New Jersey
Department of Environmental Protection

Site Remediation and Waste Management Program

Alternative Remediation Standards Technical Guidance

for Soil for the Ingestion-Dermal and Inhalation Exposure Pathways

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1. INTENDED USE OF GUIDANCE DOCUMENT

This guidance is designed to help the person responsible for conducting the remediation to comply with the New Jersey Department of Environmental Protection (Department) requirements established by the Remediation Standards, N.J.A.C. 7:26D. This guidance will be used by many different people involved in the remediation of a contaminated site; such as Licensed Site Remediation Professionals (LSRP), Non-LSRP environmental consultants and other environmental professionals. Therefore, the generic term "investigator" will be used to refer to any person that uses this guidance to remediate a contaminated site on behalf of a person responsible for conducting the remediation, including the remediating party itself.

The procedures for an investigator to develop and obtain an Alternative Remediation Standard (ARS) are outlined in the Remediation Standards at N.J.A.C. 7:26D-8. Both the development of an ARS or departure from the process provided in this guidance must be documented and adequately supported with site-specific data or other information. In applying technical guidance, the Department recognizes that professional judgment (with adequate justification) may result in a range of interpretations on the application of the guidance, depending on site conditions and other factors.

This guidance supersedes previous DEP guidance issued on this topic. Technical guidance may be used immediately upon issuance. However, the Department recognizes the challenge of using newly issued technical guidance when a remediation affected by the guidance may have already been conducted or is currently in progress. To provide for the reasonable implementation of new technical guidance, the Department will allow a six-month "phase-in" period between the date the technical guidance is issued final (or the revision date) and the time it should be used.

This guidance was prepared with stakeholder input. The following people were on the committee that prepared this document:

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2. PURPOSE

The purpose of this document is to provide detailed guidance to investigators on how to develop an ARS for soil for the ingestion-dermal exposure pathway and the inhalation exposure pathway. A site-specific or area of concern (AOC)-specific ARS for soil for these pathways may be requested by the person responsible for conducting the remediation or the Department at any time during the remediation process, when there are sufficient data and/or site-specific information, as described in this document and N.J.A.C. 7:26D, on which to base an ARS. N.J.A.C. 7:26D-8.4 and 8.5 establish the process and procedures for the investigator to establish an ARS for soil. To ensure that the proposed ARS will attain the same human health-based goals set by the Legislature, in accordance with the *Brownfield Contaminated Site Remediation Act* (N.J.S.A. 58:10B-1 et seq.), ARS for soil for the ingestion-dermal exposure pathway and inhalation exposure pathway must be based on a $1x10^{-6}$ risk level (one-in-one million additional lifetime cancer risk) for carcinogenic chemicals and a hazard quotient of 1 for chemicals with non-carcinogenic effects. This document will enable investigators to develop an ARS for soil based on the site-specific exposure assumptions associated with a specific land use, as well as physical parameters that may be changed from the default assumptions used by the Department in calculating the default soil remediation standards. This guidance document also differentiates ARS options for soil that require prior approval by the Department from those options that do not require prior approval before being used to support site remedial decisions.

The Department will not approve the use of an ARS if the person responsible for conducting the remediation cannot demonstrate that the proposed standard will attain the same human health-based goals set by the Legislature. The Department will review proposals for an ARS for soil for these pathways on a site-by-site or AOC-by-AOC basis and render a decision to the person responsible for conducting the remediation on the acceptability of the proposal for the site or AOC. An approved ARS shall be considered applicable only to the site or AOC for which it has been developed (N.J.A.C. 7:26D-8.2(a)).

3. DOCUMENT OVERVIEW

This document provides technical guidance to support the investigator in developing an ARS for soil for the ingestion-dermal and inhalation exposure pathways. This guidance helps identify when and how to calculate a site-specific or AOC-specific ARS for soil, and supplements N.J.A.C 7:26D-8.3, Appendices 6 and 7. This document does not cover situations in which interim soil remediation standards are developed by the Department or situations in which updated soil remediation standards may be justified based on the availability of new toxicity information/data (N.J.A.C. 7:26D-6 and 7). Also provided herein are references to guidance from the United States Environmental Protection Agency (USEPA) and other sources that may be helpful to investigators in developing and supporting assumptions used in ARS calculations.

