| 2,4-Dinitrotoluene/2,6-Dinitrotoluene (mixture) | 25321-14-6 | NA[1] | NA[1] | 360 | 0.17 | NA[1] |
| Di-n-octyl phthalate | 117-84-0 | NA[1] | NA[1] | 6.2 | 0.33 | NA[1] |
| 1,4-Dioxane | 123-91-1 | 45 | 2,500 | 160,000 | 0.067 | 45 |
| Endosulfan I and Endosulfan II (alpha and beta) (summed) | 115-29-7 | NA[1] | NA[1] | 4.4 | 0.0033 | NA[1] |
| Endrin | 72-20-8 | NA[1] | NA[1] | 10 | 0.0033 | NA[1] |
| Ethylbenzene | 100-41-4 | 10 | NA[2,3] | 180 | 0.0050 | 10 |
| Extractable Petroleum Hydrocarbons (Category 1) | various | NA[1] | NA[1] | NA | 80 | NA[1] |
| Extractable Petroleum Hydrocarbons (Category 2) | various | NA[1] | NA[1] | NA | 80 | NA[1] |
| Fluoranthene | 206-44-0 | NA[1] | NA[1] | 29 | 0.33 | NA[1] |
| Fluorene | 86-73-7 | NA[1] | NA[1] | 31 | 0.17 | NA |
| alpha-HCH (alpha-BHC) | 319-84-6 | NA[1] | NA[1] | 12 | 0.0017 | NA[1] |
| beta-HCH (beta-BHC) | 319-85-7 | NA[1] | NA[1] | 1.4 | 0.0017 | NA[1] |
| Heptachlor | 76-44-8 | NA[1] | NA[1] | 15 | 0.0017 | NA[1] |
| Heptachlor epoxide | 1024-57-3 | NA[1] | NA[1] | 4.1 | 0.0017 | NA[1] |
| Hexachlorobenzene | 118-74-1 | NA[1] | NA[1] | 0.078 | 0.17 | NA[1] |
| Hexachloro-1,3-butadiene | 87-68-3 | NA[1] | NA[1] | 6.1 | 0.17 | NA[1] |
| Hexachlorocyclopentadiene | 77-47-4 | NA[1] | 2.7 | 5.6 | 0.33 | 2.7 |
| Hexachloroethane | 67-72-1 | NA[1] | NA[2,3] | 28 | 0.17 | NA[2,3] |
| n-Hexane | 110-54-3 | NA[1] | NA[2,3] | 88 | NA | NA[2,3] |
| 2-Hexanone | 591-78-6 | NA[1] | 1,000 | 3,200 | 0.010 | 1,000 |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 78,000[4] | NA[1] | 0.74 | 0.17 | 78,000[4] |
| Isophorone | 78-59-1 | NA[1] | NA[2,3] | 3,400 | 0.17 | NA[2,3] |
| Isopropylbenzene | 98-82-8 | NA[1] | NA[2,3] | 98 | 0.0050 | NA[2,3] |
| Lead (total) | 7439-92-1 | NA[1] | NA[1] | NA | 0.50 | NA[1] |
| Lindane (gamma-HCH) (gamma-BHC) | 58-89-9 | NA[1] | NA[1] | 42 | 0.0017 | NA[1] |
| Manganese (total) | 7439-96-5 | NA[1] | 87,000 | NA | 0.50 | 87,000 |
| Mercury (total) | 7439-97-6 | NA[1] | 520,000[4] | 3.1[5] | 0.10 | 520,000[4] |
| Methoxychlor | 72-43-5 | NA[1] | NA[1] | 5.4 | 0.017 | NA[1] |
| Methyl acetate | 79-20-9 | NA[1] | NA[1] | 39,000 | 0.0050 | NA[1] |
| Methylene chloride (Dichloromethane) | 75-09-2 | 1,400 | NA[2,3] | 2,800 | 0.0050 | 1,400 |
| 2-Methylnaphthalene | 91-57-6 | NA[1] | NA[1] | 130 | 0.17 | NA[1] |
| 4-Methyl-2-pentanone (MIBK) | 108-10-1 | NA[1] | NA[2,3] | 3,400 | 0.010 | NA[2,3] |
| 2-Methylphenol (o-cresol) | 95-48-7 | NA[1] | NA[1] | 20,000 | 0.33 | NA[1] |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4-Methylphenol (p-cresol) | 106-44-5 | NA[1] | NA[1] | 16,000 | 0.33 | NA[1] |
| Methyl tert-butyl ether (MTBE) | 1634-04-4 | 140 | NA[2,3] | 9,100 | 0.0050 | 140 |
| Naphthalene | 91-20-3 | 5.7 | NA[2,3] | 100 | 0.17 | 5.7 |
| Nickel (total) | 7440-02-0 | 20,000 | 24,000 | NA | 0.50 | 20,000 |
| 4-Nitroaniline | 100-01-6 | NA[1] | NA[2,3] | 270 | 0.33 | NA[2,3] |
| Nitrobenzene | 98-95-3 | 7.5 | 1,000 | 1,300 | 0.17 | 7.5 |
| N-Nitrosodi-n-propylamine | 621-64-7 | NA[1] | NA[1] | 9,200 | 0.17 | NA[1] |
| N-Nitrosodiphenylamine | 86-30-6 | NA[1] | NA[1] | 190 | 0.17 | NA[1] |
| 2,2'-oxybis(1-chloropropane) | 108-60-1 | NA[1] | NA[1] | 540 | 0.33 | NA[1] |
| Pentachlorophenol | 87-86-5 | NA[1] | NA[1] | 140 | 0.33 | NA[1] |
| Phenol | 108-95-2 | NA[1] | 39,000 | 44,000 | 0.33 | 39,000 |
| Polychlorinated biphenyls (PCBs) | 1336-36-3 | NA[1] | NA[1] | 110 | 0.030 | NA[1] |
| Pyrene | 129-00-0 | NA[1] | NA[1] | 15 | 0.17 | NA[1] |
| Selenium (total) | 7782-49-2 | NA[1] | NA[1] | NA | 2.5 | NA[1] |
| Silver (total) | 7440-22-4 | NA[1] | NA[1] | NA | 0.50 | NA[1] |
| Styrene | 100-42-5 | NA[1] | NA[2,3] | 330 | 0.0050 | NA[2,3] |
| Tertiary butyl alcohol (TBA) | 75-65-0 | NA[1] | NA[1] | 160,000 | 0.10 | NA[1] |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | NA[1] | NA[1] | 2.7 | 0.17 | NA[1] |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 1746-01-6 | NA[1] | NA[1] | 0.10 | 0.0000010 | NA[1] |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | NA[1] | NA[1] | 980 | 0.0050 | NA[1] |
| Tetrachloroethene (PCE) (Tetrachloroethylene) | 127-18-4 | 47 | NA[2,3] | 89 | 0.0050 | 47 |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | NA[1] | NA[1] | 150 | 0.17 | NA[1] |
| Toluene | 108-88-3 | NA[1] | NA[2,3] | 340 | 0.0050 | NA[2,3] |
| Toxaphene | 8001-35-2 | NA[1] | NA[1] | 85 | 0.17 | NA[1] |
| 1,2,4-Trichlorobenzene | 120-82-1 | NA[1] | 94 | 140 | 0.0050 | 94 |
| 1,1,1-Trichloroethane | 71-55-6 | NA[1] | NA[2,3] | 420 | 0.0050 | NA[2,3] |
| 1,1,2-Trichloroethane | 79-00-5 | NA[1] | NA[1] | 1,300 | 0.0050 | NA[1] |
| Trichloroethene (TCE) (Trichloroethylene) | 79-01-6 | 3.0 | 9.1 | 410 | 0.0050 | 3.0 |
| Trichlorofluoromethane (Freon 11) | 75-69-4 | NA[1] | NA[1] | 790 | 0.0050 | NA[1] |
| 2,4,5-Trichlorophenol | 95-95-4 | NA[1] | NA[1] | 5,800 | 0.20 | NA[1] |
| 2,4,6-Trichlorophenol | 88-06-2 | NA[1] | NA[1] | 1,700 | 0.20 | NA[1] |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF) | 76-13-1 | NA[1] | NA[2,3] | 530 | 0.0050 | NA[2,3] |
| 1,2,4-Trimethylbenzene | 95-63-6 | NA[1] | NA[2,3] | 80 | 0.076 | NA[2,3] |
| Vanadium (total) | 7440-62-2 | NA[1] | 170,000 | NA | 2.5 | 170,000 |
| Vinyl chloride | 75-01-4 | 1.4 | 220 | 2,900 | 0.0050 | 1.4 |
| Xylenes (total) | 1330-20-7 | NA[1] | NA[2,3] | 100 | 0.0050 | NA[2,3] |
| Zinc (total) | 7440-66-6 | NA[1] | NA[1] | NA | 1.0 | NA[1] |

NA – Not applicable because soil saturation limit does not apply to this contaminant

NA[1] – Not applicable because appropriate toxicological information is not available

NA[2] – Standard not applicable because the calculated health-based criterion exceeds one million mg/kg

NA[3] – Standard not applicable because the calculated health-based criterion exceeds the soil saturation limit

[4] Exceeds soil saturation limit; however, health-based criterion based on particulate portion of the equation

[5] Value is for elemental mercury

Table A2
Soil Remediation Standards for the Inhalation Exposure Pathway – Nonresidential (mg/kg)

| Contaminant | CAS No. | Carcinogenic Inhalation Human Health-based Criterion | Noncarcinogenic Inhalation Human Health-based Criterion | Soil Saturation Concentration | Reporting Limit | Soil Remediation Standard Inhalation Nonresidential |
|---|---|---|---|---|---|---|
| Acenaphthene | 83-32-9 | NA[1] | NA[1] | 40 | 0.17 | NA[1] |
| Acetone (2-Propanone) | 67-64-1 | NA[1] | NA[1] | 160,000 | 0.010 | NA[1] |
| Acetophenone | 98-86-2 | NA[1] | NA[1] | 1,600 | 0.33 | NA[1] |
| Aldrin | 309-00-2 | NA[1] | NA[1] | 2.8 | 0.0017 | NA[1] |
| Aluminum (total) | 7429-90-5 | NA[1] | NA[2] | NA | 20 | NA[2] |
| Anthracene | 120-12-7 | NA[1] | NA[1] | 1.4 | 0.17 | NA[1] |
| Antimony (total) | 7440-36-0 | NA[1] | NA[1] | NA | 1.0 | NA[1] |
| Arsenic (total) | 7440-38-2 | 5,200 | NA[1] | NA | 0.50 | 5,200 |
| Atrazine | 1912-24-9 | NA[1] | NA[1] | 21 | 0.33 | NA[1] |
| Barium (total) | 7440-39-3 | NA[1] | NA[2] | NA | 5.0 | NA[2] |
| Benzaldehyde | 100-52-7 | NA[1] | NA[1] | 1,200 | 0.33 | NA[1] |
| Benzene | 71-43-2 | 11 | NA[2,3] | 850 | 0.0050 | 11 |
| Benzo(a)anthracene (1,2-Benzanthracene) | 56-55-3 | 370,000[4] | NA[1] | 3.3 | 0.17 | 370,000[4] |
| Benzo(a)pyrene | 50-32-8 | 37,000[4] | 16,000[4] | 1.9 | 0.17 | 16,000[4] |
| Benzo(b)fluoranthene (3,4-Benzofluoranthene) | 205-99-2 | 370,000[4] | NA[1] | 1.8 | 0.17 | 370,000[4] |
| Benzo(k)fluoranthene | 207-08-9 | NA[2,3] | NA[1] | 0.94 | 0.17 | NA[2,3] |
| Beryllium | 7440-41-7 | 9,300 | 160,000 | NA | 0.50 | 9,300 |
| 1,1'-Biphenyl | 92-52-4 | NA[1] | NA[1] | 78 | 0.17 | NA[1] |
| Bis(2-chloroethoxy)methane | 111-91-1 | NA[1] | NA[1] | 1,400 | 0.17 | NA[1] |
| Bis(2-chloroethyl)ether | 111-44-4 | NA[1] | NA[1] | 3,700 | 0.33 | NA[1] |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | NA[1] | NA[1] | 65 | 0.17 | NA[1] |
| Bromodichloromethane (Dichlorobromomethane) | 75-27-4 | NA[1] | NA[1] | 690 | 0.0050 | NA[1] |
| Bromoform | 75-25-2 | NA[1] | NA[1] | 680 | 0.0050 | NA[1] |
| Bromomethane (Methyl bromide) | 74-83-9 | NA[1] | 82 | 3,300 | 0.0050 | 82 |
| 2-Butanone (Methyl ethyl ketone) (MEK) | 78-93-3 | NA[1] | NA[2,3] | 36,000 | 0.010 | NA[2,3] |
| Butylbenzyl phthalate | 85-68-7 | NA[1] | NA[1] | 39 | 0.17 | NA[1] |
| Cadmium | 7440-43-9 | 12,000 | 80,000 | NA | 0.50 | 12,000 |
| Caprolactam | 105-60-2 | NA[1] | 1,300 | 160,000 | 0.33 | 1,300 |
| Carbon disulfide | 75-15-0 | NA[1] | NA[2,3] | 580 | 0.0050 | NA[2,3] |
| Carbon tetrachloride | 56-23-5 | 6.9 | NA[2,3] | 300 | 0.0050 | 6.9 |
| Chlordane (alpha and gamma forms summed) | 57-74-9 | NA[1] | NA[2,3] | 7.6 | 0.0017 | NA[2,3] |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4-Chloroaniline | 106-47-8 | NA[1] | NA[1] | 1,500 | 0.17 | NA[1] |
| Chlorobenzene | 108-90-7 | NA[1] | NA[2,3] | 320 | 0.0050 | NA[2,3] |
| Chloroethane (Ethyl chloride) | 75-00-3 | NA[1] | NA[2,3] | 1,700 | 0.0050 | NA[2,3] |
| Chloroform | 67-66-3 | NA[1] | NA[2,3] | 1,900 | 0.0050 | NA[2,3] |
| Chloromethane (Methyl chloride) | 74-87-3 | NA[1] | 1,200 | 1,200 | 0.0050 | 1,200 |
| 2-Chloronaphthalene | 91-58-7 | NA[1] | NA[1] | 60 | 0.17 | NA[1] |
| 2-Chlorophenol (o-Chlorophenol) | 95-57-8 | NA[1] | NA[1] | 11,000 | 0.17 | NA[1] |
| Chrysene | 218-01-9 | NA[2,3] | NA[1] | 0.72 | 0.17 | NA[2,3] |
| Cobalt (total) | 7440-48-4 | 2,500 | 48,000 | NA | 0.50 | 2,500 |
| Copper (total) | 7440-50-8 | NA[1] | NA[1] | NA | 1.0 | NA[1] |
| Cyanide | 57-12-5 | NA[1] | NA[2] | NA | 0.50 | NA[2] |
| Cyclohexane | 110-82-7 | NA[1] | NA[2,3] | 65 | 0.0050 | NA[2,3] |
| 4,4'-DDD (p,p'-TDE) | 72-54-8 | NA[1] | NA[1] | 21 | 0.0033 | NA[1] |
| 4,4'-DDE (p,p'-DDX) | 72-55-9 | NA[1] | NA[1] | 9.4 | 0.0033 | NA[1] |
| 4,4'-DDT | 50-29-3 | NA[1] | NA[1] | 1.9 | 0.0033 | NA[1] |
| Dibenz(a,h)anthracene | 53-70-3 | 37,000[4] | NA[1] | 9.5 | 0.17 | 37,000[4] |
| Dibromochloromethane (Chlorodibromomethane) | 124-48-1 | NA[1] | NA[1] | 600 | 0.0050 | NA[1] |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 0.12 | 52 | 470 | 0.0050 | 0.12 |
| 1,2-Dibromoethane (Ethylene dibromide) | 106-93-4 | 0.41 | 780 | 920 | 0.0050 | 0.41 |
| 1,2-Dichlorobenzene (o-Dichlorobenzene) | 95-50-1 | NA[1] | NA[2,3] | 140 | 0.0050 | NA[2,3] |
| 1,3-Dichlorobenzene (m-Dichlorobenzene) | 541-73-1 | NA[1] | NA[1] | 110 | 0.0050 | NA[1] |
| 1,4-Dichlorobenzene (p-Dichlorobenzene) | 106-46-7 | NA[1] | NA[2,3] | 74 | 0.0050 | NA[2,3] |
| 3,3'-Dichlorobenzidine | 91-94-1 | NA[1] | NA[1] | 20 | 0.33 | NA[1] |
| Dichlorodifluoromethane (Freon 12) | 75-71-8 | NA[1] | NA[1] | 540 | 0.0050 | NA[1] |
| 1,1-Dichloroethane | 75-34-3 | NA[1] | NA[1] | 1,200 | 0.0050 | NA[1] |
| 1,2-Dichloroethane | 107-06-2 | NA[1] | 320 | 2,000 | 0.0050 | 320 |
| 1,1-Dichloroethene (1,1-Dichloroethylene) | 75-35-4 | NA[1] | 240 | 830 | 0.0050 | 240 |
| 1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene) | 156-59-2 | NA[1] | NA[1] | 1,600 | 0.0050 | NA[1] |
| 1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene) | 156-60-5 | NA[1] | NA[1] | 1,300 | 0.0050 | NA[1] |
| 2,4-Dichlorophenol | 120-83-2 | NA[1] | NA[1] | 2,600 | 0.17 | NA[1] |
| 1,2-Dichloropropane | 78-87-5 | 27 | 140 | 810 | 0.0050 | 27 |
| 1,3-Dichloropropene (total) | 542-75-6 | 23 | 650 | 880 | 0.0050 | 23 |
| Dieldrin | 60-57-1 | NA[1] | NA[1] | 7.9 | 0.0033 | NA[1] |

| | | | | | | |
|---|---|---|---|---|---|---|
| Diethylphthalate | 84-66-2 | NA[1] | NA[1] | 390 | 0.17 | NA[1] |
| 2,4-Dimethylphenol | 105-67-9 | NA[1] | NA[1] | 8,900 | 0.17 | NA[1] |
| Di-n-butyl phthalate | 84-74-2 | NA[1] | NA[1] | 28 | 0.17 | NA[1] |
| 2,4-Dinitrophenol | 51-28-5 | NA[1] | NA[1] | 430 | 0.33 | NA[1] |
| 2,4-Dinitrotoluene/2,6-Dinitrotoluene (mixture) | 25321-14-6 | NA[1] | NA[1] | 360 | 0.17 | NA[1] |
| Di-n-octyl phthalate | 117-84-0 | NA[1] | NA[1] | 6.2 | 0.33 | NA[1] |
| 1,4-Dioxane | 123-91-1 | 210 | 11,000 | 160,000 | 0.067 | 210 |
| Endosulfan I and Endosulfan II (alpha and beta) (summed) | 115-29-7 | NA[1] | NA[1] | 4.4 | 0.0033 | NA[1] |
| Endrin | 72-20-8 | NA[1] | NA[1] | 10 | 0.0033 | NA[1] |
| Ethylbenzene | 100-41-4 | 48 | NA[2,3] | 180 | 0.0050 | 48 |
| Extractable Petroleum Hydrocarbons (Category 1) | various | NA[1] | NA[1] | NA | 80 | NA[1] |
| Extractable Petroleum Hydrocarbons (Category 2) | various | NA[1] | NA[1] | NA | 80 | NA[1] |
| Fluoranthene | 206-44-0 | NA[1] | NA[1] | 29 | 0.33 | NA[1] |
| Fluorene | 86-73-7 | NA[1] | NA[1] | 31 | 0.17 | NA[1] |
| alpha-HCH (alpha-BHC) | 319-84-6 | NA[1] | NA[1] | 12 | 0.0017 | NA[1] |
| beta-HCH (beta-BHC) | 319-85-7 | NA[1] | NA[1] | 1.4 | 0.0017 | NA[1] |
| Heptachlor | 76-44-8 | NA[1] | NA[1] | 15 | 0.0017 | NA[1] |
| Heptachlor epoxide | 1024-57-3 | NA[1] | NA[1] | 4.1 | 0.0017 | NA[1] |
| Hexachlorobenzene | 118-74-1 | NA[1] | NA[1] | 0.078 | 0.17 | NA[1] |
| Hexachloro-1,3-butadiene | 87-68-3 | NA[1] | NA[1] | 6.1 | 0.17 | NA[1] |
| Hexachlorocyclopentadiene | 77-47-4 | NA[1] | NA[2,3] | 5.6 | 0.33 | NA[2,3] |
| Hexachloroethane | 67-72-1 | NA[1] | NA[2,3] | 28 | 0.17 | NA[2,3] |
| n-Hexane | 110-54-3 | NA[1] | NA[2,3] | 88 | NA | NA[2,3] |
| 2-Hexanone | 591-78-6 | NA[1] | NA[2,3] | 3,200 | 0.010 | NA[2,3] |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 370,000[4] | NA[1] | 0.74 | 0.17 | 370,000[4] |
| Isophorone | 78-59-1 | NA[1] | NA[2,3] | 3,400 | 0.17 | NA[2,3] |
| Isopropylbenzene | 98-82-8 | NA[1] | NA[2,3] | 98 | 0.0050 | NA[2,3] |
| Lead (total) | 7439-92-1 | NA[1] | NA[1] | NA | 0.50 | NA[1] |
| Lindane (gamma-HCH) (gamma-BHC) | 58-89-9 | NA[1] | NA[1] | 42 | 0.0017 | NA[1] |
| Manganese (total) | 7439-96-5 | NA[1] | 400,000 | NA | 0.50 | 400,000 |
| Mercury (total) | 7439-97-6 | NA[1] | NA[2,3] | 3.1[5] | 0.10 | NA[2,3] |
| Methoxychlor | 72-43-5 | NA[1] | NA[1] | 5.4 | 0.017 | NA[1] |
| Methyl acetate | 79-20-9 | NA[1] | NA[1] | 39,000 | 0.0050 | NA[1] |
| Methylene chloride (Dichloromethane) | 75-09-2 | NA[2,3] | NA[2,3] | 2,800 | 0.0050 | NA[2,3] |
| 2-Methylnaphthalene | 91-57-6 | NA[1] | NA[1] | 130 | 0.17 | NA[1] |
| 4-Methyl-2-pentanone (MIBK) | 108-10-1 | NA[1] | NA[2,3] | 3,400 | 0.010 | NA[2,3] |
| 2-Methylphenol (o-cresol) | 95-48-7 | NA[1] | NA[1] | 20,000 | 0.33 | NA[1] |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4-Methylphenol (p-cresol) | 106-44-5 | NA[1] | NA[1] | 16,000 | 0.33 | NA[1] |
| Methyl tert-butyl ether (MTBE) | 1634-04-4 | 650 | NA[2,3] | 9,100 | 0.0050 | 650 |
| Naphthalene | 91-20-3 | 27 | NA[2,3] | 100 | 0.17 | 27 |
| Nickel (total) | 7440-02-0 | 93,000 | 110,000 | NA | 0.50 | 93,000 |
| 4-Nitroaniline | 100-01-6 | NA[1] | NA[2,3] | 270 | 0.33 | NA[2,3] |
| Nitrobenzene | 98-95-3 | 36 | NA[2,3] | 1,300 | 0.17 | 36 |
| N-Nitrosodi-n-propylamine | 621-64-7 | NA[1] | NA[1] | 9,200 | 0.17 | NA[1] |
| N-Nitrosodiphenylamine | 86-30-6 | NA[1] | NA[1] | 190 | 0.17 | NA[1] |
| 2,2'-oxybis(1-chloropropane) | 108-60-1 | NA[1] | NA[1] | 540 | 0.33 | NA[1] |
| Pentachlorophenol | 87-86-5 | NA[1] | NA[1] | 140 | 0.33 | NA[1] |
| Phenol | 108-95-2 | NA[1] | NA[2,3] | 44,000 | 0.33 | NA[2,3] |
| Polychlorinated biphenyls (PCBs) | 1336-36-3 | NA[1] | NA[1] | 110 | 0.030 | NA[1] |
| Pyrene | 129-00-0 | NA[1] | NA[1] | 15 | 0.17 | NA[1] |
| Selenium (total) | 7782-49-2 | NA[1] | NA[1] | NA | 2.5 | NA[1] |
| Silver (total) | 7440-22-4 | NA[1] | NA[1] | NA | 0.50 | NA[1] |
| Styrene | 100-42-5 | NA[1] | NA[2,3] | 330 | 0.0050 | NA[2,3] |
| Tertiary butyl alcohol (TBA) | 75-65-0 | NA[1] | NA[1] | 160,000 | 0.10 | NA[1] |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | NA[1] | NA[1] | 2.7 | 0.17 | NA[1] |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 1746-01-6 | NA[1] | NA[1] | 0.10 | 0.0000010 | NA[1] |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | NA[1] | NA[1] | 980 | 0.0050 | NA[1] |
| Tetrachloroethene (PCE) (Tetrachloroethylene) | 127-18-4 | NA[2,3] | NA[2,3] | 89 | 0.0050 | NA[2,3] |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | NA[1] | NA[1] | 150 | 0.17 | NA[1] |
| Toluene | 108-88-3 | NA[1] | NA[2,3] | 340 | 0.0050 | NA[2,3] |
| Toxaphene | 8001-35-2 | NA[1] | NA[1] | 85 | 0.17 | NA[1] |
| 1,2,4-Trichlorobenzene | 120-82-1 | NA[1] | NA[2,3] | 140 | 0.0050 | NA[2,3] |
| 1,1,1-Trichloroethane | 71-55-6 | NA[1] | NA[2,3] | 420 | 0.0050 | NA[2,3] |
| 1,1,2-Trichloroethane | 79-00-5 | NA[1] | NA[1] | 1,300 | 0.0050 | NA[1] |
| Trichloroethene (TCE) (Trichloroethylene) | 79-01-6 | 14 | 42 | 410 | 0.0050 | 14 |
| Trichlorofluoromethane (Freon 11) | 75-69-4 | NA[1] | NA[1] | 790 | 0.0050 | NA[1] |
| 2,4,5-Trichlorophenol | 95-95-4 | NA[1] | NA[1] | 5,800 | 0.20 | NA[1] |
| 2,4,6-Trichlorophenol | 88-06-2 | NA[1] | NA[1] | 1,700 | 0.20 | NA[1] |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF) | 76-13-1 | NA[1] | NA[2,3] | 530 | 0.0050 | NA[2,3] |
| 1,2,4-Trimethylbenzene | 95-63-6 | NA[1] | NA[2,3] | 80 | 0.076 | NA[2,3] |
| Vanadium (total) | 7440-62-2 | NA[1] | 800,000 | NA | 2.5 | 800,000 |
| Vinyl chloride | 75-01-4 | 6.4 | 1,000 | 2,900 | 0.0050 | 6.4 |
| Xylenes (total) | 1330-20-7 | NA[1] | NA[2,3] | 100 | 0.0050 | NA[2,3] |
| Zinc (total) | 7440-66-6 | NA[1] | NA[1] | NA | 1.0 | NA[1] |

NA – Not applicable because soil saturation limit does not apply to this contaminant

NA[1] Not applicable because appropriate toxicological information is not available

NA[2] Standard not applicable because the calculated health-based criterion exceeds one million mg/kg

NA[3] Standard not applicable because the calculated health-based criterion exceeds the soil saturation limit

[4] Exceeds soil saturation limit; however, health-based criterion based on particulate portion of the equation

[5] Value is for elemental mercury

Table A3
Benchmarks Supporting Inhalation Standards
Soil Inhalation Toxicity Factors

| Contaminant | CAS No. | Soil Inhalation Recommendation | Soil Inhalation Toxicity Factor(s) |
|---|---|---|---|
| Acenaphthene | 83-32-9 | No inhalation-based toxicity factors are available[18] | None |
| Acetone | 67-64-1 | No inhalation-based toxicity factors are available[1] | None |
| Acetophenone | 98-86-2 | No inhalation-based toxicity factors are available[2] | None |
| Aldrin | 309-00-2 | No inhalation-based toxicity factors are available[17] | None |
| Aluminum | 7429-90-5 | PPRTV RfC | PPRTV RfC (2006)<br>5E-03 mg/m3 |
| Anthracene | 120-12-7 | No inhalation-based toxicity factors are available[18] | None |
| Antimony | 7440-36-0 | No inhalation-based toxicity factors are available[19] | None |
| Arsenic | 7440-38-2 | IRIS IUR | IRIS IUR (1998)<br>4.3E-03 (ug/m3)-1 |
| Atrazine | 1912-24-9 | No inhalation-based toxicity factors are available | None |
| Barium | 7440-39-3 | HEAST RfC | HEAST RfC (1997)<br>5E-04 mg/m3 |
| Benzaldehyde | 100-52-7 | No inhalation-based toxicity factors are available | None |
| Benzene | 71-43-2 | IRIS IUR<br>IRIS RfC | IRIS IUR (2000)<br>7.8E-06 (ug/m3)-1<br>IRIS RfC (2003)<br>3E-02 mg/m3 |
| Benzo(a)anthracene | 56-55-3 | IRIS IUR (benzo(a)pyrene) adjusted for benzo(a)anthracene | IRIS IUR (2017)<br>6.0E-05 (ug/m3)-1 (adjusted for benzo(a)anthracene) |
| Benzo(a)pyrene | 50-32-8 | IRIS IUR<br>IRIS RfC | IRIS IUR (2017)<br>6.0E-04 (ug/m3)-1<br>IRIS RfC (2017)<br>2.0E-06 mg/m3 |
| Benzo(b)fluoranthene | 205-99-2 | IRIS IUR (benzo(a)pyrene) adjusted for benzo(b)fluoranthene | IRIS IUR (2017)<br>6.0E-05 (ug/m3)-1 (adjusted for benzo(b)fluoranthene) |
| Benzo(k)fluoranthene | 207-08-9 | IRIS IUR (benzo(a)pyrene) adjusted for benzo(k) fluoranthene | IRIS IUR (2017)<br>6.0E-06 (ug/m3)-1 (adjusted for benzo(k) fluoranthene) |

| | | | |
|---|---|---|---|
| Beryllium | 7440-41-7 | IRIS IUR<br>IRIS RfC | IRIS IUR (1998)<br>2.4E-03 (ug/m3)-1<br>IRIS RfC (1998)<br>2E-05 mg/m3 |
| 1,1'-Biphenyl | 92-52-4 | No inhalation-based toxicity factors are available | None |
| Bis(2-chloroethoxy) methane | 111-91-1 | No inhalation-based toxicity factors are available | None |
| Bis(2-chloroethyl) ether | 111-44-4 | No inhalation-based toxicity factors are available[17] | None |
| Bis(2-ethylhexyl) phthalate | 117-81-7 | No inhalation-based toxicity factors are available[17] | None |
| Bromodichloromethane | 75-27-4 | No inhalation-based toxicity factors are available[17] | None |
| Bromoform | 75-25-2 | No inhalation-based toxicity factors are available[17] | None |
| Bromomethane | 74-83-9 | IRIS RfC | IRIS RfC (1992)<br>5E-03 mg/m3 |
| 2-Butanone | 78-93-3 | IRIS RfC[3] | IRIS RfC (2003)<br>5E+00 mg/m3 |
| Butylbenzylphthalate | 85-68-7 | No inhalation-based toxicity factors are available | None |
| Cadmium | 7440-43-9 | IRIS IUR<br>ATSDR RfC | IRIS IUR (1992)<br>1.8E-03 (ug/m3)-1 ATSDR RfC (2013) 1E-05 mg/m3 |
| Caprolactam | 105-60-2 | CalEPA RfC | CalEPA RfC (2013)<br>2.2E-03 mg/m3 |
| Carbon disulfide | 75-15-0 | IRIS RfC | IRIS RfC (1995)<br>7E-01 mg/m3 |
| Carbon tetrachloride | 56-23-5 | IRIS IUR<br>IRIS RfC | IRIS IUR (2010)<br>6E-06 (ug/m3)-1<br>IRIS RfC (2010)<br>1E-01 mg/m3 |
| Chlordane<br>(alpha plus gamma mixture) | 57-74-9 | IRIS RfC | IRIS RfC (1998)<br>7E-04 mg/m3 |
| 4-Chloroaniline | 106-47-8 | No inhalation-based toxicity factors are available | None |
| Chlorobenzene | 108-90-7 | PPRTV RfC | PPRTV RfC (2006)<br>5E-02 mg/m3 |
| Chloroethane | 75-00-3 | IRIS RfC | IRIS RfC (1991)<br>1E+01 mg/m3 |
| Chloroform | 67-66-3 | ATSDR RfC<br>No other inhalation-based toxicity factors are available[17] | ATSDR RfC (2013)<br>9.8E-02 mg/m3 |
| Chloromethane | 74-87-3 | IRIS RfC[4] | IRIS RfC (2001)<br>9E-02 mg/m3 |
| 2-Chloronaphthalene | 91-58-7 | No inhalation-based toxicity factors are available | None |
| 2-Chlorophenol | 95-57-8 | No inhalation-based toxicity factors are available[17] | None |

| | | | |
|---|---|---|---|
| Chrysene | 218-01-9 | IRIS IUR (benzo(a)pyrene) adjusted for chrysene | IRIS IUR (2017)<br>6.0E-07 (ug/m3)-1<br>(adjusted for chrysene) |
| Cobalt | 7440-48-4 | PPRTV IUR<br>PPRTV RfC | PPRTV IUR (2008)<br>9E-03(ug/m3)-1<br>PPRTV RfC (2008)<br>6E-06 mg/m3 |
| Copper | 7440-50-8 | No inhalation-based toxicity factors are available[5] | None |
| Cyanide | 57-12-5 | IRIS RfC | IRIS RfC (2010)<br>8E-04 mg/m3 |
| Cyclohexane | 110-82-7 | IRIS RfC | IRIS RfC (2003)<br>6E+00 mg/m3 |
| 4,4'-DDD | 72-54-8 | No inhalation-based toxicity factors are available[17] | None |
| 4,4'-DDE | 72-55-9 | No inhalation-based toxicity factors are available[17] | None |
| 4,4'-DDT | 50-29-3 | No inhalation-based toxicity factors are available[17] | None |
| Dibenz(a,h)anthracene | 53-70-3 | IRIS IUR (benzo(a)pyrene) adjusted for dibenzo(a,h) anthracene | IRIS IUR (2017)<br>6.0E-04(ug/m3)-1<br>(adjusted for dibenzo(a,h) anthracene) |
| Dibromochloromethane | 124-48-1 | No inhalation-based toxicity factors are available[17] | None |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | PPRTV IUR<br>IRIS RfC | PPRTV IUR (2006)<br>6E-03 (ug/m3)-1<br>IRIS RfC (1991)<br>2E-04 mg/m3 |
| 1,2-Dibromoethane | 106-93-4 | IRIS IUR<br>IRIS RfC | IRIS IUR (2004)<br>6E-04 (ug/m3)-1<br>IRIS RfC (2004)<br>9E-03 mg/m3 |
| 1,2-Dichlorobenzene | 95-50-1 | HEAST RfC | HEAST RfC (1997)<br>2E-01 mg/m3 |
| 1,3-Dichlorobenzene | 541-73-1 | No inhalation-based toxicity factors are available | None |
| 1,4-Dichlorobenzene | 106-46-7 | IRIS RfC<br>No other inhalation-based toxicity factors are available[17] | IRIS RfC (1994)<br>8E-01 mg/m3 |
| 3,3'-Dichlorobenzidine | 91-94-1 | No inhalation-based toxicity factors are available | None |
| Dichlorodifluoromethane | 75-71-8 | No inhalation-based toxicity factors are available[6] | None |
| 1,1-Dichloroethane | 75-34-3 | No inhalation-based toxicity factors are available[7] | None |
| 1,2-Dichloroethane | 107-06-2 | PPRTV RfC<br>No other inhalation-based toxicity factors are available[17] | PPRTV RfC (2010)<br>7E-03 mg/m3 |