In particular, this document provides:

- Background on the default soil remediation standards 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 exposure factors for deriving an ARS for soil for exposure assumptions relevant to an alternative land use (i.e., active recreational land use, passive recreational land use, restricted access areas, and infrequent access areas);

- ARS for soil options for child and adult lead models that require prior approval by the Department before being used;

- 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, soil organic carbon content, and fraction of vegetative cover;

- Information regarding the Department's calculators 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.

4. BACKGROUND

The Department has developed default human health-based soil remediation standards based on residential (child and adult) and nonresidential (outdoor worker) land use. The soil remediation standards are used to evaluate current and potential future human exposure to contaminated soil via incidental ingestion and dermal contact (the ingestion-dermal exposure pathway) and inhalation of airborne particulates and vapors in ambient air (the inhalation exposure pathway). With the exception of arsenic, the soil remediation standards are human health-based values. The default soil remediation standards for arsenic are based upon State background[1] levels of arsenic in soil.

In the development of the default health-based soil remediation standards, the Department applies a threshold cancer risk[2] of $1x10^{-6}$ and Hazard Quotient of 1, as mandated by the *Brownfield Contaminated Site Remediation Act* (N.J.S.A. 58:10B-1 et seq.). The soil remediation standards use default exposure parameters for residential and nonresidential land use that are consistent with those used by USEPA in the Superfund program (USEPA 2014a, USEPA 2018). These default exposure parameters are intended to reflect a reasonable maximum exposure (RME). The RME is considered to be the highest exposure that is reasonably expected to occur at a site (USEPA 1989). It is considered "reasonable" because it is a product of factors (e.g., concentration, exposure frequency and exposure duration), some of which are based upon the average value of the exposure distribution, while others are based upon the 95th percentile value of the exposure distribution (NCP 1990). In accordance with Appendix 7 of N.J.A.C. 7:26D, the Department will not change default parameters used in calculating the default soil remediation standards for residential[3] or non-residential[4] land use, except for physical parameters that can be modified for the inhalation exposure pathway (i.e., fraction of organic carbon, contaminant depth and vegetative cover).

4.1. Basis of Default Soil Remediation Standards for the Ingestion-Dermal Exposure Pathway

4.1.1. Residential

For residential exposure to soil (e.g., through children's outdoor play; gardening, landscaping by adults), the soil remediation standards for the ingestion-dermal exposure pathway consider concurrent exposure via the ingestion and dermal soil exposure routes.

The ingestion component of the ingestion-dermal exposure pathway considers the potential for human exposure to chemicals through incidental ingestion of contaminated soil and dust. Incidental soil ingestion among children commonly occurs through mouthing of objects or unintentional hand-to-mouth activity. Children have a greater potential than adults for exposure to soil through ingestion as a result of these behavioral patterns that are present throughout early

[1] N.J.A.C. 7:26D https://www.nj.gov/dep/rules/proposals/20200406a.pdf (see pages 53-55), Sanders 2002
[2] By policy, SRWMP does not consider mutagenic mode of action when calculating carcinogenic remediation standards.
[3] Residential means properties used for residences, schools and childcare facilities as defined in N.J.A.C 7:26D-1.5.
[4] Nonresidential means properties used for commercial or industrial purposes as defined in N.J.A.C 7:26D-1.5.

childhood. Adults may also ingest soil or dust particles that adhere to objects, food or their hands.

The dermal component of the ingestion-dermal exposure pathway considers contaminant absorption through the skin[5]. The adult resident is assumed to have their arms, hands, head and lower legs exposed; the child is assumed to have their arms, hands, head, lower legs and feet exposed (USEPA 2014a, USEPA 2004).