| | | | |
|---|---|---|---|
| 1,1-Dichloroethene | 75-35-4 | A soil inhalation remediation standard can be developed using an IRIS RfC with a Group C carcinogen factor | IRIS RfC (2002/2005)<br>2E-01 mg/m3<br>RfC Group C carcinogen factor 10 |
| cis-1,2-Dichloroethene | 156-59-2 | No inhalation-based toxicity factors are available | None |
| trans-1,2-Dichloroethene | 156-60-5 | No inhalation-based toxicity factors are available[8] | None |
| 2,4-Dichlorophenol | 120-83-2 | No inhalation-based toxicity factors are available[17] | None |
| 1,2-Dichloropropane | 78-87-5 | PPRTV IUR<br>IRIS RfC | PPRTV IUR (2016) 3.7E-06 (ug/m3)-1<br>IRIS RfC (1991)<br>4E-03 mg/m3 |
| 1,3-Dichloropropene (cis and trans) | 542-75-6 | IRIS IUR<br>IRIS RfC | IRIS IUR (2000)<br>4E-06 (ug/m3)-1<br>IRIS RfC (2000)<br>2E-02 mg/m3 |
| Dieldrin | 60-57-1 | No inhalation-based toxicity factors are available | None |
| Diethylphthalate | 84-66-2 | No inhalation-based toxicity factors are available[17] | None |
| 2,4-Dimethylphenol | 105-67-9 | No inhalation-based toxicity factors are available[17] | None |
| Di-n-butylphthalate | 84-74-2 | No inhalation-based toxicity factors are available[17] | None |
| 2,4-Dinitrophenol | 51-28-5 | No inhalation-based toxicity factors are available[17] | None |
| 2,4-Dinitrotoluene /2,6-Dinitrotoluene (mixture) | 25321-14-6 | No inhalation-based toxicity factors are available[17] | None |
| Di-n-octylphthalate | 117-84-0 | No inhalation-based toxicity factors are available[9] | None |
| 1,4-Dioxane | 123-91-1 | IRIS IUR<br>IRIS RfC | IRIS IUR (2013)<br>5.0E-06 (ug/m3)-1<br>IRIS RfC (2013)<br>3E-02 mg/m3 |
| Endosulfan I and Endosulfan II (alpha and beta) | 115-29-7 | No inhalation-based toxicity factors are available[17] | None |
| Endrin | 72-20-8 | No inhalation-based toxicity factors are available[17] | None |
| Ethylbenzene | 100-41-4 | CalEPA IUR<br>IRIS RfC | CalEPA IUR (2007)<br>2.5E-06 (ug/m3)-1<br>IRIS RfC (1991)<br>1E+00 mg/m3 |
| Extractable Petroleum Hydrocarbons (EPH) (Category 1) | various | No inhalation-based toxicity factors are available | None |
| Extractable Petroleum Hydrocarbons (EPH) (category 2) | various | No inhalation-based toxicity factors are available | None |
| Fluoranthene | 206-44-0 | No inhalation-based toxicity factors are available[18] | None |

| | | | |
|---|---|---|---|
| Fluorene | 86-73-7 | No inhalation-based toxicity factors are available[18] | None |
| alpha-HCH (alpha-BHC) | 319-84-6 | No inhalation-based toxicity factors are available[17] | None |
| beta-HCH (beta-BHC) | 319-85-7 | No inhalation-based toxicity factors are available[17] | None |
| Heptachlor | 76-44-8 | No inhalation-based toxicity factors are available[17] | None |
| Heptachlor epoxide | 1024-57-3 | No inhalation-based toxicity factors are available[17] | None |
| Hexachlorobenzene | 118-74-1 | No inhalation-based toxicity factors are available[17] | None |
| Hexachloro-1,3-butadiene | 87-68-3 | No inhalation-based toxicity factors are available[17] | None |
| Hexachlorocyclopentadiene | 77-47-4 | IRIS RfC | IRIS RfC (2001)<br>2E-04 mg/m3 |
| Hexachloroethane | 67-72-1 | IRIS RfC | IRIS RfC (2011)<br>3E-02 mg/m3 |
| n-Hexane | 110-54-3 | IRIS RfC | IRIS RfC (2005)<br>7E-01 mg/m3 |
| 2-Hexanone | 591-78-6 | IRIS RfC | IRIS RfC (2009)<br>3E-02 mg/m3 |
| Indeno(1,2,3,-cd) pyrene | 193-39-5 | IRIS IUR (benzo(a)pyrene) adjusted for indeno(1,2,3,-cd) pyrene. | IRIS IUR (2017)<br>6.0E-05 (ug/m3)-1<br>(adjusted for indeno(1,2,3,-cd) pyrene) |
| Isophorone | 78-59-1 | CalEPA RfC | CalEPA RfC (2001)<br>2E-00 mg/m3 |
| Isopropylbenzene | 98-82-8 | IRIS RfC | IRIS RfC (1997)<br>4E-01 mg/m3 |
| Lead | 7439-92-1 | No inhalation-based toxicity factors are available[17] | None |
| Lindane (gamma-HCH) (gamma-BHC) | 58-89-9 | No inhalation-based toxicity factors are available[17] | None |
| Manganese | 7439-96-5 | IRIS RfC | IRIS RfC (1993)<br>5E-05 mg/m3 |
| Mercury | 7439-97-6 | IRIS RfC | IRIS RfC (1995)<br>3E-04 mg/m3 |
| Methoxychlor | 72-43-5 | No inhalation-based toxicity factors are available[17] | None |
| Methyl acetate | 79-20-9 | No inhalation-based toxicity factors are available | None |
| Methylene chloride | 75-09-2 | IRIS IUR<br>IRIS RfC | IRIS IUR (2011)<br>1E-08 (ug/m3)-1<br>IRIS RfC (2011)<br>6E-01 mg/m3 |
| 2-Methylnaphthalene | 91-57-6 | No inhalation-based toxicity factors are available[18] | None |
| 4-Methyl-2-pentanone | 108-10-1 | IRIS RfC | IRIS RfC (2003)<br>3E+00 mg/m3 |
| 2-Methylphenol | 95-48-7 | No inhalation-based toxicity factors are available[17] | None |

| | | | |
|---|---|---|---|
| 4-Methylphenol | 106-44-5 | No inhalation-based toxicity factors are available[17] | None |
| Methyl tert-butyl ether (MTBE) | 1634-04-4 | CalEPA IUR<br>IRIS RfC with a Group C carcinogen factor | CalEPA IUR (1999)<br>2.6E-07 (ug/m3)-1<br>IRIS RfC (1993)<br>3E+00 mg/m3<br>Group C carcinogen factor 10 |
| Naphthalene | 91-20-3 | CalEPA IUR<br>IRIS RfC with a Group C carcinogen factor | CalEPA IUR (2011)<br>3.4E-05 (ug/m3)-1<br>IRIS RfC (1998)<br>3E-03 mg/m3<br>Group C carcinogen factor 10 |
| Nickel | 7440-02-0 | IRIS IUR<br>CalEPA RfC | IRIS IUR (1987/2006)<br>2.4E-04 (ug/m3)-1<br>CalEPA RfC (2012)<br>1.4E-05 mg/m3 |
| 4-Nitroaniline | 100-01-6 | PPRTV RfC | PPRTV RfC (2009)<br>6E-03 mg/m3 |
| Nitrobenzene | 98-95-3 | IRIS IUR<br>IRIS RfC. | IRIS IUR (2009)<br>4E-05 (ug/m3)-1<br>IRIS RfC (2009)<br>9E-03 mg/m3 |
| N-Nitroso-di-n- propylamine | 621-64-7 | No inhalation-based toxicity factors are available[17] | None |
| N-Nitrosodiphenylamine | 86-30-6 | No inhalation-based toxicity factors are available[17] | None |
| 2,2'-Oxybis(1-choloropropane) | 108-60-1 | No inhalation-based toxicity factors are available | None |
| Pentachlorophenol | 87-86-5 | No inhalation-based toxicity factors are available[17] | None |
| Phenol | 108-95-2 | CalEPA RfC | CalEPA RfC (2000)<br>2E-01 mg/m3 |
| Polychlorinated biphenyls (PCBs) | 1336-36-3 | No inhalation-based toxicity factors are available[17] | None |
| Pyrene | 129-00-0 | No inhalation-based toxicity factors are available[18] | None |
| Selenium | 7782-49-2 | No inhalation-based toxicity factors are available | None |
| Silver | 7440-22-4 | No inhalation-based toxicity factors are available[17] | None |
| Styrene | 100-42-5 | IRIS RfC[10] | IRIS RfC (1992)<br>1E+00 mg/m3 |
| Tertiary butyl alcohol (TBA) | 75-65-0 | No inhalation-based toxicity factors are available[17] | None |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | No inhalation-based toxicity factors are available | None |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 1746-01-6 | No inhalation-based toxicity factors are available | None |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | No inhalation-based toxicity factors are available[17] | None |

| | | | |
|---|---|---|---|
| Tetrachloroethene (PCE) | 127-18-4 | IRIS IUR<br>IRIS RfC | IRIS IUR (2012)<br>2.6E-07 (ug/m3)-1<br>IRIS RfC (2012)<br>4E-02 mg/m3 |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | No inhalation-based toxicity factors are available | None |
| Toluene | 108-88-3 | IRIS RfC | IRIS RfC (2005)<br>5E+00 mg/m3 |
| Toxaphene | 8001-35-2 | No inhalation-based toxicity factors are available[17] | None |
| 1,2,4-Trichlorobenzene | 120-82-1 | PPRTV RfC | PPRTV RfC (2009)<br>2E-03 mg/m3 |
| 1,1,1-Trichloroethane | 71-55-6 | IRIS RfC[11] | IRIS RfC (2007)<br>5E+00 mg/m3 |
| 1,1,2-Trichloroethane | 79-00-5 | No inhalation-based toxicity factors are available[12] | None |
| Trichloroethene (TCE) | 79-01-6 | IRIS IUR<br>IRIS RfC[13] | IRIS IUR (2011)<br>4.1E-06 (ug/m3)-1<br>IRIS RfC (2011)<br>2E-03 mg/m3 |
| Trichlorofluoromethane | 75-69-4 | No inhalation-based toxicity factors are available[14] | None |
| 2,4,5-Trichlorophenol | 95-95-4 | No inhalation-based toxicity factors are available[17] | None |
| 2,4,6-Trichlorophenol | 88-06-2 | No inhalation-based toxicity factors are available[17] | None |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 76-13-1 | PPRTV RfC | PPRTV RfC (2016)<br>5E+00 mg/m3 |
| 1,2,4-Trimethylbenzene | 95-63-6 | IRIS RfC | IRIS RfC (2016)<br>6E-02 mg/m3 |
| Vanadium | 7440-62-2 | ATSDR RfC | ATSDR RfC (2012)<br>1E-04 mg/m3 |
| Vinyl Chloride | 75-01-4 | IRIS IUR<br>IRIS RfC[15] | IRIS IUR (2000)<br>4.4E-06 (ug/m3)-1<br>IRIS RfC (2000)<br>1E-01 mg/m3 |
| Xylenes | 1330-20-7 | IRIS RfC | IRIS RfC (2003)<br>1.E-01 mg/m3 |
| Zinc | 7440-66-6 | No inhalation-based toxicity factors are available[16] | None |

[1] An ATSDR RfC exists for acetone using the results of the Stewart 1975 study. The USEPA IRIS notes that this study should only be used in the development of a short-term exposure RfC and not a long-term (chronic) exposure RfC.

[2] A HEAST RfC exists for acetophenone, but a subsequent PPRTV review (2010) questions the use of the HEAST RfC.

[3] A NJDWQI RfC exists for 2-butanone, but the IRIS RfC has been determined by the Department to be more appropriate. The existing NJDWQI RfC is based on a route-to-route conversion of a NJDWQI RfD. The Department's Site Remediation and Waste Management Program policy does not allow, except where warranted, for the development of soil remediation standards based on route-to-route conversion of toxicity factors. This policy conforms with USEPA policy concerning route-to-route conversion of toxicity factors.

[4] A HEAST IUR exists for chloromethane, but a subsequent PPRTV review (2012) states that the use of the HEAST IUR is "Inadequate for an assessment of carcinogenic potential."

[5] A CalEPA RfC that once existed for copper has been retracted by CalEPA.

[6] A HEAST RfC and a PPRTV RfC exist for dichlorodifluoromethane. Both RfCs are derived using the same study (Prendergast 1967). The PPRTV is listed as an appendix value. The PPRTV RfC is listed as an appendix value because the Prendergast study was determined by the USEPA to have flaws. It is the Department's Site Remediation and Waste Management Program policy not to use PPRTV appendix values to develop soil remediation standards. As the HEAST RfC developed using the Prendergast study, the Department decided not to use this RfC in the development of a soil remediation standard.

[7] A HEAST RfC exists for 1,1-dichloroethane, but a subsequent PPRTV review (2006) indicated that data were inadequate to derive a chronic exposure RfC for 1,1-dichloroethane. A CalEPA IUR also exists for 1,1-dichloroethane but is based on a route-to-route conversion of an oral study. The Department's Site Remediation and Waste Management Program policy does not allow, except where warranted, for the development of soil remediation standards based on route-to-route conversion of toxicity factors.

[8] A PPRTV RfC exists for trans-1,2-dichloroethene but a subsequent IRIS assessment (2010) stated "the available inhalation data from the Freund study are insufficient to support reference value derivation and RfC."

[9] A 1985 USEPA IUR that once existed for di-n-octylphthalate has been retracted by the USEPA.

[10] A HEAST 1991 IUR exists for styrene but USEPA NCEA does not recommend its use.

[11] Although an NJDWQI RfC exists for 1,1,1-trichloroethane, the Department determined that the IRIS RfC is a scientifically better toxicity value to develop a non-cancer-based soil inhalation remediation standard.

[12] Although a PPRTV RfC for 1,1,2-trichloroethane exists, it is listed as an Appendix value. The PPRTV Appendix value is based on a study that was determined by USEPA to have flaws. It is the Department's Site Remediation and Waste Management Program policy not to use PPRTV Appendix values to develop soil remediation standards. An IRIS IUR also exists for 1,1,2-trichloroethane but is based on a route-to-route conversion of an oral study. The Department's Site Remediation and Waste Management Program policy does not allow, except where warranted, for the development of soil remediation standards based on route-to-route conversion of toxicity factors.

[13] The IRIS RfC for trichloroethene is based on a route-to-route conversion of an ingestion study, which was determined to be acceptable by the USEPA as substantiated by additional evaluation including physiologically-based pharmacokinetic modeling.

[14] A HEAST RfC exists for trichlorofluoromethane, but a subsequent PPRTV review (2009) indicated that data used to derive the RfC were inadequate.

[15] The IRIS RfC for vinyl chloride is based on a route-to-route conversion of an ingestion study, which was determined to be acceptable by the USEPA as substantiated by additional evaluation including physiologically-based pharmacokinetic modeling.

[16] A CalEPA RfC that once existed for zinc has been retracted by CalEPA.

[17] There is an inhalation toxicity factor available for this contaminant, but it is based on a route-to-route conversion of an oral study. The Department's Site Remediation and Waste Management Program policy does not allow, except where warranted with physiologically-based pharmacokinetic modeling, for the development of soil remediation standards based on route-to-route conversion of toxicity factors.

[18] The 2008 inhalation toxicity factor was based on an equivalency factor from Nisbet and LaGoy (1992). Nisbet and LaGoy did not conduct any original research and relied on studies using dermal application and subcutaneous injection, with one study using intrapulmonary administration (not inhalation). This Nisbet and LaGoy study develops TEFs for PAHs compared to B[a]P. The Department did not use this study because it was not derived from an inhalation study.

[19] The former IRIS RfC was withdrawn.

# Appendix B

## Inhalation Toxicity Factors

| COMPOUND | CAS No. | IUR ($\mu g/m^3)^{-1}$ | IUR Source | RfC ($mg/m^3$) | RfC Source |
|---|---|---|---|---|---|
| Acenaphthene | 83-32-9 | NA | NA | NA | NA |
| Acetone | 67-64-1 | NA | NA | NA | NA |
| Acetophenone | 98-86-2 | NA | NA | NA | NA |
| Aldrin | 309-00-2 | NA | NA | NA | NA |
| Aluminum | 7429-90-5 | NA | NA | 5.00E-03 | PPRTV (2006) |
| Anthracene | 120-12-7 | NA | NA | NA | NA |
| Antimony | 7440-36-0 | NA | NA | NA | NA |
| Arsenic | 7440-38-2 | 4.30E-03 | IRIS (1998) | NA | NA |
| Atrazine | 1912-24-9 | NA | NA | NA | NA |
| Barium | 7440-39-3 | NA | NA | 5.00E-04 | HEAST (1997) |
| Benzaldehyde | 100-52-7 | NA | NA | NA | NA |
| Benzene | 71-43-2 | 7.80E-06 | IRIS (2000) | 3.00E-02 | IRIS (2003) |
| Benzo(a)anthracene | 56-55-3 | 6.0E-05 | IRIS (2017) (adjusted for benzo(a)anthracene) | NA | NA |
| Benzo(a) pyrene | 50-32-8 | 6.0E-04 | IRIS (2017) | 2.0E-06 | IRIS (2017) |
| Benzo(b) fluoranthene | 205-99-2 | 6.0E-05 | IRIS (2017) (adjusted for benzo(b)fluoranthene) | NA | NA |
| Benzo(k) fluoranthene | 207-08-9 | 6.0E-06 | IRIS (2017) (adjusted for benzo(k) fluoranthene) | NA | NA |
| Beryllium | 7440-41-7 | 2.40E-03 | IRIS (1998) | 2.00E-05 | IRIS (1998) |
| 1,1'-Biphenyl | 92-52-4 | NA | NA | NA | NA |
| Bis(2-chloroethoxy) methane | 111-91-1 | NA | NA | NA | NA |
| Bis(2-chloroethyl) ether | 111-44-4 | NA | NA | NA | NA |
| Bis(2-ethylhexyl) phthalate | 117-81-7 | NA | NA | NA | NA |
| Bromodichloromethane | 75-27-4 | NA | NA | NA | NA |
| Bromoform | 75-25-2 | NA | NA | NA | NA |

| | | | | | |
|---|---|---|---|---|---|
| Bromomethane | 74-83-9 | NA | NA | 5.00E-03 | IRIS (1992) |
| 2-Butanone | 78-93-3 | NA | NA | 5.00E+00 | IRIS (2003) |
| Butylbenzylphthalate | 85-68-7 | NA | NA | NA | NA |
| Cadmium | 7440-43-9 | 1.80E-03 | IRIS (1992) | 1.00E-05 | ATSDR (2013) |
| Caprolactam | 105-60-2 | NA | NA | 2.20E-03 | CalEPA (2013) |
| Carbon disulfide | 75-15-0 | NA | NA | 7.00E-01 | IRIS (1995) |
| Carbon tetrachloride | 56-23-5 | 6.00E-06 | IRIS (2010) | 1.00E-01 | IRIS (2010) |
| Chlordane (alpha plus gamma mixture) | 57-74-9 | NA | NA | 7.00E-04 | IRIS (1998) |
| 4-Chloroaniline | 106-47-8 | NA | NA | NA | NA |
| Chlorobenzene | 108-90-7 | NA | NA | 5.00E-02 | PPRTV (2006) |
| Chloroethane | 75-00-3 | NA | NA | 1.00E+01 | IRIS (1991) |
| Chloroform | 67-66-3 | NA | NA | 9.80E-02 | ATSDR (2013) |
| Chloromethane | 74-87-3 | NA | NA | 9.00E-02 | IRIS (2001) |
| 2-Chloronaphthalene | 91-58-7 | NA | NA | NA | NA |
| 2-Chlorophenol | 95-57-8 | NA | NA | NA | NA |
| Chrysene | 218-01-9 | 6.0E-07 | IRIS (2017) (adjusted for chrysene) | NA | NA |
| Cobalt | 7440-48-4 | 9.00E-03 | PPRTV (2008) | 6.00E-06 | PPRTV (2008) |
| Copper | 7440-50-8 | NA | NA | NA | NA |
| Cyanide | 57-12-5 | NA | NA | 8.00E-04 | IRIS (2010) |
| Cyclohexane | 110-82-7 | NA | NA | 6.00E+00 | IRIS (2003) |
| 4,4'-DDD | 72-54-8 | NA | NA | NA | NA |
| 4,4'-DDE | 72-55-9 | NA | NA | NA | NA |
| 4,4'-DDT | 50-29-3 | NA | NA | NA | NA |
| Dibenz(a,h)anthracene | 53-70-3 | 6.0E-04 | IRIS (2017) (adjusted for dibenzo(a,h) anthracene) | NA | NA |
| Dibromochloromethane | 124-48-1 | NA | NA | NA | NA |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 6.00E-03 | PPRTV (2006) (Mutagenic MOA) | 2.00E-04 | IRIS (1991) |
| 1,2-Dibromoethane | 106-93-4 | 6.00E-04 | IRIS (2004) | 9.00E-03 | IRIS (2004) |
| 1,2-Dichlorobenzene | 95-50-1 | NA | NA | 2.00E-01 | HEAST (1997) |

| | | | | | |
|---|---|---|---|---|---|
| 1,3-Dichlorobenzene | 541-73-1 | NA | NA | NA | NA |
| 1,4-Dichlorobenzene | 106-46-7 | NA | NA | 8.00E-01 | IRIS (1994) |
| 3,3'-dichlorobenzidine | 91-94-1 | NA | NA | NA | NA |
| Dichlorodifluoromethane | 75-71-8 | NA | NA | NA | NA |
| 1,1-Dichloroethane | 75-34-3 | NA | NA | NA | NA |
| 1,2-Dichloroethane | 107-06-2 | NA | NA | 7.00E-03 | PPRTV (2010) |
| 1,1-Dichloroethene | 75-35-4 | NA | NA | 2.00E-01 | IRIS (2002/2005) (RfC requires Class C carcinogen adjustment) |
| cis-1,2-Dichloroethene | 156-59-2 | NA | NA | NA | NA |
| trans-1,2-Dichloroethene | 156-60-5 | NA | NA | NA | NA |
| 2,4-Dichlorophenol | 120-83-2 | NA | NA | NA | NA |
| 1,2-Dichloropropane | 78-87-5 | 3.7E-06 | PPRTV (2016) | 4.00E-03 | IRIS (1991) |
| 1,3-Dichloropropene (cis and trans) | 542-75-6 | 4.00E-06 | IRIS (2000) | 2.00E-02 | IRIS (2000) |
| Dieldrin | 60-57-1 | NA | NA | NA | NA |
| Diethylphthalate | 84-66-2 | NA | NA | NA | NA |
| 2,4-Dimethylphenol | 105-67-9 | NA | NA | NA | NA |
| Di-n-butylphthalate | 84-74-2 | NA | NA | NA | NA |
| 2,4-Dinitrophenol | 51-28-5 | NA | NA | NA | NA |
| 2,4-Dinitrotoluene /2,6-Dinitrotoluene (mixture) | 25321-14-6 | NA | NA | NA | NA |
| Di-n-octylphthalate | 117-84-0 | NA | NA | NA | NA |
| 1,4-Dioxane | 123-91-1 | 5.00E-06 | IRIS (2013) | 3.00E-02 | IRIS (2013) |
| Endosulfan I and Endosulfan II (alpha and beta) | 115-29-7 | NA | NA | NA | NA |
| Endrin | 72-20-8 | NA | NA | NA | NA |
| Ethylbenzene | 100-41-4 | 2.50E-06 | CalEPA (2007) | 1.00E+00 | IRIS (1991) |
| Extractable Petroleum Hydrocarbons (EPH) Number 2 Fuel Oil/Diesel Fuel | various | NA | NA | NA | NA |

| | | | | | |
|---|---|---|---|---|---|
| Extractable Petroleum Hydrocarbons (EPH) All petroleum hydrocarbons except Number 2 Fuel Oil/Diesel Fuel | various | NA | NA | NA | NA |
| Fluoranthene | 206-44-0 | NA | NA | NA | NA |
| Fluorene | 86-73-7 | NA | NA | NA | NA |
| alpha-HCH (alpha-BHC) | 319-84-6 | NA | NA | NA | NA |
| beta-HCH (beta-BHC) | 319-85-7 | NA | NA | NA | NA |
| Heptachlor | 76-44-8 | NA | NA | NA | NA |
| Heptachlor epoxide | 1024-57-3 | NA | NA | NA | NA |
| Hexachlorobenzene | 118-74-1 | NA | NA | NA | NA |
| Hexachloro-1,3-butadiene | 87-68-3 | NA | NA | NA | NA |
| Hexachlorocyclopentadiene | 77-47-4 | NA | NA | 2.00E-04 | IRIS (2001) |
| Hexachloroethane | 67-72-1 | NA | NA | 3.00E-02 | IRIS (2011) |
| n-Hexane | 110-54-3 | NA | NA | 7.00E-01 | IRIS (2005) |
| 2-Hexanone | 591-78-6 | NA | NA | 3.00E-02 | IRIS (2009) |
| Indeno(1,2,3-cd) pyrene | 193-39-5 | 6.0E-05 | IRIS (2017) (adjusted for indeno(1,2,3-cd) pyrene) | NA | NA |
| Isophorone | 78-59-1 | NA | NA | 2.00E+00 | CalEPA (2001) |
| Isopropylbenzene | 98-82-8 | NA | NA | 4.00E-01 | IRIS (1997) |
| Lead | 7439-92-1 | NA | NA | NA | NA |
| Lindane (gamma-HCH) (gamma-BHC) | 58-89-9 | NA | NA | NA | NA |
| Manganese | 7439-96-5 | NA | NA | 5.00E-05 | IRIS (1993) |
| Mercury | 7439-97-6 | NA | NA | 3.00E-04 | IRIS (1995) |
| Methoxychlor | 72-43-5 | NA | NA | NA | NA |
| Methyl acetate | 79-20-9 | NA | NA | NA | NA |
| Methylene chloride | 75-09-2 | 1.00E-08 | IRIS (2011) (mutagenic MOA) | 6.00E-01 | IRIS (2011) |
| 2-Methylnaphthalene | 91-57-6 | NA | NA | NA | NA |
| 4-Methyl-2-pentanone | 108-10-1 | NA | NA | 3.00E+00 | IRIS (2003) |
| 2-Methylphenol | 95-48-7 | NA | NA | NA | NA |

| | | | | | |
|---|---|---|---|---|---|
| 4-Methylphenol | 106-44-5 | NA | NA | NA | NA |
| Methyl tert-butyl ether | 1634-04-4 | 2.60E-07 | CalEPA (1999) | 3.00E+00 | IRIS (1993) |
| Naphthalene | 91-20-3 | 3.40E-05 | CalEPA (2011) | 3.00E-03 | IRIS (1998) |
| Nickel | 7440-02-0 | 2.40E-04 | IRIS (1987/2006) | 1.40E-05 | CalEPA (2012) |
| 4-Nitroaniline | 100-01-6 | NA | NA | 6.00E-03 | PPRTV (2009) |
| Nitrobenzene | 98-95-3 | 4.00E-05 | IRIS (2009) | 9.00E-03 | IRIS (2009) |
| N-Nitroso-di-n propylamine | 621-64-7 | NA | NA | NA | NA |
| N-Nitrosodiphenylamine | 86-30-6 | NA | NA | NA | NA |
| 2,2'-Oxybis(1-choloropropane) | 108-60-1 | NA | NA | NA | NA |
| Pentachlorophenol | 87-86-5 | NA | NA | NA | NA |
| Phenol | 108-95-2 | NA | NA | 2.00E-01 | CalEPA (2000) |
| Polychlorinated biphenyls (PCBs) | 1336-36-3 | NA | NA | NA | NA |
| Pyrene | 129-00-0 | NA | NA | NA | NA |
| Selenium | 7782-49-2 | NA | NA | NA | NA |
| Silver | 7440-22-4 | NA | NA | NA | NA |
| Styrene | 100-42-5 | NA | NA | 1.00E+00 | IRIS (1993) |
| Tertiary butyl alcohol | 75-65-0 | NA | NA | NA | NA |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | NA | NA | NA | NA |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 1746-01-6 | NA | NA | NA | NA |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | NA | NA | NA | NA |
| Tetrachloroethene (PCE) | 127-18-4 | 2.60E-07 | IRIS (2012) | 4.00E-02 | IRIS (2012) |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | NA | NA | NA | NA |
| Toluene | 108-88-3 | NA | NA | 5.00E+00 | IRIS (2005) |
| Toxaphene | 8001-35-2 | NA | NA | NA | NA |
| 1,2,4-Trichlorobenzene | 120-82-1 | NA | NA | 2.00E-03 | PPRTV (2009) |
| 1,1,1-Trichloroethane | 71-55-6 | NA | NA | 5.00E+00 | IRIS (2007) |
| 1,1,2-Trichloroethane | 79-00-5 | NA | NA | NA | NA |
| Trichloroethene (TCE) | 79-01-6 | 4.10E-06 | IRIS (2011) | 2.00E-03 | IRIS (2011) |
| Trichlorofluoromethane | 75-69-4 | NA | NA | NA | NA |

| | | | | | |
|---|---|---|---|---|---|
| 2,4,5-Trichlorophenol | 95-95-4 | NA | NA | NA | NA |
| 2,4,6-Trichlorophenol | 88-06-2 | NA | NA | NA | NA |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 76-13-1 | NA | NA | 5.00E+00 | PPRTV (2016) |
| 1,2,4-Trimethylbenzene | 95-63-6 | NA | NA | 6.00E-02 | IRIS (2016) |
| Vanadium | 7440-62-2 | NA | NA | 1.00E-04 | ATSDR (2012) |
| Vinyl Chloride | 75-01-4 | 4.40E-06 | IRIS (2000) (mutagenic MOA) | 1.00E-01 | IRIS (2000) |
| Xylenes | 1330-20-7 | NA | NA | 1.00E-01 | IRIS (2003) |
| Zinc | 7440-66-6 | NA | NA | NA | NA |

# Appendix C

## Inhalation Group C Carcinogen Compounds

| Chemical | CAS Number |
|---|---|
| Atrazine | 1912-24-9 |
| Butylbenzyl phthalate | 85-68-7 |
| Dibromochloromethane | 124-48-1 |
| 1,4 Dichlorobenzene | 106-46-7 |
| **1,1 Dichloroethene** | **75-35-4** |
| b- HCH | 319-85-7 |
| Hexachloro-1,3-butadiene | 87-68-3 |
| Hexachloroethane | 67-72-1 |
| Isophorone | 78-59-1 |
| 2 Methylphenol | 95-48-7 |
| 4 Methylphenol | 106-44-5 |
| **Methyl tertiary butyl ether (MTBE)** | **1634-04-4** |
| **Naphthalene** | **91-20-3** |
| Tertiary butyl alcohol (TBA) | 75-65-0 |
| 1,1,2,2 Tetrachloroethane | 79-34-5 |
| 1,1,2 Trichloroethane | 79-00-5 |

Bold contaminants are relevant for the inhalation exposure pathway.

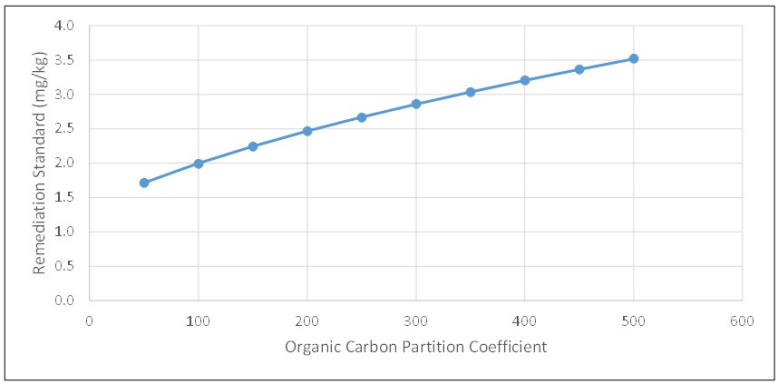
# Appendix D

## Sensitivity Analysis – Volatile Organic Compounds

For this analysis, only one variable was modified at a time, with the other chemical and environmental values being held at their default New Jersey values. Soil and chemical properties were varied within their normal ranges. Results below are shown for benzene, but observed sensitivities are similar for all volatile organic compounds.

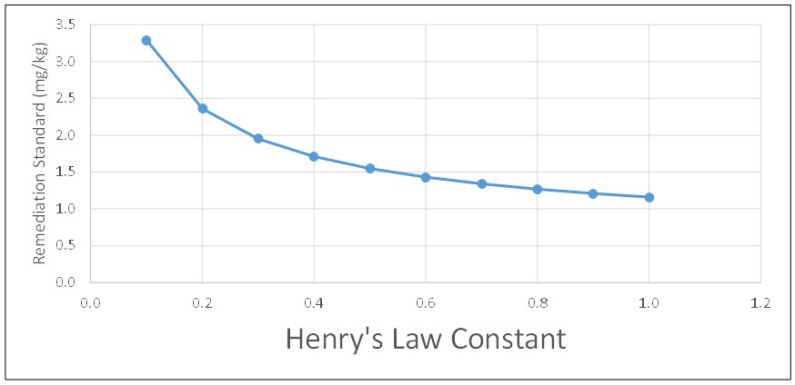
1. Sensitivity of the remediation standard to the organic carbon partition coefficient ($K_{oc}$). Sensitivity to this parameter is small, due to the weak adsorption of all these chemicals to soil. A ten-fold variation in the $K_{oc}$ value only affected the calculated standard by approximately a factor of two.

| $K_{oc}$ ($cm^3/g$) | Remediation Standard (mg/kg) |
|---|---|
| 50 | 1.714 |
| 100 | 1.996 |
| 150 | 2.243 |
| 200 | 2.465 |
| 250 | 2.669 |
| 300 | 2.858 |
| 350 | 3.036 |
| 400 | 3.203 |
| 450 | 3.363 |
| 500 | 3.515 |



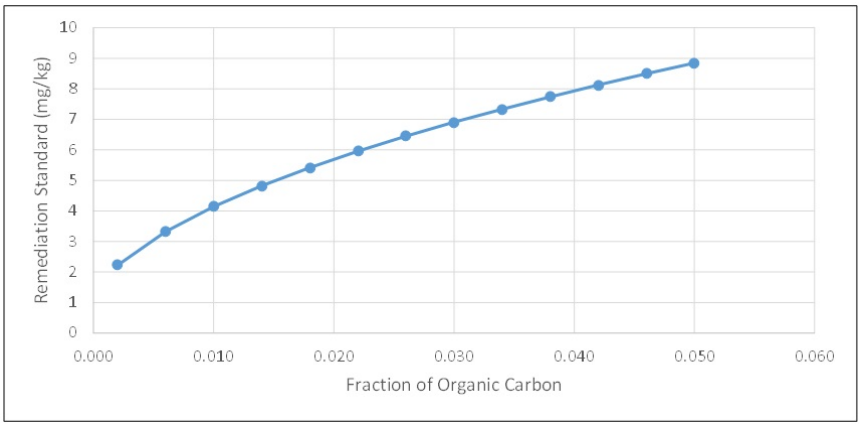

2. Sensitivity of the remediation standard to the Henry's law constant (H'). Dimensionless Henry's law constants for volatile organic chemicals are usually in the range of 0.1 to 1. This variation in the value of H' has a relatively small effect on the calculated remediation standard, which varied by less than a factor of three.

| H' | Remediation Standard (mg/kg) |
|---|---|
| 0.1 | 3.292 |
| 0.2 | 2.359 |
| 0.3 | 1.951 |
| 0.4 | 1.711 |
| 0.5 | 1.549 |
| 0.6 | 1.431 |
| 0.7 | 1.340 |
| 0.8 | 1.268 |
| 0.9 | 1.208 |
| 1.0 | 1.159 |



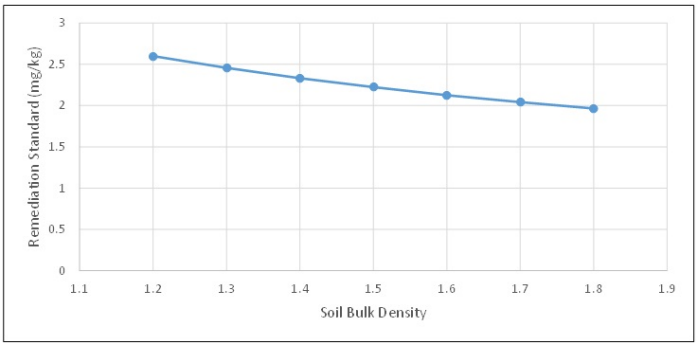
3. Sensitivity of the remediation standard to organic carbon content of soil ($f_{oc}$). The organic carbon content of soil generally ranges from about 0.002 to 0.05. This variation in organic carbon has a relatively small effect on calculated remediation standards, which varied by a factor of four.

| $f_{oc}$ (g/g) | Remediation Standard (mg/kg) |
|---|---|
| 0.002 | 2.223 |
| 0.006 | 3.323 |
| 0.010 | 4.141 |
| 0.014 | 4.822 |
| 0.018 | 5.418 |
| 0.022 | 5.955 |
| 0.026 | 6.447 |
| 0.030 | 6.904 |
| 0.034 | 7.333 |
| 0.038 | 7.738 |
| 0.042 | 8.123 |
| 0.046 | 8.490 |
| 0.050 | 8.842 |