Residential land use exposure assumptions for carcinogenic contaminants account for an individual's exposure to soil 350 days/year over 26 years. This calculation incorporates childhood exposure over the first six years followed by adult exposure for 20 years (USEPA 2014a). Doing so reflects the differences in the degree of exposure that would occur as both a child and an adult. For example, differences in daily soil ingestion rates (child-200 mg/day; adult-100 mg/day), body weights (child-15 kg; adult- 80 kg), skin surface area (child-2,373 cm^2; adult - 6,032 cm^2), soil adherence factor (child-0.2 mg/cm^2; adult - 0.07 mg/cm^2) and exposure duration (child-six years; adult-20 years) are incorporated into the calculation (see Appendix C Table C-1).

For the residential land use exposure assumptions for non-carcinogenic contaminants, the Department has adopted Superfund's approach that uses a protective "childhood only" residential exposure (USEPA 1993, USEPA 1996a and USEPA 2002). A child's ingestion rate of 200 mg/day of soil/dust for six years, soil adherence factor (0.2 mg/cm^2) and skin surface area (2,373 cm^2) are used in the calculation (see Appendix C Table C-2).

A combined ingestion-dermal exposure pathway is developed for carcinogens and non-carcinogens applicable to residential land use. The equations used to calculate the soil remediation standards for the ingestion-dermal exposure pathway can be found in N.J.A.C. 7:26D-Appendix 2 and the *Soil Remediation Standards for the Ingestion-Dermal Exposure Pathway Basis and Background* document (NJDEP 2021a).

4.1.2. Nonresidential

The nonresidential ingestion-dermal land use exposure assumptions for carcinogens and non-carcinogens are based on an adult only outdoor worker. The worker is assumed to be a full-time employee whose daily activities will result in an incidental ingestion rate of 100 mg of soil/dust per day as a result of outdoor maintenance work performed 225 days per year for 25 years (USEPA 2014a or Appendix C, Tables C-3 and C-4). The worker is assumed to have only their arms, hands, and face exposed during work hours (3,527 cm^2) and a soil adherence factor of 0.12 mg/cm^2 (see Appendix C Tables C-3 and C-4).

A combined ingestion-dermal exposure pathway is developed for carcinogens and non-carcinogens applicable to nonresidential land use. The equations used to calculate the soil remediation standards for the ingestion-dermal exposure pathway can be found in N.J.A.C.

[5] USEPA Superfund has developed a method to extrapolate oral toxicity values to toxicity factors appropriate for evaluating dermal toxicity. For detailed information on the derivation of the dermal exposure pathway, see the Soil Remediation Standards for the Ingestion-Dermal Exposure Pathway Basis and Background document (NJDEP 2021a) and (USEPA 2004).

7:26D-Appendix 2 and the *Soil Remediation Standards for the Ingestion-Dermal Exposure Pathway Basis and Background* document (NJDEP 2021a).

4.2. Basis of the Default Soil Remediation Standards for the Inhalation Exposure Pathway

For residential and nonresidential exposure to soil, the soil remediation standards for the inhalation exposure pathway assesses exposure to volatile organic compounds and particulates in ambient air. The equations used to calculate the soil remediation standards for the inhalation exposure pathway can be found in N.J.A.C. 7:26D-Appendix 3 and the *Soil Remediation Standards for the Inhalation Exposure Pathway Basis and Background* document (NJDEP 2021b). 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 (see Appendix C Tables C-5 and C-6).

The default soil remediation standards for the inhalation exposure pathway assume the following exposure parameters for residential land use: 24 hours/day, 350 days/year for 26 years (six years as a child and 20 years as an adult). The default soil remediation standards for the inhalation exposure pathway assume the following exposure parameters for nonresidential land use utilizing the outdoor worker: eight hours/day, 225 days/year for 25 years (see Appendix C Table C-5).