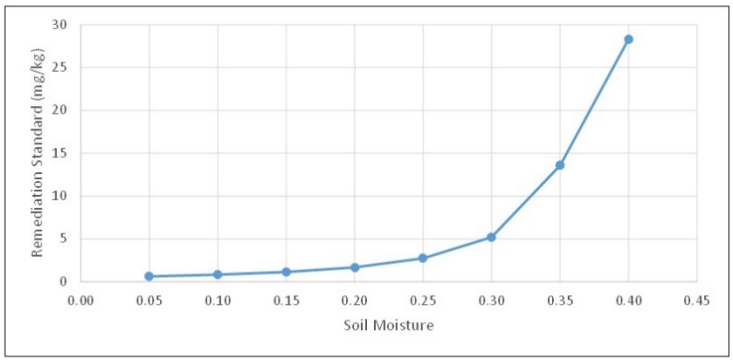

4. Sensitivity of remediation standard to soil bulk density ($\rho_b$). Soil bulk densities vary over a relatively narrow range, from about 1.2 to 1.8. This causes only small variations in the calculated remediation standard.

| $\rho_b$ (g/cm$^3$) | Remediation Standard (mg/kg) |
|---|---|
| 1.2 | 2.601 |
| 1.3 | 2.457 |
| 1.4 | 2.332 |
| 1.5 | 2.223 |
| 1.6 | 2.126 |
| 1.7 | 2.041 |
| 1.8 | 1.964 |



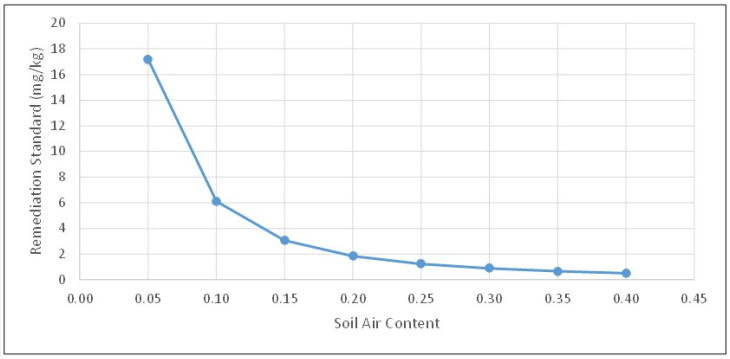
5. Sensitivity of remediation standard to soil moisture ($\theta_w$). Soil moisture has a substantial effect on calculated remediation standards. This parameter may range from about 0.05 (v/v) to saturation volume (about 0.4 (v/v)). At higher moisture levels, small changes result in significant increases in the remediation standard. This is due to the exponential behavior of the model with respect to soil moisture. The default soil moisture is 0.23 (v/v), which is not on the most sensitive portion of the curve.

| $\Theta_W$ (v/v) | Remediation Standard (mg/kg) |
|---|---|
| 0.05 | 0.628 |
| 0.10 | 0.833 |
| 0.15 | 1.151 |
| 0.20 | 1.691 |
| 0.25 | 2.733 |
| 0.30 | 5.206 |
| 0.35 | 13.582 |
| 0.40 | 28.295 |



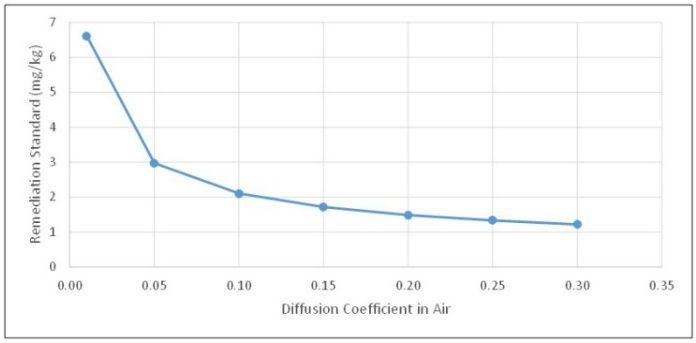

6. Sensitivity of remediation standard to soil air content ($\theta_a$). This parameter is inversely related to soil moisture, and shows a similar, but mirrored sensitivity behavior. At low soil air content levels (corresponding to high soil moisture contents), small changes in this parameter have a large effect on the remediation standard. The default soil air content is 0.18 (v/v), which is in the midrange of the curve, where the sensitivity is lower.

| $\Theta_A$ (v/v) | Remediation Standard (mg/kg) |
|---|---|
| 0.05 | 17.200 |
| 0.10 | 6.110 |
| 0.15 | 3.058 |
| 0.20 | 1.845 |
| 0.25 | 1.236 |
| 0.30 | 0.885 |
| 0.35 | 0.663 |
| 0.40 | 0.512 |



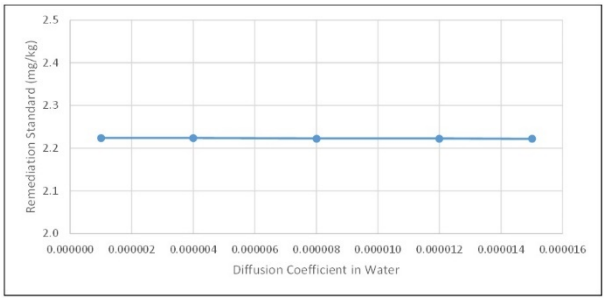

7. Sensitivity of remediation standard to diffusion coefficient in air, ($D_i$). The remediation standard is inversely related to $D_i$, but the sensitivity is relatively low. For most volatiles, $D_i$ varies from about 0.07 to 0.1 $cm^2$/sec, and this range has little effect on the calculated standard.

| $D_i$ ($cm^2$/sec) | Remediation Standard (mg/kg) |
|---|---|
| 0.01 | 6.621 |
| 0.05 | 2.973 |
| 0.10 | 2.104 |
| 0.15 | 1.718 |
| 0.20 | 1.488 |
| 0.25 | 1.331 |
| 0.30 | 1.215 |



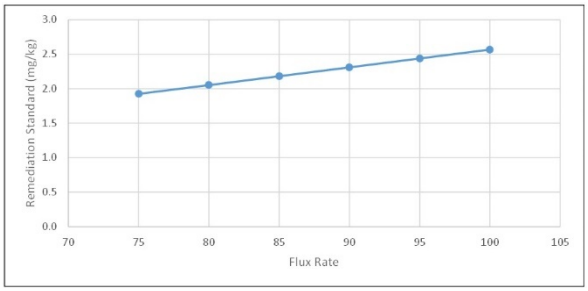
8. Sensitivity of remediation standard to the diffusion coefficient in water, ($D_w$). The normal range of this parameter for volatiles is $1x10^{-5}$ to $1x10^{-6}$ $cm^2/sec$. It has virtually no effect on the calculated remediation standard.

| $D_w$ ($cm^2/sec$) | Remediation Standard (mg/kg) |
|---|---|
| 0.000001 | 2.224 |
| 0.000004 | 2.224 |
| 0.000008 | 2.223 |
| 0.000012 | 2.223 |
| 0.000015 | 2.222 |




9. Sensitivity of remediation standard to Q/C. The Q/C value determines the dispersion and dilution of a contaminant as it leaves the soil surface and enters the atmosphere. The remediation standard is linearly related to the value of this parameter.

| Q/C ($(g/m^2\text{-}s)/(kg/m^3)$) | Remediation Standard (mg/kg) |
|---|---|
| 75 | 1.925 |
| 80 | 2.053 |
| 85 | 2.182 |
| 90 | 2.310 |
| 95 | 2.439 |
| 100 | 2.567 |




| **Summary of Sensitivity Analyses: Volatile Organic Chemicals** | |
|---|---|
| **Parameter** | **Sensitivity** |
| Organic Carbon Partition Coefficient, $K_{oc}$ | Low |
| Henry's Law Constant, H' | Moderate |
| Organic Carbon Content of Soil, $f_{oc}$ | Moderate |
| Soil Bulk Density, $\rho_b$ | Low |
| Soil Moisture, $\theta_w$ | High |
| Soil Air Content, $\theta_a$ | High |
| Diffusion Coefficient in Air, $D_i$ | Low |
| Diffusion Coefficient in Water, $D_w$ | None |
| Q/C | Linear |

# Appendix E

## Default Soil Moisture Content -Volatile Organic Compounds

The soil moisture has a large effect on the inhalation remediation standards for volatile organic compounds. An average annual soil moisture of 0.23 (v/v) was calculated for New Jersey sandy loam soil using a simple relationship described in the *USEPA Soil Screening Level User's Guide* (USEPA, 1996):

$$\boldsymbol{\theta_w = n(I/K_s)^{1/(2b+3)}} \qquad \textbf{(Equation 7 from Appendix I)}$$

where *n* is the total soil porosity, *I* is the soil moisture infiltration rate (m/yr), $K_s$ is the saturated hydraulic conductivity of the soil (m/yr), and the factor 1/(2b+3) is determined by the soil type and is provided in a lookup table in the User's Guide. Rather than estimating soil porosity as described in the User's Guide it was preferred to use a value of 0.41 for sandy loam soil that was statistically derived from the extensive soil database of Carsel and Parrish (1988). This reference is one of EPA's data sources for soil properties for the USEPA SSL document. Additionally, a $K_s$ value of 387 m/yr for sandy loam soil (from Carsel and Parrish, 1988) was used instead of the lookup value of 230 m/yr provided in the user's guide because it is a more recent evaluation.

The final parameter for Equation 1 above is the infiltration rate, I. Infiltration rates for New Jersey soils were determined using a New Jersey-specific tool available from the New Jersey Geological Survey. The New Jersey Geological Survey has published a method for determining infiltration rates for New Jersey as a function of location, soil type and land use (Hoffman, 1999; Charles et al., 1996). Using several of the most commonly occurring soils in New Jersey (Tedrow, 1986), infiltration rates were calculated for each soil in each county where the soil had a significant presence (Table E1). For each calculation, data from a climate station from a municipality located in the area where the soil would occur was used. Three land uses were selected for each calculation: landscaped, bare soil, and agricultural soil. All three of these soil types assume 100% of the surface area is permeable. All sandy loam soils with significant acreage in the state (as mapped by Tedrow, 1986) were used, since this soil texture has been targeted as the default soil texture for New Jersey standards (see main body of this document). In addition, other soil textures with a large presence in the state (as mapped by Tedrow, 1986) were also studied, in order to determine the overall variation of infiltration rates in the state, and to verify that sandy loam soil was appropriate as a default soil texture. A limitation of this method is that the infiltration calculated (below the root zone) is assumed to be equal to groundwater recharge (Charles et al., 1996).

## Table E1
## Recharge rates for various soils, locations and land uses in New Jersey

| Soil Name | Primary Counties of Occurrence | Representative Municipality | Recharge (in/yr) | | |
|---|---|---|---|---|---|
| | | | Landscaped Open Space | Unvegetated | General Agriculture |
| Sassafras sandy loam | Mercer | Washington Twp. | 13.2 | 8.8 | 11.6 |
| Sassafras sandy loam | Middlesex | South River Boro | 14.2 | 9.3 | 12.5 |
| Sassafras sandy loam | Burlington | Delran Twp. | 12.8 | 8.5 | 11.3 |
| Sassafras sandy loam | Salem | Alloway Twp. | 11.6 | 7.9 | 10.2 |
| Sassafras sandy loam | Cumberland | Bridgeton City | 11 | 7.6 | 9.7 |
| Freehold sandy loam | Monmouth | Millstone Twp. | 13.1 | 8.6 | 11.5 |
| Freehold sandy loam | Burlington | Chesterfield Twp. | 13.1 | 8.6 | 11.5 |
| Freehold sandy loam | Camden | Runnemede Boro | 11.7 | 7.8 | 10.2 |
| Freehold sandy loam | Gloucester | Swedesboro Boro | 11.5 | 7.7 | 10.1 |
| Collington sandy loam | Monmouth | Holmdel Twp. | 13.4 | 8.5 | 11.7 |
| Colts Neck sandy loam | Monmouth | Colts Neck Twp. | 13.2 | 8.7 | 11.9 |
| Westphalia sandy loam | Camden | Lindenwold Boro | 11.6 | 7.3 | 10.1 |
| Westphalia sandy loam | Gloucester | Harrison Twp. | 11.4 | 7.3 | 9.9 |
| Aura sandy loam | Gloucester | Elk Twp. | 11.9 | 8.1 | 10.5 |
| Aura sandy loam | Salem | Pittsgrove Twp. | 11.7 | 8 | 10.4 |
| Aura sandy loam | Cumberland | Upper Deerfield Twp. | 11.5 | 7.9 | 10.2 |
| Dunnellen sandy loam | Bergen | Oradell Boro | 16.4 | 10.3 | 14.4 |
| Dunnellen sandy loam | Union | Plainfield City | 15.6 | 9.9 | 13.8 |
| Dunnellen sandy loam | Middlesex | Piscataway Twp. | 15.1 | 9.7 | 13.3 |
| Galestown sand | Mercer | Trenton City | 15.1 | 13 | 14.3 |
| Galestown sand | Burlington | Burlington City | 14.9 | 12.8 | 14.1 |
| Lakewood sand | Monmouth | Neptune Twp. | 17.5 | 14.7 | 16.6 |
| Lakewood sand | Ocean | Manchester Twp. | 17.2 | 14.4 | 16.3 |
| Lakewood sand | Burlington | Pemberton Twp. | 15.5 | 13.3 | 14.7 |
| Downer loamy sand | Monmouth | Neptune Twp. | 16.2 | 10.8 | 14.6 |
| Downer loamy sand | Ocean | Manchester Twp. | 15.9 | 10.6 | 14.2 |
| Downer loamy sand | Burlington | Pemberton Twp. | 14.4 | 9.7 | 12.9 |
| Downer loamy sand | Atlantic | Galloway Twp. | 11.5 | 7.9 | 10.2 |
| Downer loamy sand | Cumberland | Vineland City | 12.3 | 8.5 | 11 |
| Hammonton loamy sand | Atlantic | Estelle Manor City | 12.1 | 8.5 | 10.7 |
| Hammonton loamy sand | Cumberland | Hopewell Twp. | 12.1 | 8.5 | 10.7 |
| Hammonton loamy sand | Cape May | Lower Twp. | 10.2 | 7.4 | 8.9 |
| Boonton loam | Passaic | Hawthorne Boro | 13.9 | 6.4 | 11.6 |
| Boonton loam | Hudson | Harrison Town | 10.1 | 4.7 | 8.5 |
| Boonton loam | Essex | Newark City | 10.1 | 4.7 | 8.5 |

| Soil Name | Primary Counties of Occurrence | Representative Municipality | Recharge (in/yr) | | |
|---|---|---|---|---|---|
| | | | Landscaped Open Space | Unvegetated | General Agriculture |
| Boonton loam | Union | Roselle Park | 10.1 | 4.7 | 8.5 |
| Boonton loam | Middlesex | Perth Amboy City | 13.1 | 6 | 10.9 |
| Boonton loam | Bergen | Ramsey Boro | 13.9 | 6.4 | 11.6 |
| Rockaway loam | Passaic | Ringwood Boro | 17.2 | 8.6 | 14.6 |
| Rockaway loam | Morris | Rockaway Twp. | 16.5 | 8.3 | 14 |
| Rockaway loam | Sussex | Franklin Boro | 15.2 | 7.7 | 13 |
| Annandale loam | Morris | Chester Twp. | 16.9 | 8.4 | 13.9 |
| Annandale loam | Warren | Pohatcong Twp. | 12.4 | 6.7 | 10.2 |
| Annandale loam | Hunterdon | Tewksbury Twp. | 16.3 | 8.2 | 13.5 |
| Penn silt loam | Somerset | Hillsborough Twp. | 12.6 | 5.6 | 10.5 |
| Penn silt loam | Hunterdon | Delaware Twp. | 12 | 5.3 | 10 |

**Table E2**
**Summary of infiltration rates of New Jersey Soils**

| Soil Texture | Average infiltration rates (in./yr) | | | |
|---|---|---|---|---|
| | Landscaped | Unvegetated | Agriculture | Overall |
| Sandy loam | 12.8 | 8.4 | 11.3 | 10.9 |
| Sand | 16 | 13.6 | 15.2 | 15 |
| Loamy sand | 13.1 | 9 | 11.6 | 11.2 |
| Loam | 13.8 | 6.7 | 11.6 | 10.7 |
| Silt loam | 12.3 | 5.4 | 10.2 | 9.3 |
| | | | | |
| All soils | 13.5 | 8.5 | 11.8 | 11.3 |

Table E2 indicates that an 11 inches/yr (0.28 m/yr) infiltration is representative, on average, for sandy loam, loamy sand, and loam soils. Silt loam soils have slightly lower infiltration rates, while sand soils yield rates a few inches higher. As discussed in the main body of the text of this document, it was decided to use sandy loam soil texture as the default soil type for New Jersey, as it was felt that use of a sand soil would be conservative for much of the state. The results above confirm that assuming an infiltration rate of 11 inches/yr (0.28 m/yr) is adequately protective for sandy loam soil and most other soil textures.

Using Equation 1 and all input parameters discussed above, the average soil moisture for sandy loam was determined to be 0.23 (v/v).