Default physical parameters used in the calculation of the soil remediation standards for the inhalation exposure pathway include the assumption of an infinite source[6] for volatile organic contaminants, soil properties based on sandy loam, and New Jersey-specific meteorological conditions. These parameters are: the inverse concentration at the center of the source (Q/C) of 86.6 $(g/m^2\text{-}s)/(kg/m^3)$ for the default residential land use and 85 $(g/m^2\text{-}s)/(kg/m^3)$ for the default nonresidential land use; soil bulk density (ρ_b) (1.5 g/cm^3); air -filled soil porosity (θ_a) (0.18 L_{air}/L_{soil}); water-filled soil porosity (θ_w) (0.23 L_{water}/L_{soil}); total soil porosity (n) (0.41 L_{pore}/L_{soil}); and organic carbon content of soil (f_{oc}) (0.002 g/g). The Q/C value gives an estimate of dispersion based on meteorological conditions. The Q/C value was changed from Superfund's default value based on meteorological modeling for New Jersey [see *Soil Remediation Standards for the Inhalation Exposure Pathway Basis and Background* document (NJDEP 2021b)]. The source area used in developing the Q/C value for the default residential land use is 0.5 acres and the source area used in developing the Q/C value for the default nonresidential land use is two acres [see *Soil Remediation Standards for the Inhalation Exposure Pathway Basis and Background* document (NJDEP 2021b)].

The Department deviates from USEPA Superfund's default value for the fraction of organic content (f_{oc}) of 0.006 g/g, using a value of 0.002 g/g instead. The reason for this is that the Jury model (Jury et al. 1984) calculates contaminant transport for the entire soil column, using a single value for f_{oc}. Using a surface default value of 0.006 g/g 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 Superfund subsurface default value for f_{oc} of 0.002 g/g was used instead of the

[6] Section 1.3.4 of USEPA 1996a.

surface default value of 0.006 g/g (USEPA 1996a). This latter value does not represent typical soil organic carbon values in the subsurface and would reduce the extent of contaminant volatilization.

The soil-to-air volatilization factor 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 the soil-to-air volatilization factor is based on the volatilization model developed by Jury et al. (1984) for infinite sources.

4.3. Determining When to Develop an Alternative Remediation Standard for Soil

Overall, the soil exposures assumed in developing default health-based soil remediation standards represent the RME at residential and nonresidential sites. There may be site-specific conditions (e.g., alternate land use or physical parameters) that could justify modification of some of these exposure factors. Such conditions may be identified in the process of developing and refining the conceptual site model (NJDEP 2019a) and receptor evaluation (N.J.A.C. 7:26E-1.12). This may include current and future land uses that would result in exposures that are different than those assumed in the development of the default soil remediation standards. Examples of these land uses could include, but are not limited to:

- Active recreational land use, such as sports playing fields and playgrounds;
- Passive recreational land use, such as land and trails used for walking, cycling, and hunting;
- Restricted access areas, such as right-of-way areas used for the inspection or in the repair of utilities; and
- Infrequent access areas, such as ecological preservation and conservation areas.

Likewise, there may be site-specific data and information that would justify modification of the physical parameters assumed by the Department in developing the default health-based soil remediation standards for the inhalation exposure pathway. This may include recognition that site-specific volatile soil contamination extends to a specific depth, the vegetative cover over an area is greater than 50%, or that the fraction of organic content (f_{oc}) is greater than 0.002 g/g for the entire contaminant depth as determined by site characterization sampling.

These physical conditions or variations in land use may warrant the development of an ARS for soil for the ingestion-dermal and inhalation exposure pathways. Under certain circumstances, the development of an ARS for soil may require the establishment of institutional controls (e.g., deed notice) to ensure that the assumptions used in the development of the ARS are maintained into the future. Any ARS for soil developed for alternative land use will also require prior approval before use in support of site-specific or AOC-specific remedial decisions (N.J.A.C. 7:26D Appendices 6 and 7). Finally, some of the fundamental assumptions embedded in the derivation of the soil remediation standards are used in combination with methodologies presented in the most current version of *Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria* (https://www.nj.gov/dep/srp/guidance/#attainment_comp). Any evaluation of soil concentrations [e.g., calculation of average concentrations over the exposure unit ("functional area")] relative to an ARS for soil should be consistent with the

underlying assumptions for the derivation of the soil remediation standards and as described in the attainment guidance.