## References

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# Appendix F

## Chemical Specific Properties

| Chemical | CAS No. | Water Solubility (mg/L) | Source | Henry's Law Constant (atm-m3/mol, 25°C) | Source | Henry's Law Constant (dimensionless, 25°C) | Source | Air Diffusivity ($cm^2$/sec) | Source | Water Diffusivity ($cm^2$/sec) | Source | $K_{oc}$ (L/kg) | Source | $K_d$ (L/kg) | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acenaphthene | 83-32-9 | 3.9 | USEPA | 1.84E-04 | USEPA | 7.5225E-03 | USEPA | 5.0614E-02 | USEPA | 8.3300E-06 | USEPA | 5027 | USEPA | NA | |
| Acetone (2-Propanone) | 67-64-1 | 1000000 | USEPA | 3.50E-05 | USEPA | 1.4309E-03 | USEPA | 1.0592E-01 | USEPA | 1.1471E-05 | USEPA | 2.364 | USEPA | NA | |
| Acetophenone | 98-86-2 | 6130 | USEPA | 1.04E-05 | USEPA | 4.2520E-04 | USEPA | 6.5222E-02 | USEPA | 8.7228E-06 | USEPA | 51.85 | USEPA | NA | |
| Aldrin | 309-00-2 | 0.017 | USEPA | 4.40E-05 | USEPA | 1.7989E-03 | USEPA | 2.2812E-02 | USEPA | 5.8402E-06 | USEPA | 82020 | USEPA | NA | |
| Aluminum (total) | 7429-90-5 | NA | | NA | | NA | | NA | | NA | | NA | | 1500 | USEPA |
| Anthracene | 120-12-7 | 0.0434 | USEPA | 5.56E-05 | USEPA | 2.2731E-03 | USEPA | 3.8973E-02 | USEPA | 7.8522E-06 | USEPA | 16360 | USEPA | NA | |
| Antimony (total) | 7440-36-0 | NA | | NA | | NA | | NA | | NA | | NA | | 45 | USEPA |
| Arsenic (total) | 7440-38-2 | NA | | NA | | NA | | NA | | NA | | NA | | 261 | USEPA 2002, pH 5.3 |
| Atrazine | 1912-24-9 | 34.7 | USEPA | 2.36E-09 | USEPA | 9.6484E-08 | USEPA | 2.6466E-02 | USEPA | 6.8378E-06 | USEPA | 224.5 | USEPA | NA | |
| Barium (total) | 7440-39-3 | NA | | NA | | NA | | NA | | NA | | NA | | 171 | USEPA 2002, pH 5.3 |
| Benzaldehyde | 100-52-7 | 6950 | USEPA | 2.67E-05 | USEPA | 1.0916E-03 | USEPA | 7.4393E-02 | USEPA | 9.4627E-06 | USEPA | 11.09 | USEPA | NA | |
| Benzene | 71-43-2 | 1790 | USEPA | 5.55E-03 | USEPA | 2.2690E-01 | USEPA | 8.9534E-02 | USEPA | 1.0263E-05 | USEPA | 145.8 | USEPA | NA | |
| Benzo(a) anthracene (1,2-Benzanthracene) | 56-55-3 | 0.0094 | USEPA | 1.20E-05 | USEPA | 4.9059E-04 | USEPA | 2.6144E-02 | USEPA | 6.7495E-06 | USEPA | 176900 | USEPA | NA | |
| Benzo(a)pyrene | 50-32-8 | 0.00162 | USEPA | 4.57E-07 | USEPA | 1.8683E-05 | USEPA | 4.7583E-02 | USEPA | 5.5597E-06 | USEPA | 587400 | USEPA | NA | |
| Benzo(b) fluoranthene (3,4-Benzofluoranthene) | 205-99-2 | 0.0015 | USEPA | 6.57E-07 | USEPA | 2.6860E-05 | USEPA | 4.7583E-02 | USEPA | 5.5597E-06 | USEPA | 599400 | USEPA | NA | |
| Benzo(k) fluoranthene | 207-08-9 | 0.0008 | USEPA | 5.84E-07 | USEPA | 2.3875E-05 | USEPA | 4.7583E-02 | USEPA | 5.5597E-06 | USEPA | 587400 | USEPA | NA | |
| Beryllium | 7440-41-7 | NA | | NA | | NA | | NA | | NA | | NA | | 3.50E+01 | USEPA 2002, pH 5.3 |
| 1,1'-Biphenyl | 92-52-4 | 7.48 | USEPA | 3.08E-04 | USEPA | 1.2592E-02 | USEPA | 4.7059E-02 | USEPA | 7.5618E-06 | USEPA | 5129 | USEPA | NA | |
| Bis(2-chloroethoxy) methane | 111-91-1 | 7800 | USEPA | 3.85E-06 | USEPA | 1.5740E-04 | USEPA | 6.1186E-02 | USEPA | 7.1492E-06 | USEPA | 14.38 | USEPA | NA | |
| Bis(2-chloroethyl) ether | 111-44-4 | 17200 | USEPA | 1.70E-05 | USEPA | 6.9501E-04 | USEPA | 5.6719E-02 | USEPA | 8.7070E-06 | USEPA | 32.21 | USEPA | NA | |
| Bis(2-ethylhexyl) phthalate | 117-81-7 | 0.27 | USEPA | 2.70E-07 | USEPA | 1.1038E-05 | USEPA | 1.7340E-02 | USEPA | 4.1807E-06 | USEPA | 119600 | USEPA | NA | |
| Bromodichloromethane (Dichlorobromomethane) | 75-27-4 | 3032 | USEPA | 2.12E-03 | USEPA | 8.6672E-02 | USEPA | 5.6263E-02 | USEPA | 1.0731E-05 | USEPA | 31.82 | USEPA | NA | |
| Bromoform | 75-25-2 | 3100 | USEPA | 5.35E-04 | USEPA | 2.1872E-02 | USEPA | 3.5732E-02 | USEPA | 1.0356E-05 | USEPA | 31.82 | USEPA | NA | |
| Bromomethane (Methyl bromide) | 74-83-9 | 15200 | USEPA | 7.34E-03 | USEPA | 3.0008E-01 | USEPA | 1.0050E-01 | USEPA | 1.3468E-05 | USEPA | 13.22 | USEPA | NA | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2-Butanone (Methyl ethyl ketone) (MEK) | 78-93-3 | 223000 | USEPA | 5.69E-05 | USEPA | 2.3262E-03 | USEPA | 9.1446E-02 | USEPA | 1.0193E-05 | USEPA | 4.51 | USEPA | NA | |
| Butylbenzyl phthalate | 85-68-7 | 2.69 | USEPA | 1.26E-06 | USEPA | 5.1513E-05 | USEPA | 2.0832E-02 | USEPA | 5.1733E-06 | USEPA | 7155 | USEPA | NA | |
| Cadmium | 7440-43-9 | NA | | NA | | NA | | NA | | NA | | NA | | 2.30E+01 | USEPA 2002, pH 5.3 |
| Caprolactam | 105-60-2 | 772000 | USEPA | 2.53E-08 | USEPA | 1.0343E-06 | USEPA | 6.9242E-02 | USEPA | 8.9994E-06 | USEPA | 24.5 | USEPA | NA | |
| Carbon disulfide | 75-15-0 | 2160 | USEPA | 1.44E-02 | USEPA | 5.8872E-01 | USEPA | 1.0644E-01 | USEPA | 1.2977E-05 | USEPA | 21.73 | USEPA | NA | |
| Carbon tetrachloride | 56-23-5 | 793 | USEPA | 2.76E-02 | USEPA | 1.1284E+00 | USEPA | 5.7143E-02 | USEPA | 9.7849E-06 | USEPA | 43.89 | USEPA | NA | |
| Chlordane (alpha and gamma forms summed) | 57-74-9 | 0.0562 | EPI Suite | 4.86E-052 | EPI Suite | 1.9869E-032 | EPI Suite | 1.7900E-023 | WATER 9* | 4.3700E-063 | WATER 9* | 675405 | EPI Suite - MCI | NA | |
| 4-Chloroaniline | 106-47-8 | 3900 | USEPA | 1.16E-06 | USEPA | 4.7424E-05 | USEPA | 7.0385E-02 | USEPA | 1.0253E-05 | USEPA | 112.7 | USEPA | NA | |
| Chlorobenzene | 108-90-7 | 498 | USEPA | 3.11E-03 | USEPA | 1.2715E-01 | USEPA | 7.2130E-02 | USEPA | 9.4765E-06 | USEPA | 233.9 | USEPA | NA | |
| Chloroethane (Ethyl chloride) | 75-00-3 | 6710 | USEPA | 1.11E-02 | USEPA | 4.5380E-01 | USEPA | 1.0376E-01 | USEPA | 1.1619E-05 | USEPA | 21.73 | USEPA | NA | |
| Chloroform | 67-66-3 | 7950 | USEPA | 3.67E-03 | USEPA | 1.5004E-01 | USEPA | 7.6920E-02 | USEPA | 1.0891E-05 | USEPA | 31.82 | USEPA | NA | |
| Chloromethane (Methyl chloride) | 74-87-3 | 5320 | USEPA | 8.82E-03 | USEPA | 3.6059E-01 | USEPA | 1.2396E-01 | USEPA | 1.3648E-05 | USEPA | 13.22 | USEPA | NA | |
| 2-Chloronaphthalene | 91-58-7 | 11.7 | USEPA | 3.20E-04 | USEPA | 1.3082E-02 | USEPA | 4.4691E-02 | USEPA | 7.7301E-06 | USEPA | 2478 | USEPA | NA | |
| 2-Chlorophenol (o-Chlorophenol) | 95-57-8 | 11300 | USEPA | 1.12E-05 | USEPA | 4.57890E-04 | USEPA | 6.6118E-02 | USEPA | 9.4784E-06 | USEPA | 398 | USEPA 2002, pH 5.3 | NA | |
| Chrysene | 218-01-9 | 0.002 | USEPA | 5.23E-06 | USEPA | 2.1382E-04 | USEPA | 2.6114E-02 | USEPA | 6.7495E-06 | USEPA | 180500 | USEPA | NA | |
| Cobalt (total) | 7440-48-4 | NA | | NA | | NA | | NA | | NA | | NA | | 4.50E+01 | USEPA |
| Copper (total) | 7440-50-8 | NA | | NA | | NA | | NA | | NA | | NA | | 3.50E+01 | USEPA |
| Cyanide | 57-12-5 | NA | | NA | | NA | | NA | | NA | | NA | | 9.90E+00 | USEPA |
| Cyclohexane | 110-82-7 | 55 | USEPA | 1.50E-01 | USEPA | 6.1325E+00 | USEPA | 7.9973E-02 | USEPA | 9.1077E-06 | USEPA | 145.8 | USEPA | NA | |
| 4,4'-DDD (p,p'-TDE) | 72-54-8 | 0.09 | USEPA | 6.60E-06 | USEPA | 2.6983E-04 | USEPA | 4.0608E-02 | USEPA | 4.7447E-06 | USEPA | 117500 | USEPA | NA | |
| 4,4'-DDE (p,p'-DDX) | 72-55-9 | 0.04 | USEPA | 4.16E-05 | USEPA | 1.7007E-03 | USEPA | 2.3000E-02 | USEPA | 5.8592E-06 | USEPA | 117500 | USEPA | NA | |
| 4,4'-DDT | 50-29-3 | 0.0055 | USEPA | 8.32E-06 | USEPA | 3.4015E-04 | USEPA | 3.7933E-02 | USEPA | 4.4322E-06 | USEPA | 168600 | USEPA | NA | |
| Dibenz(a,h)anthracene | 53-70-3 | 0.00249 | USEPA | 1.41E-07 | USEPA | 5.7645E-06 | USEPA | 4.4567E-02 | USEPA | 5.2073E-06 | USEPA | 1912000 | USEPA | NA | |
| Dibromochloromethane (Chlorodibromomethane) | 124-48-1 | 2700 | USEPA | 7.83E-04 | USEPA | 3.2011E-02 | USEPA | 3.6636E-02 | USEPA | 1.0561E-05 | USEPA | 31.82 | USEPA | NA | |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 1230 | USEPA | 1.47E-04 | USEPA | 6.0098E-03 | USEPA | 3.2135E-02 | USEPA | 8.9048E-06 | USEPA | 115.8 | USEPA | NA | |
| 1,2-Dibromoethane (Ethylene dibromide) | 106-93-4 | 3910 | USEPA | 6.50E-04 | USEPA | 2.6574E-02 | USEPA | 4.303480E-02 | USEPA | 1.0400E-05 | USEPA | 39.6 | USEPA | NA | |
| 1,2-Dichlorobenzene (o-Dichlorobenzene) | 95-50-1 | 156 | USEPA | 1.92E-03 | USEPA | 7.8496E-02 | USEPA | 5.617030E-02 | USEPA | 8.9213E-06 | USEPA | 382.9 | USEPA | NA | |
| 1,3-Dichlorobenzene (m-Dichlorobenzene) | 541-73-1 | 125 | EPI Suite | 2.63E-03 | EPI Suite | 1.0751E-01 | EPI Suite | 6.920000E-02 | WATER 9 | 7.8600E-06 | WATER 9 | 375.3 | EPI Suite - MCI | NA | |
| 1,4-Dichlorobenzene (p-Dichlorobenzene) | 106-46-7 | 81.3 | USEPA | 2.41E-03 | USEPA | 9.8528E-02 | USEPA | 5.5043E-02 | USEPA | 8.6797E-06 | USEPA | 375.3 | USEPA | NA | |
| 3,3'-Dichlorobenzidine | 91-94-1 | 3.1 | USEPA | 2.84E-11 | USEPA | 1.1611E-09 | USEPA | 4.7482E-02 | USEPA | 5.5478E-06 | USEPA | 3190 | USEPA | NA | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dichlorodifluoromethane (Freon 12) | 75-71-8 | 280 | USEPA | 3.43E-01 | USEPA | 1.4023E+01 | USEPA | 7.6029E-02 | USEPA | 1.0839E-05 | USEPA | 43.89 | USEPA | NA | |
| 1,1-Dichloroethane | 75-34-3 | 5040 | USEPA | 5.62E-03 | USEPA | 2.2976E-01 | USEPA | 8.3645E-02 | USEPA | 1.0621E-05 | USEPA | 31.82 | USEPA | NA | |
| 1,2-Dichloroethane | 107-06-2 | 8600 | USEPA | 1.18E-03 | USEPA | 4.8242E-02 | USEPA | 8.5722E-02 | USEPA | 1.0995E-05 | USEPA | 39.6 | USEPA | NA | |
| 1,1-Dichloroethene (1,1-Dichloroethylene) | 75-35-4 | 2420 | USEPA | 2.61E-02 | USEPA | 1.0670E+00 | USEPA | 8.6311E-02 | USEPA | 1.0956E-05 | USEPA | 31.82 | USEPA | NA | |
| 1,2-Dichloroethene (cis) (c-1,2-Dichloroethylene) | 156-59-2 | 6410 | USEPA | 4.08E-03 | USEPA | 1.6680E-01 | USEPA | 8.8406E-02 | USEPA | 1.1335E-05 | USEPA | 39.6 | USEPA | NA | |
| 1,2-Dichloroethene (trans) (t-1,2-Dichloroethylene) | 156-60-5 | 4520 | USEPA | 9.38E-03 | USEPA | 3.8348E-01 | USEPA | 8.7609E-02 | USEPA | 1.1191E-05 | USEPA | 39.6 | USEPA | NA | |
| 2,4-Dichlorophenol | 120-83-2 | 5500 | USEPA | 4.29E-06 | USEPA | 1.7538E-04 | USEPA | 4.8577E-02 | USEPA | 8.6786E-06 | USEPA | 1591 | USEPA 2002, pH 5.3 | NA | |
| 1,2-Dichloropropane | 78-87-5 | 2800 | USEPA | 2.82E-03 | USEPA | 1.1529E-01 | USEPA | 7.3340E-02 | USEPA | 9.7252E-06 | USEPA | 60.7 | USEPA | NA | |
| 1,3-Dichloropropene (total) | 542-75-6 | 2800 | USEPA | 3.55E-03 | USEPA | 1.4513E-01 | USEPA | 7.6272E-02 | USEPA | 1.0123E-05 | USEPA | 72.17 | USEPA | NA | |
| Dieldrin | 60-57-1 | 0.195 | USEPA | 1.00E-05 | USEPA | 4.0883E-04 | USEPA | 2.3286E-02 | USEPA | 6.0062E-06 | USEPA | 20090 | USEPA | NA | |
| Diethylphthalate | 84-66-2 | 1080 | USEPA | 6.10E-07 | USEPA | 2.4939E-05 | USEPA | 2.6074E-02 | USEPA | 6.7227E-06 | USEPA | 104.9 | USEPA | NA | |
| 2,4-Dimethylphenol | 105-67-9 | 7870 | USEPA | 9.51E-07 | USEPA | 3.8879E-05 | USEPA | 6.2245E-02 | USEPA | 8.3140E-06 | USEPA | 491.8 | USEPA | NA | |
| Di-n-butyl phthalate | 84-74-2 | 11.2 | USEPA | 1.81E-06 | USEPA | 7.3998E-05 | USEPA | 2.1436E-02 | USEPA | 5.3255E-06 | USEPA | 1157 | USEPA | NA | |
| 2,4-Dinitrophenol | 51-28-5 | 2790 | USEPA | 8.60E-08 | USEPA | 3.5159E-06 | USEPA | 4.06670E-02 | USEPA | 9.0756E-06 | USEPA | 1.78E-02 | USEPA 2002, pH 5.3 | NA | |
| 2,4-Dinitrotoluene/2,6-Dinitrotoluene (mixture) | 25321-14-6 | 270 | USEPA | 3.97E-07 | USEPA | 1.6230E-05 | USEPA | 5.9131E-02 | USEPA | 6.9090E-06 | USEPA | 587.4 | USEPA | NA | |
| Di-n-octyl phthalate | 117-84-0 | 0.022 | USEPA | 2.57E-06 | USEPA | 1.0506E-04 | USEPA | 3.5559E-02 | USEPA | 4.1548E-06 | USEPA | 140800.00 | USEPA | NA | |
| 1,4-Dioxane | 123-91-1 | 1000000 | USEPA | 4.80E-06 | USEPA | 1.9624E-04 | USEPA | 8.7374E-02 | USEPA | 1.0541E-05 | USEPA | 2.633 | USEPA | NA | |
| Endosulfan I and Endosulfan II (alpha and beta) (summed) | 115-29-7 | 0.325 | USEPA | 6.50E-05 | USEPA | 2.6574E-03 | USEPA | 2.2484E-02 | USEPA | 5.7628E-06 | USEPA | 6761 | USEPA | NA | |
| Endrin | 72-20-8 | 0.25 | USEPA | 6.36E-06 | USEPA | 2.600E-04 | USEPA | 3.6158E-02 | USEPA | 4.2248E-06 | USEPA | 20090 | USEPA | NA | |
| Ethylbenzene | 100-41-4 | 169 | USEPA | 7.88E-03 | USEPA | 3.2216E-01 | USEPA | 6.8465E-02 | USEPA | 8.4558E-06 | USEPA | 446.1 | USEPA | NA | |
| Extractable Petroleum Hydrocarbons (No. 2 Fuel Oil and Diesel) | various | NA | | NA | | NA | | NA | | NA | | NA | USEPA | NA | |
| Extractable Petroleum Hydrocarbons (Other) | various | NA | | NA | | NA | | NA | | NA | | NA | USEPA | NA | |
| Fluoranthene | 206-44-0 | 0.26 | USEPA | 8.86E-06 | USEPA | 3.6222E-04 | USEPA | 2.7596E-02 | USEPA | 7.1827E-06 | USEPA | 55450 | USEPA | NA | |
| Fluorene | 86-73-7 | 1.69 | USEPA | 9.62E-05 | USEPA | 3.9329E-03 | USEPA | 4.3974E-02 | USEPA | 7.8890E-06 | USEPA | 9160 | USEPA | NA | |
| alpha-HCH (alpha-BHC) | 319-84-6 | 2 | USEPA | 6.70E-06 | USEPA | 2.7392E-04 | USEPA | 4.3284E-02 | USEPA | 5.0574E-06 | USEPA | 2807 | USEPA | NA | |
| beta-HCH (beta-BHC) | 319-85-7 | 0.24 | USEPA | 4.40E-06 | USEPA | 1.7988E-05 | USEPA | 2.7667E-02 | USEPA | 7.3955E-06 | USEPA | 2807 | USEPA | NA | |
| Heptachlor | 76-44-8 | 0.18 | USEPA | 2.94E-04 | USEPA | 1.2020E-02 | USEPA | 2.2344E-02 | USEPA | 5.6959E-06 | USEPA | 41260 | USEPA | NA | |
| Heptachlor epoxide | 1024-57-3 | 0.2 | USEPA | 2.10E-05 | USEPA | 8.5850E-04 | USEPA | 2.4001E-02 | USEPA | 6.2475E-06 | USEPA | 10110 | USEPA | NA | |
| Hexachlorobenzene | 118-74-1 | 0.0062 | USEPA | 1.70E-03 | USEPA | 6.9501E-02 | USEPA | 2.8974E-02 | USEPA | 7.8497E-06 | USEPA | 6195 | USEPA | NA | |
| Hexachloro-1,3-butadiene | 87-68-3 | 3.2 | USEPA | 1.03E-02 | USEPA | 4.2110E-01 | USEPA | 2.6744E-02 | USEPA | 7.0264E-06 | USEPA | 845.2 | USEPA | NA | |
| Hexachlorocyclopentadiene | 77-47-4 | 1.8 | USEPA | 2.70E-02 | USEPA | 1.1038E+00 | USEPA | 2.7238E-02 | USEPA | 7.2170E-06 | USEPA | 1404 | USEPA | NA | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hexachloroethane | 67-72-1 | 50 | USEPA | 3.89E-03 | USEPA | 1.5904E-01 | USEPA | 3.209380E-02 | USEPA | 8.8904E-06 | USEPA | 196.8 | USEPA | NA | |
| n-Hexane | 110-54-3 | 9.5 | USEPA | 1.80E+00 | USEPA | 7.3590E+01 | USEPA | 7.3108E-02 | USEPA | 8.1658E-06 | USEPA | 131.5 | USEPA | NA | |
| 2-Hexanone | 591-78-6 | 17200 | USEPA | 9.32E-05 | USEPA | 3.8103E-03 | USEPA | 7.0356E-02 | USEPA | 8.4404E-06 | USEPA | 14.98 | USEPA | NA | |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 0.00019 | USEPA | 3.48E-07 | USEPA | 1.4227E-05 | USEPA | 4.4784E-02 | USEPA | 5.2327E-06 | USEPA | 1951000 | USEPA | NA | |
| Isophorone | 78-59-1 | 12000 | USEPA | 6.64E-06 | USEPA | 2.7146E-04 | USEPA | 5.2505E-02 | USEPA | 7.5296E-06 | USEPA | 65.15 | USEPA | NA | |
| Isopropylbenzene | 98-82-8 | 61.3 | USEPA | 1.15E-02 | USEPA | 4.7016E-01 | USEPA | 6.0304E-02 | USEPA | 7.8566E-06 | USEPA | 697.8 | USEPA | NA | |
| Lead (total) | 7439-92-1 | NA | | NA | | NA | | NA | | NA | | NA | | 9.00E+02 | USEPA |
| Lindane (gamma-HCH) (gamma-BHC) | 58-89-9 | 7.3 | USEPA | 5.14E-06 | USEPA | 2.1014E-04 | USEPA | 4.3284E-02 | USEPA | 5.0574E-06 | USEPA | 2807 | USEPA | NA | |
| Manganese (total) | 7439-96-5 | NA | | NA | | NA | | NA | | NA | | NA | | 6.50E+01 | USEPA |
| Mercury (total) | 7439-97-6 | NA | | NA | | NA | | NA | | NA | | NA | | 2.00E-01 | USEPA 2002, pH 5.3 |
| Methoxychlor | 72-43-5 | 0.1 | USEPA | 2.03E-07 | USEPA | 8.2993E-06 | USEPA | 2.2085E-02 | USEPA | 5.5926E-06 | USEPA | 26890 | USEPA | NA | |
| Methyl acetate | 79-20-9 | 243000 | USEPA | 1.15E-04 | USEPA | 4.7016E-03 | USEPA | 9.5776E-02 | USEPA | 1.1008E-05 | USEPA | 3.064 | USEPA | NA | |
| Methylene chloride (Dichloromethane) | 75-09-2 | 13000 | USEPA | 3.25E-03 | USEPA | 1.3287E-01 | USEPA | 9.9936E-02 | USEPA | 1.2512E-05 | USEPA | 21.73 | USEPA | NA | |
| 2-Methylnaphthalene | 91-57-6 | 24.6 | USEPA | 5.18E-04 | USEPA | 2.1177E-02 | USEPA | 5.2432E-02 | USEPA | 7.7811E-06 | USEPA | 2478 | USEPA | NA | |
| 4-Methyl-2-pentanone (MIBK) | 108-10-1 | 19000 | USEPA | 1.38E-04 | USEPA | 5.6419E-03 | USEPA | 6.9780E-02 | USEPA | 8.3477E-06 | USEPA | 12.6 | USEPA | NA | |
| 2-Methylphenol (o-cresol) | 95-48-7 | 25900 | USEPA | 1.20E-06 | USEPA | 4.9060E-05 | USEPA | 7.2835E-02 | USEPA | 9.3168E-06 | USEPA | 306.5 | USEPA | NA | |
| 4-Methylphenol (p-cresol) | 106-44-5 | 21500 | USEPA | 1.00E-06 | USEPA | 4.0883E-05 | USEPA | 7.2394E-02 | USEPA | 9.2397E-06 | USEPA | 300.4 | USEPA | NA | |
| Methyl tert-butyl ether (MTBE) | 1634-04-4 | 51000 | USEPA | 5.87E-04 | USEPA | 2.3998E-02 | USEPA | 7.5267E-02 | USEPA | 8.5904E-06 | USEPA | 11.56 | USEPA | NA | |
| Naphthalene | 91-20-3 | 31 | USEPA | 4.40E-04 | USEPA | 1.7988E-02 | USEPA | 6.0499E-02 | USEPA | 8.3770E-06 | USEPA | 1544 | USEPA | NA | |
| Nickel (total) | 7440-02-0 | NA | | NA | | NA | | NA | | NA | | NA | | 2.40E+01 | USEPA 2002, pH 5.3 |
| 4-Nitroaniline | 100-01-6 | 728 | USEPA | 1.26E-09 | USEPA | 5.153E-08 | USEPA | 6.3660E-02 | USEPA | 9.7545E-06 | USEPA | 109.1 | USEPA | NA | |
| Nitrobenzene | 98-95-3 | 2090 | USEPA | 2.40E-05 | USEPA | 9.8119E-04 | USEPA | 6.8054E-02 | USEPA | 9.4494E-06 | USEPA | 226.4 | USEPA | NA | |
| N-Nitrosodi-n-propylamine | 621-64-7 | 13000 | USEPA | 5.38E-06 | USEPA | 2.1995E-04 | USEPA | 5.6440E-02 | USEPA | 7.7580E-06 | USEPA | 275.4 | USEPA | NA | |
| N-Nitrosodiphenylamine | 86-30-6 | 35 | USEPA | 1.21E-06 | USEPA | 4.9648E-05 | USEPA | 5.5886E-02 | USEPA | 6.5299E-06 | USEPA | 2632 | USEPA | NA | |
| 2,2'-oxybis(1-chloropropane) | 108-60-1 | 1700 | USEPA | 7.42E-05 | USEPA | 3.0335E-03 | USEPA | 3.9889E-02 | USEPA | 7.3606E-06 | USEPA | 82.92 | USEPA | NA | |
| Pentachlorophenol | 87-86-5 | 14 | USEPA | 2.45E-08 | USEPA | 1.0016E-06 | USEPA | 2.9520E-02 | USEPA | 8.0121E-06 | USEPA | 51001 | USEPA 2002, pH 5.3 | NA | |
| Phenol | 108-95-2 | 82800 | USEPA | 3.33E-07 | USEPA | 1.3614E-05 | USEPA | 8.3398E-02 | USEPA | 1.0254E-05 | USEPA | 187.2 | USEPA | NA | |
| Polychlorinated biphenyls (PCBs) | 1336-36-3 | 0.7 | USEPA | 4.15E-04 | USEPA | 1.6966E-02 | USEPA | 2.4340E-02 | USEPA | 6.2671E-06 | USEPA | 78100 | USEPA | NA | |
| Pyrene | 129-00-0 | 0.135 | USEPA | 1.19E-05 | USEPA | 4.8650E-04 | USEPA | 2.778730E-02 | USEPA | 7.2479E-06 | USEPA | 54340 | USEPA | NA | |
| Selenium (total) | 7782-49-2 | NA | | NA | | NA | | NA | | NA | | NA | | 1.40E+01 | USEPA 2002, pH 5.3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Silver (total) | 7440-22-4 | NA | | NA | | NA | | NA | | NA | | NA | | 2.60E-01 | USEPA 2002, pH 5.3 |
| Styrene | 100-42-5 | 310 | USEPA | 2.75E-03 | USEPA | 1.1243E-01 | USEPA | 7.1114E-02 | USEPA | 8.7838E-06 | USEPA | 446.1 | USEPA | NA | |
| Tertiary butyl alcohol (TBA) | 75-65-0 | 1000000 | EPI Suite | 9.05E-06 | EPI Suite | 3.6996E-04 | EPI Suite | 9.8500E-02 | WATER 9* | 1.1400E-05 | WATER 9* | 2.111 | EPI Suite - MCI | NA | |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | 0.595 | USEPA | 1.00E-03 | USEPA | 4.0883E-02 | USEPA | 3.1896E-02 | USEPA | 8.7531E-06 | USEPA | 2220 | USEPA | NA | |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 1746-01-6 | 0.0002 | USEPA | 5.00E-05 | USEPA | 2.0442E-03 | USEPA | 4.7028E-02 | USEPA | 6.7568E-06 | USEPA | 249100 | USEPA | NA | |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | 2830 | USEPA | 3.67E-04 | USEPA | 1.5004E-02 | USEPA | 4.8921E-02 | USEPA | 9.2902E-06 | USEPA | 94.94 | USEPA | NA | |
| Tetrachloroethene (PCE) (Tetrachloroethylene) | 127-18-4 | 206 | USEPA | 1.77E-02 | USEPA | 7.2363E-01 | USEPA | 5.0466E-02 | USEPA | 9.4551E-06 | USEPA | 94.94 | USEPA | NA | |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | 23 | USEPA | 8.84E-06 | USEPA | 3.6140E-04 | USEPA | 5.0338E-02 | USEPA | 5.8816E-06 | USEPA | 3140 | USEPA | NA | |
| Toluene | 108-88-3 | 526 | USEPA | 6.64E-03 | USEPA | 2.7146E-01 | USEPA | 7.7804E-02 | USEPA | 9.2043E-06 | USEPA | 233.9 | USEPA | NA | |
| Toxaphene | 8001-35-2 | 0.55 | USEPA | 6.00E-06 | USEPA | 2.4530E-04 | USEPA | 3.2439E-02 | USEPA | 3.7902E-06 | USEPA | 77200 | USEPA | NA | |
| 1,2,4-Trichlorobenzene | 120-82-1 | 49 | USEPA | 1.42E-03 | USEPA | 5.8054E-02 | USEPA | 3.9599E-02 | USEPA | 8.4033E-06 | USEPA | 1356 | USEPA | NA | |
| 1,1,1-Trichloroethane | 71-55-6 | 1290 | USEPA | 1.72E-02 | USEPA | 7.0319E-01 | USEPA | 6.4817E-02 | USEPA | 9.5990E-06 | USEPA | 43.89 | USEPA | NA | |
| 1,1,2-Trichloroethane | 79-00-5 | 4590 | USEPA | 8.24E-04 | USEPA | 3.3688E-02 | USEPA | 6.6890E-02 | USEPA | 1.0026E-05 | USEPA | 60.7 | USEPA | NA | |
| Trichloroethene (TCE) (Trichloroethylene) | 79-01-6 | 1280 | USEPA | 9.85E-03 | USEPA | 4.0270E-01 | USEPA | 6.8662E-02 | USEPA | 1.0221E-05 | USEPA | 60.7 | USEPA | NA | |
| Trichlorofluoromethane (Freon 11) | 75-69-4 | 1100 | USEPA | 9.70E-02 | USEPA | 3.9657E+00 | USEPA | 6.5356E-02 | USEPA | 1.0048E-05 | USEPA | 43.89 | USEPA | NA | |
| 2,4,5-Trichlorophenol | 95-95-4 | 1200 | USEPA | 1.62E-06 | USEPA | 6.6230E-05 | USEPA | 3.1394E-02 | USEPA | 8.0893E-06 | USEPA | 23401 | USEPA 2002, pH 5.3 | NA | |
| 2,4,6-Trichlorophenol | 88-06-2 | 800 | USEPA | 2.60E-06 | USEPA | 1.0630E-04 | USEPA | 3.1395E-02 | USEPA | 8.0896E-06 | USEPA | 9991 | USEPA 2002, pH 5.3 | NA | |
| 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon TF) | 76-13-1 | 170 | USEPA | 5.26E-01 | USEPA | 2.1504E+01 | USEPA | 3.7566E-02 | USEPA | 8.5920E-06 | USEPA | 196.8 | USEPA | NA | |
| 1,2,4-Trimethylbenzene | 95-63-6 | 57 | USEPA | 6.16E-03 | USEPA | 2.5184E-01 | USEPA | 6.0675E-02 | USEPA | 7.9208E-06 | USEPA | 614.3 | USEPA | NA | |
| Vanadium (total) | 7440-62-2 | NA | | NA | | NA | | NA | | NA | | NA | | 1.00E+03 | USEPA |
| Vinyl chloride | 75-01-4 | 8800 | USEPA | 2.78E-02 | USEPA | 1.1365E+00 | USEPA | 1.0712E-01 | USEPA | 1.2004E-05 | USEPA | 21.73 | USEPA | NA | |
| Xylenes (total) | 1330-20-7 | 106 | USEPA | 6.63E-03 | USEPA | 2.7105E-01 | USEPA | 6.8515E-02 | USEPA | 8.4640E-06 | USEPA | 382.9 | USEPA | NA | |
| Zinc (total) | 7440-66-6 | NA | | NA | | NA | | NA | | NA | | NA | | 2.30E+01 | USEPA 2002, pH 5.3 |