When developing an ARS for soil, both the ingestion-dermal and inhalation exposure pathways must be considered. An ARS for soil which increases a value for one exposure pathway may result in the other exposure pathway driving the remedial decision making. For example, the default residential soil remediation standard for benzene is controlled by the inhalation exposure pathway and is 2.2 mg/kg; however, the health-based default residential soil remediation standard for the ingestion-dermal exposure pathway is 3.0 mg/kg. If, for example, an investigator proposed an ARS for soil for the inhalation exposure pathway by changing the depth of contamination in the soil from an infinite depth to a site-specific depth range of six inches (15 cm) to 10 feet (305 cm) below ground surface, it would result in an ARS for soil for the inhalation exposure pathway of 8.8 mg/kg. Since the 8.8 mg/kg value for the inhalation exposure pathway is greater than the 3.0 mg/kg value derived for the ingestion-dermal exposure pathway, the soil cleanup level for the site or AOC for benzene would default to the soil remediation standard for the ingestion-dermal exposure pathway of 3.0 mg/kg.

The ARS for soil process must also consider the migration to ground water exposure pathway addressed in the *Alternative Remediation Standards Technical Guidance for Soil and Soil Leachate for the Migration to Ground Water Exposure Pathway* (NJDEP 2021c). In addition to the ARS for soil process, ecological remediation goals must be considered for environmentally sensitive natural resources in accordance with N.J.A.C. 7:26E-1.16 and -4.8 and as addressed in the *Ecological Evaluation Technical Guidance* (NJDEP 2018). The Department's default soil remediation standards and this ARS guidance document also do not address the vapor intrusion exposure pathway. As a result, the Department's latest *Vapor Intrusion Technical (VIT) Guidance* document (NJDEP, 2021d) should be consulted regarding the potential for vapor intrusion related impacts from contaminated soil. If an ARS for soil for the ingestion-dermal exposure pathway is developed and approved by the Department for Category 1 or Category 2 Extractable Petroleum Hydrocarbons (EPH), consult the Department's *Evaluation of Extractable Petroleum Hydrocarbons in Soil Technical Guidance* (NJDEP, 2019b) for EPH specific guidance.

This document provides technical guidance on how to develop an ARS pursuant to N.J.A.C. 7:26D-8.4 and N.J.A.C. 7:26D-8.5 for contaminated sites in New Jersey. Although the investigator should understand the purpose and intent of this guidance, investigators developing the ARS for soil should be experienced in the use of techniques and methodologies of risk assessment (USEPA 1989), and should be able to interpret and apply appropriate guidance that includes, but is not limited to, USEPA's *Risk Assessment Guidance for Superfund Part E* (USEPA 2004), *Part F* (USEPA 2009) and other appropriate sources.[7] If the LSRP does not possess the necessary expertise, consulting with a qualified investigator is appropriate, pursuant to N.J.S.A. 58:10C-16.

[7] https://www.epa.gov/risk/superfund-risk-assessment-human-health-topics

5. DEVELOPMENT OF ALTERNATIVE REMEDIATION STANDARDS FOR SOIL

5.1. Introduction

The *Brownfield and Contaminated Site Remediation Act* (N.J.S.A. 58:10B-1 et seq.) requires the Department to consider site-specific factors when developing an ARS for soil. This document will address ARS for soil options for the ingestion-dermal and inhalation exposure pathways. Site-specific factors may vary from those used by the Department in the development of the default soil remediation standards pursuant to N.J.A.C. 7:26D. Procedures for the development of an ARS for soil for alternative land use and lead require prior approval by the Department, other ARS options for soil do not.