# Appendix G

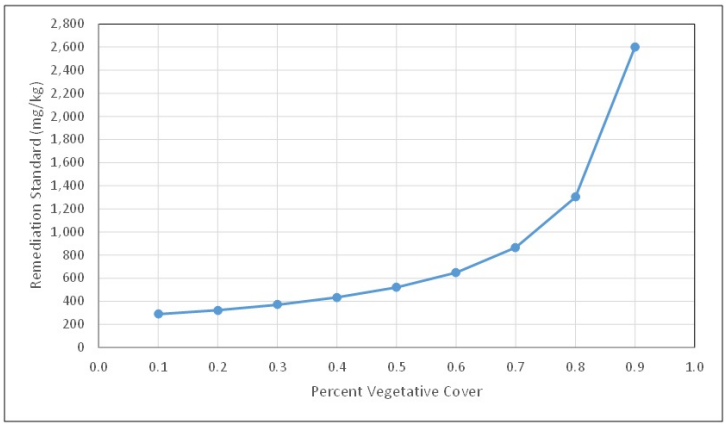
## Sensitivity Analysis - Particulates

For this sensitivity analysis, only one variable was modified at a time as the other variables are held at their USEPA default or default New Jersey value. In most cases, the parameters were varied by documented values. This analysis was conducted for ground cover and wind speed variables in the particulate emission factor.

1. Sensitivity of the particulate portion of the InhSRS equation to the amount of ground cover

   The amount of vegetative cover assumed for wind erosion effects was 50% as a reasonable compromise between no vegetation and complete cover. The 50% vegetative cover was also assumed as default by USEPA. Vegetative cover has a significant effect.

| Percent Vegetative Cover | Remediation Standard (mg/kg) |
|---|---|
| 0.1 | 290 |
| 0.2 | 324 |
| 0.3 | 371 |
| 0.4 | 434 |
| 0.5 | 521 |
| 0.6 | 649 |
| 0.7 | 867 |
| 0.8 | 1,301 |
| 0.9 | 2,599 |

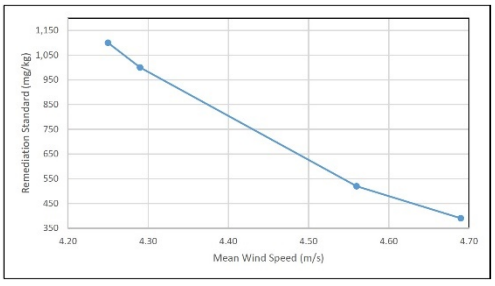



2. Sensitivity of the particulate portion of the InhSRS equation to mean wind speed.

   The mean annual wind speed (4.69 m/s) and equivalent threshold wind speed value used in the Department's calculations are default values taken from *USEPA's Soil Screening Guidance: Technical Background Document* (1996). The other mean wind speeds shown are site-specific values for Philadelphia (4.29 m/s), Atlantic City (4.25 m/s), and Newark (4.56 m/s). These mean wind speeds are 30-year (24-year for Atlantic City) normals statistically calculated by the

   National Oceanic and Atmospheric Administration (NOAA) (2003a, 2003b, 2003c). The effect of mean wind speed is significant.

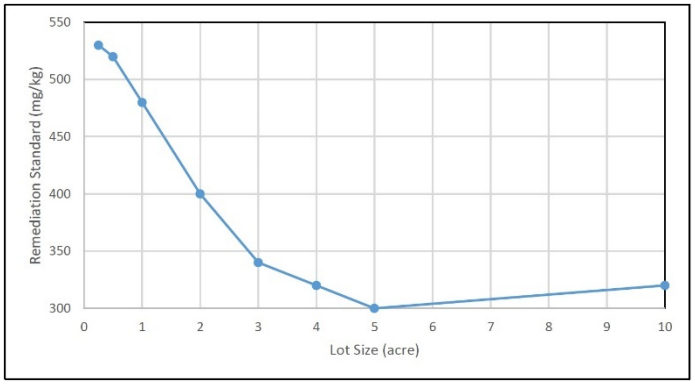
| Mean Wind Speed (m/s) | Remediation Standard (mg/kg) |
|---|---|
| 4.25 | 1,100 |
| 4.29 | 1,000 |
| 4.56 | 520 |
| 4.69 | 390 |



3. Sensitivity of the particulate portion of the InhSRS equation to residential site size

   A large number of comments on USEPA's December 1994 Soil Screening Guidance suggest that most contaminated soil sources are 0.5 acres or less. The USEPA's Office of Emergency and Remedial Response (OERR) conducted an analysis of the effects of changing the default source area from 30 acres to 0.5 acre. The results of the analysis indicated that the particulate portion of the SRS are sensitive to varying the source area. The reduction in the source area from 30 acres to 0.5 acre increases the particulate portion of the SRS for the inhalation exposure pathway by about a factor of 2 (USEPA, 1996). The effect of site size on the particulate portion of the InhSRS is significant.