The Department has developed spreadsheet calculators and made them available to investigators on the Department's Site Remediation and Waste Management Program (SRWMP) Remediation Standards website.[8] These calculators allow the investigator to input site-specific parameters in order to calculate an appropriate ARS for soil. The Department will also review other proposed approaches incorporating different models used by USEPA for lead, varying assumptions, and other relevant information on a case-by-case basis. If the Department approves their use, these approaches may then be used to develop an acceptable ARS for soil; however, the Department reserves the right to determine the acceptability of these proposals. The investigator may contact the Department to determine if a technical consultation would be advisable to determine the acceptability of their proposal prior to developing an ARS for soil.

> Contact information for technical consultations can be found at http://www.state.nj.us/dep/srp/srra/technical_consultation/.

The Department will continue to evaluate other factors for potential use in the ARS process. An acceptable ARS for soil may require the use of institutional controls, engineering controls and remediation permits. The ARS for soil will be used in the compliance process in lieu of a default soil remediation standard.

The procedures to update soil remediation standards based on new toxicity data or to develop interim soil remediation standards based on available toxicity information are not addressed in this guidance. These procedures are outlined in N.J.A.C. 7:26D-6 and 7. Pursuant to N.J.A.C.7:26D-6, the person responsible for conducting the remediation of a site may request the Department develop an interim soil remediation standard when a contaminant of concern (COC) is not listed in the Remediation Standards Appendix 1, Tables 1, 2, 3 or 4. The Department may establish an interim soil remediation standard provided applicable toxicity information is available for the contaminant. The investigator may contact the Department for a technical consultation to determine if an interim soil remediation standard request is appropriate at a site or for an AOC. The form requesting development of an interim soil remediation standard may be found on the Department's website[9]. The Department must approve an interim soil remediation

[8] http://www.nj.gov/dep/srp/guidance/rs/index.html
[9] http://www.nj.gov/dep/srp/srra/forms/

standard prior to its use (N.J.A.C.7:26D-6). The Department will periodically update soil remediation standards as outlined in N.J.A.C. 7:26D-7.

The health-based soil remediation standards for the ingestion-dermal and inhalation exposure pathways are developed using USEPA recommended default exposure parameters for residential and nonresidential land use scenarios. These default exposure parameters reflect an RME that may not be adjusted for these two land uses. The default parameters for the residential and nonresidential land use for these pathways include averaging time, exposure frequency, exposure duration, exposure time, soil ingestion rate and soil adherence factor. The Department has determined that these variables represent reasonably conservative default values and are designed to be consistent with Superfund's concept of the RME protective of the majority of the population. A modification of one or more of these default parameters may be argued as being site-specific at a particular time (e.g., four-day work week); however, the Department cannot ensure that property conditions will remain the same. Therefore, the Department will continue to protect for the RME resident or worker exposure on the site.

The parameters included in the development of the soil remediation standards are shown in Table 1, with those parameters that may be adjusted in the ARS process noted.

Table 1: Parameters and Assumptions Used for Deriving Soil Remediation Standards

Ingestion	Dermal Contact	Inhalation of Particulates	Inhalation of Volatiles
Factors Which Can Be Changed Via ARS Process			
Exposure Factors • Exposure Frequency (days/year) • Exposure Duration (years)	**Exposure Factors** • Exposure Frequency (days/year) • Exposure Duration (years)	**Exposure Factors** • Exposure Time (hours/day) • Exposure Frequency (days/year) • Exposure Duration (years) **Fate and Transport Modeling** • Vegetative Cover Fraction (unitless)	**Exposure Factors** • Exposure Time (hours/day) • Exposure Frequency (days/year) • Exposure Duration (years) **Fate and Transport Modeling** • Depth of Contamination (cm) • Fraction of Organic Carbon (unitless)
Factors Which Cannot Be Changed Via ARS Process			
Exposure Factors ♦ Soil Ingestion Rate (mg/day) ♦ Body Weight (kg)	**Exposure Factors** ♦ Skin Surface Area (cm^2/day) ♦ Adherence Factor (mg/cm^2) ♦ Body Weight (kg) **Chemical-Specific Physical Parameters** ♦ Dermal Absorption Fraction (unitless)	**Fate and Transport Modeling** ♦ Dispersion Factor, Q/C $(g/m^2\text{-}s)/(kg/m^3)$ ♦ Source Area Size (m^2) ♦ Averaging Time ♦ Mean Annual Wind Speed (m/s) ♦ Anemometer Height (unitless)	**Fate and Transport Modeling** ♦ Dispersion Factor, Q/C $(g/m^2\text{-}s)/(kg/m^3)$ ♦ Source Area Size (m^2) ♦ Averaging Time ♦ Air-filled Soil Porosity (L/L) ♦ Water-filled Soil Porosity (L/L) ♦ Total Porosity (L/L) ♦ Soil Bulk Density (g/cm^3) ♦ Exposure Interval (sec) **Chemical-Specific Physical Parameters** ♦ Soil Organic Carbon-water Partition Coefficient (cm^3/g) ♦ Diffusivity in Air (cm^2/sec) ♦ Diffusivity in Water (cm^2/sec) ♦ Henry's Law Constant (unitless)
Factors Which Cannot Be Changed Via ARS Process, But May Be Updated In Accordance With N.J.A.C. 7:26D-7			
Chemical-Specific Toxicity ❖ Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$ ❖ Non-cancer Reference Dose (mg/kg-day)	**Chemical-Specific Toxicity** ❖ Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$ ❖ Non-cancer Reference Dose (mg/kg-day)	**Chemical-Specific Toxicity** ❖ Cancer Inhalation Unit Risk $(\mu g/m^3)^{-1}$ ❖ Non-cancer Reference Concentration ($\mu g/m^3$)	**Chemical-Specific Toxicity** ❖ Cancer Inhalation Unit Risk $(\mu g/m^3)^{-1}$ ❖ Non-cancer Reference Concentration ($\mu g/m^3$)

5.2. Alternative Remediation Standard for Soil Requests Requiring Prior Approval by the Department

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. All ARS for soil options are applicable to both the carcinogenic and non-carcinogenic health endpoints. All relevant exposure pathways and scenarios must be evaluated. The lower of the derived ARS for either the carcinogenic or non-carcinogenic health endpoint for the most protective exposure pathway will be the final ARS for soil, taking into account background levels and reporting limits, as appropriate. The ARS for soil options for lead are applicable to residential, nonresidential, and alternative land use scenarios. All ARS for soil options for the ingestion-dermal exposure pathway require prior approval by the Department. All ARS for soil options for the inhalation exposure pathway involving alternative land use require prior approval by the Department; however, the options utilizing site-specific physical parameters do not require prior approval by the Department.

5.2.1. Alternative Land Use Scenarios

These scenarios consist of land use that cannot be defined as either residential or nonresidential in accordance with N.J.A.C. 7:26D-1.5 (e.g., park lands, conservation areas, utility right of ways, etc.). Such an alternative land use may be used to justify development of an ARS for soil for both the ingestion-dermal exposure pathway and the inhalation exposure pathway. An ARS for soil may be based on a site-specific land use that changes the extent of exposure to which people are likely subject to at a site. The extent of exposure to soil at sites with these alternative types of land uses would be expected to be different than the default exposure assumptions identified in N.J.A.C. 7:26D.