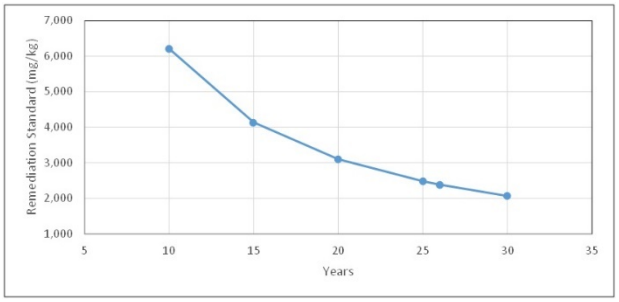
| Lot Size (acre) | Remediation Standard (mg/kg) |
|---|---|
| 0.25 | 530 |
| 0.5 | 520 |
| 1 | 480 |
| 2 | 400 |
| 3 | 340 |
| 4 | 320 |
| 5 | 300 |
| 10 | 320 |




4. Sensitivity of the particulate portion of the InhSRS equation to exposure frequency in days per year

   The USEPA's *Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors*. OSWER Directive 9200.1-120.4-12. February (USEPA, 2014) recommends an exposure frequency of 225 days per year for the outdoor worker, 250 days per year for an indoor worker, and 350 days per year for residential exposure. Exposure frequency has a significant effect on the particulate portion of the SRS equation.

| Years | Remediation Standard (mg/kg) |
|---|---|
| 10 | 6,208 |
| 15 | 4,139 |
| 20 | 3,104 |
| 25 | 2,483 |
| 26 | 2,388 |
| 30 | 2,069 |

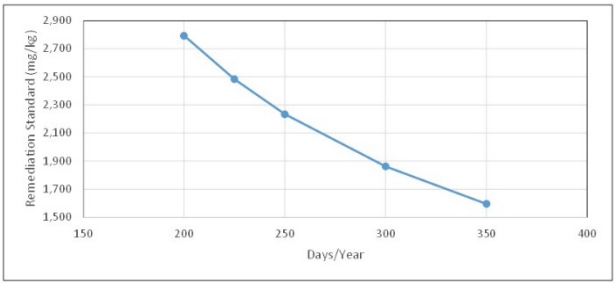



5. Sensitivity of the particulate portion of the InhSRS equation to exposure duration in years

   The USEPA's *Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors*. OSWER Directive 9200.1-120.4-12. February (USEPA, 2014) recommends an exposure duration of 25 years for the non-residential scenario worker and a duration of 26 years for residential exposure. Exposure

duration has a slightly greater effect on the particulate portion of the SRS than the exposure frequency.

| Days/Year | Remediation Standard (mg/kg) |
|---|---|
| 200 | 2,794 |
| 225 | 2,483 |
| 250 | 2,234 |
| 300 | 1,862 |
| 350 | 1,596 |




| Summary of Sensitivity Analyses: Particulates | |
|---|---|
| **Residential** | |
| **Parameter** | **Sensitivity** |
| Ground cover | High |
| Mean wind speed | High |
| Residential site size | High |
| | |
| **Non-residential** | |
| **Parameter** | **Sensitivity** |
| Non-residential site size | High |
| Exposure frequency in days per year | High |
| Exposure duration in years | High |

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# Appendix H

## Site Size Justification

**Non-residential Exposure Scenario:**

To calculate an inhalation exposure pathway, soil remediation standard for a non-residential exposure scenario, it is necessary to determine a default value for the size of a non-residential site. This information on a statewide basis is not readily available. Two sources of data regarding site size were examined and eventually used to develop a number. The Department fully recognizes the implications of using databases of limited size, but this was the best available option for developing a New Jersey specific value.

One source originates from the Department's program overseeing the remediation of facilities subject to the Industrial Site Recovery Act. Site size information was provided for 154 individual sites. The site sizes ranged from 0.11 acres to 13.16 acres with a median of 1 acre and an upper 95% confidence limit of the median equal to 1.9 acres. The 25th percentile value is 1 acre and the 75th percentile is 3.13 acres. The interquartile range (the range between the 25th and 75th percentile) is 2.13 acres. A strict arithmetic mean equals 2.58 acres; however, the population itself appears to be lognormal in nature. Taking this into account, the 95% upper confidence limit of the mean is 3.10 acres. Examination of the inputs yielded a qualitative judgment that this data set would be biased towards small sites since smaller sites would be more numerous in the data set.

The other source originates from the Site Remediation and Waste Management Program conducting remediation using public funds. Specifically, the site data in the Publicly Funded Cleanups Site Status Report for the years 1995 to 2002 was examined. Excluded were landfills, parks, and regional ground water or radiation remediations. Site sizes on 138 sites were obtained. The site sizes range from 0.07 acres to 640 acres with a median of 1.6 acres and an upper 95% confidence limit of the median equal to 2 acres. The 25th percentile value is 0.5 acre and the 75th percentile is 8.8 acres. The interquartile range (the range between the 25th and 75th percentile) is 8.3 acres. A strict arithmetic mean equals 16.06 acres; however, the population itself appears to be lognormal in nature. Taking this into account, the 95% upper confidence limit of the mean is 17.86 acres.

It is recognized that the largest sites were excluded from the evaluation in the case of the second set of data. However, as an offset to this, data under the purview of the underground storage tank program were also not included. This type of site, which is extremely numerous, would have a tendency to be smaller in size and consequently would likely reduce the average site size. The Department views these impacts as offsetting in nature.

The evaluation of the two data sets above yielded the following conclusion. The available data are lognormal distributions and there is a bias towards the inclusion of smaller sites. The median of these populations provides a better measure of the central tendency than the geometric mean. Because a true mean would necessarily be larger than the median in such a distribution, as well as in consideration of the data bias towards smaller sites, an upper bound of the median could serve as a better measure of central tendency. The upper 95% confidence limits of the two

populations are 2 and 3 acres, respectively. The lower 95% confidence limits of the two populations are both 1 acre. It is concluded on this basis that 2 acres represents a reasonable estimate of the average site size of a non-residential type site because it is centrally located within the bounded ranges for the medians of both data sets.

**Residential Exposure Scenario:**

In the SSG, the USEPA assumes a residential lot is 0.5 acres in size. A New Jersey specific evaluation effort consisted of tabulating site size data for 3,000 single family residences in each of the 21 counties of New Jersey. A real estate database provided the input data (Win2Data). Potential erroneous entries and those with zero or no area value entered were excluded from the data collected. Also excluded were lot sizes greater than 20 acres, which were usually large forested, farmed, or open space areas. The number of sites excluded in this manner was minimal.

A strict averaging (no weighting or filtering) of the 63,000 single family residence site size data points yielded a statewide mean of 0.475 acres. The larger average lot sizes in Atlantic, Hunterdon, and Salem Counties did influence the result. A mean value excluding the data from these counties would have resulted in an average lot size of 0.302 acres. However, because the purpose of the soil remediation standard effort is to develop a statewide standard, the mean derived from all the data is the more appropriate choice. Consequently, the assumed lot size for a residential exposure scenario will be 0.475 acres, which when rounded is 0.5 acres. This selection of 0.5 acres as the default residential lot size again returns the Department to consistency with the current USEPA assumption.

# Appendix I

## Supporting Equations

Equation 3 - Volatilization Factor (VF):

$$VF = Q/C * \frac{(3.14 * DA * T)^{1/2}}{(2 * \rho_b * D_A)} * 10^{-4}\, m^2/cm^2$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $VF$ | Soil-to-air volatilization factor | $m^3/kg$ | Chemical specific |
| $Q/C$ | Inverse concentration at center of source | $(g/m^2)/(kg/m^3)$ | 86.6 (Residential)<br>85 (Nonresidential) |
| $D_A$ | Apparent diffusivity | $Cm^2/s$ | Chemical specific |
| $T$ | Exposure interval | Seconds | $8.20 \times 10^8$ |
| $r_b$ | Dry soil bulk density | $g/cm^3$ | 1.5 |

Equation 4 - Apparent Diffusivity ($D_A$):

$$DA = \frac{\left[\left(\theta \rightleftarrows a^{10/3} * D_i * H'\right) + \left(\theta w^{10/3} * Dw\right)\right]/n^2}{(\rho_b * Kd) + \theta w + (\theta a * H')}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $D_A$ | Apparent diffusivity | $Cm^2/s$ | Chemical specific |
| $\theta_a$ | Air-filled soil porosity | $L_{air}/L_{soil}$ | 0.18 |
| $D_i$ | Diffusivity in air | $Cm^2/s$ | Chemical specific |
| $H'$ | Henry's law constant | Unitless | Chemical specific |
| $\theta_w$ | Water-filled soil porosity | $L_{water}/L_{soil}$ | 0.23 |
| $D_w$ | Diffusivity in water | $Cm^2/s$ | Chemical specific |
| $n$ | Total soil porosity | $L_{pore}/L_{soil}$ | 0.41 |
| $\rho_b$ | Dry soil bulk density | $g/cm^3$ | 1.5 |
| $K_d$ | Soil-water partition coefficient | $cm^3/g$ | Chemical specific |

Equation 5 - Soil-Water Partition Coefficient ($K_d$):

$$\boldsymbol{Kd = Koc * foc}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $K_d$ | Soil-water partition coefficient | $cm^3/g$ | Chemical specific |
| $K_{oc}$ | Soil organic carbon-water partition coefficient | $cm^3/g$ | Chemical specific |
| $f_{oc}$ | Organic carbon content of soil | g/g | 0.002 |

Equation 6 - Air-Filled Soil Porosity ($\theta_a$):

$$\boldsymbol{\theta_a = n - \theta w}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $\theta_a$ | Air-filled soil porosity | $L_{air}/L_{soil}$ | 0.18 |
| $n$ | Total soil porosity | $L_{pore}/L_{soil}$ | 0.41 |
| $\theta_w$ | Water-filled soil porosity | $L_{water}/L_{soil}$ | 0.23 |

Equation 7 - Soil Moisture Content:

$$\boldsymbol{\theta_w = n(I/K_s)^{\frac{1}{2b+3}}}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $\theta_w$ | Water-filled soil porosity | $L_{water}/L_{soil}$ | 0.23 |
| $n$ | Total soil porosity | $L_{pore}/L_{soil}$ | 0.41 |
| $I$ | Soil moisture infiltration rate | m/yr | |
| $K_s$ | Saturated hydraulic conductivity of the soil | m/yr | |
| $1/(2b+3)$ | Determined by soil type provided in *Soil Screening Guidance: Technical Background Document EPA/540/R-95/128 (May 1996); Attachment A – "Conceptual Site Model," Table A-2* | | |

Appendix E contains additional information regarding this equation.

Equation 8 - Particulate Emission Factor (PEF):

$$PEF = Q/C * \left[ \frac{3{,}600\ sec/hr}{0.036 * (1 - v) * \left(\frac{U_m}{U_t}\right)^3 * F(x)} \right]$$

| Parameter | Defintion | Units | Default |
|---|---|---|---|
| ***PEF*** | Particulate emission factor | $m^3/kg$ | $1.67 \times 10^9$ (Residential)<br>$1.64 \times 10^9$ (Nonresidential) |
| ***Q/C*** | Inverse concentration at center of source | $(g/m^2\text{-}s)/(kg/m^3)$ | 86.6 (Residential)<br>85 (Nonresidential) |
| ***v*** | Fraction of vegetative cover | Percent | 50% |
| $U_m$ | Mean annual wind speed | m/s | 4.56 |
| $U_t$ | Equivalent threshold value of wind speed at 7 m | m/s | 11.32 |

Equation 9 - Q/C, Inverse Concentration Factor for Dispersion:

$$\frac{Q}{C} = \frac{J_s^{ave}}{C_{air} * \frac{10^{-9} kg}{\mu g}}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| ***Q/C*** | Inverse concentration factor for air dispersion | $[g/m^2\text{-}s)/(kg/m^3)]$ | 86.6 (Residential)<br>85 (Nonresidential) |
| $J_s^{ave}$ | Average rate of contaminant | $g/m^2\text{-}s$ | |
| $C_{air}$ | Maximum contaminant concentration | $\mu g/m^3$ | |

Equation 10 - average rate of contaminant flux:

$$J_s^{ave} = \frac{ER}{A}$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $J_s^{ave}$ | Average rate of contaminant flux | $g/m^2\text{-}s$ | |
| ***ER*** | Emission rate (normalized) | g/s | 1 |
| ***A*** | Area | $m^2$ | 2,023 (0.5 acre) |

Equation 11 - Soil Saturation Limit ($C_{sat}$):

$$C_{sat} = \frac{S}{\rho_b} * [(K_d * \rho_b) + \theta_w + (H' * \theta_a)]$$

| Parameter | Definition | Units | Default |
|---|---|---|---|
| $C_{sat}$ | Soil saturation concentration | mg/Kg | |
| $S$ | Solubility in water | mg/L water | Chemical specific |
| $r_b$ | Dry soil bulk density | $g/cm^3$ | 1.5 |
| $K_d$ | Soil- water partition coefficient | $cm^3/g$ | Chemical specific |
| $q_a$ | Air-filled soil porosity | $L_{air}/L_{soil}$ | 0.18 |
| $q_w$ | Water-filled soil porosity | $L_{water}/L_{soil}$ | 0.23 |
| $H'$ | Henry's Law constant | Unitless | Chemical specific |

# Appendix J

**Calculation of an Alternative Remediation Standard using code from the EMSOFT Model and a Finite Contamination Thickness**

## Introduction

The default remediation guidance uses a simplified form of the model of Jury et al. (1990), which assumes an infinite depth of contamination. The full version of this model allows for a finite depth range to be specified (Jury et al., 1990). The full Jury model can be evaluated using a computer FORTRAN model known as EMSOFT (https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=12461). Assuming a finite depth range will reduce the mass of contaminant in the soil, which will reduce the average volatilization flux. This in turn will result in a higher remediation standard. Calculation of an Alternative Remediation Standard using the Jury model is likely to be worthwhile (result in a higher criteria) if the thickness of the contaminated zone is not extensive. The EMSOFT FORTRAN Model has been incorporated into the Department's calculator and may be used for volatile contaminants where the depth of contamination has been defined for a site or AOC.

## Theoretical basis

For volatile organic chemicals (dimensionless Henry's law constant >> $2.5 \times 10^{-5}$), volatilization from the soil surface is limited only by the diffusion rate through the soil, with no restriction imposed by the stagnant air layer at the soil surface (Jury et al., 1984). If soil moisture advection is not considered, and if a chemical is assumed to be present from the soil surface to an infinite depth, the volatilization flux equation can be expressed as follows (Jury et al., 1984):

$$J = C_0 (D_A / \pi \times t)^{1/2} \qquad (1)$$

where $J$ is the volatilization flux (mg/cm$^2$/day) as a function of time $t$ (days), $C_0$ is the concentration of contaminant at time zero on a volume basis (mg/cm$^3$), and $D_A$ is the soil diffusion coefficient (cm$^2$/day, from Equation 6 of the EPA SSG document). An average volatilization flux may be calculated by integrating Equation 1 from time 0 to time t, to give cumulative flux, and dividing by the time interval:

$$\frac{\int_0^t C_0 (D_A / \pi \times t)^{1/2}}{t} \quad (2)$$

The solution to this equation is

$$2C_0 \sqrt{D_A / \pi \times t} \quad (3)$$

If Equation 3 is normalized for concentration by dividing $C_0$ (which has units of mg/cm$^3$) by the initial concentration on a weight basis ($C_S$, which has units of mg/g), the equation is transformed to

$$2\rho_b \sqrt{D_A / \pi \times t} \quad (4)$$

where Equation 4 now represents the average volatilization flux per unit concentration of contaminant on a weight basis, and $\rho_b$ is the bulk density of the soil as described in the EPA SSG document (g/cm$^3$). Note that Equation 4 is equivalent to the inverse of the second factor of Equation 6 in the EPA SSG document. Thus, the average volatilization flux using the Jury model can be used along with the inverse of the mean concentration at the center of a square source (g/m$^2$/s per kg/m$^3$ – see Q/C factor of Equation 6 in the EPA SSG document) to calculate the volatilization factor.

While the above derivation was carried out using a simplified form of the Jury model, the average volatilization flux from the full Jury model can be used in the same manner. The full version of the Jury model (Jury et al., 1990) considers a finite source of contaminant located in a depth range of $L$ to $L + W$, where L is the depth of the top of the contamination, and W is the thickness of the contamination. Advection of soil moisture, due to precipitation infiltration, may also be considered, as well as degradation of the contaminant. These additional features in the full version of the model may result in a significantly lower average volatilization flux, and in turn, a higher calculated remediation standard. The portion of the EMSOFT FORTRAN code used to calculate the average volatilization flux was converted to visual basic and incorporated

into the Department calculator. Visual basic code was added to read in the necessary input parameters and to output the calculated average volatilization flux to the Department calculator. The Department calculator calculates the volatilization factor (VF) as follows:

1. The time-averaged volatilization flux ($mg/cm^2/day$) is converted to units of $gm/m^2/sec$ by multiplying by 10,000 $cm^2/m^2$, then dividing by 86,400 sec/day, and dividing by 1,000 mg/g.

2. The converted value is divided by $1X10^{-6}$ to give the normalized volume-based flux, J ($gm/m^2/sec$).

3. The VF is calculated as follows:

$$VF = \frac{Q/C}{J}$$

where Q/C is either 86.6 $(g/m^2/sec)/(kg/m^3)$ (residential sites) or 85 $(g/m^2/sec)/(kg/m^3)$ (non-residential sites), and VF is the volatilization factor ($m^3/kg$).

The site-specific soil remediation standard is calculated by putting the calculated VF into the residential and nonresidential equations for this exposure pathway.

**References**

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