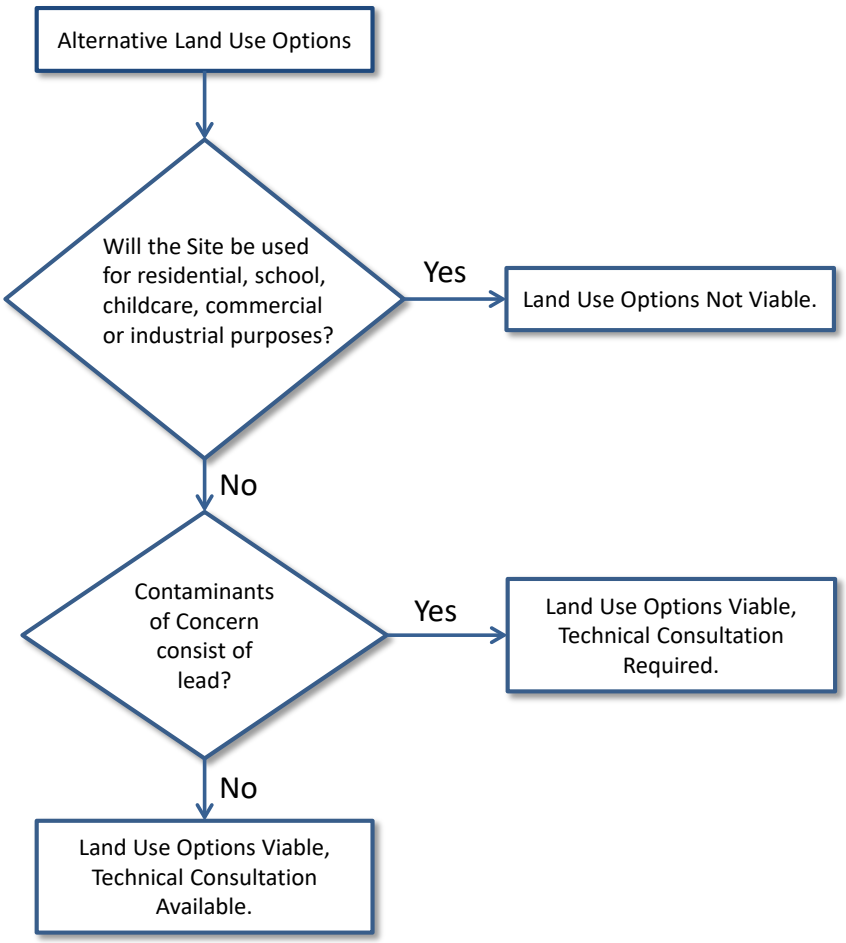
Once the alternative land use has been determined and appropriate exposure parameters, representative of RME are selected, the information should be input into the Department's calculators and all necessary information submitted to the Department for approval prior to using the ARS for soil for remedial decision-making at a site or AOC. In accordance with N.J.A.C 7:26D, site- or AOC-specific exposure frequency (days per year) and exposure duration (years) may be used in the calculation of an ARS for soil for the ingestion-dermal exposure pathway, and site- or AOC-specific exposure frequency (days per year), exposure time (hours per day) and exposure duration (years) may be used in the calculation of an ARS for soil for the inhalation exposure pathway. The Department shall require the use of institutional controls, engineering controls and soil remedial action permits, as appropriate, pursuant to N.J.A.C. 7:26D-8, Appendices 6 and 7 for an ARS for soil based on a site-specific alternative land use to ensure that the exposure assumptions used in developing the ARS remain valid into the future.

When developing an ARS for soil for the ingestion-dermal and inhalation exposure pathways, based on site-specific land use, the following general steps should be followed:

1. Determine the current and future land use of the site and the appropriate receptor-specific exposure frequency, exposure time and exposure duration associated with the land use in accordance with this guidance; and
2. Use the exposure frequency, exposure time (as appropriate) and exposure duration in the Department's calculators located on the Department's SRWMP Remediation Standards

website[10] to calculate an ARS for soil (see Figure 1). The calculator will identify the most sensitive endpoint (cancer or non-cancer) for both exposure pathways and receptor (child or adult) for the ingestion-dermal exposure pathway only to generate the ARS for soil numerical value.

Figure 1: Alternative Land Use Scenarios



The following are several categories of alternative land uses provided as examples of the types of exposure assumptions that may be considered in development of an ARS for soil. Guidance for acceptable exposure parameters associated with each type of land use and examples are provided for each category. Table 2 also presents the ARS for soil numerical results for the six (6) alternative land use examples that are discussed in Sections 5.2.1.1 through 5.2.1.4. These are not to be considered exhaustive, nor should they be considered default scenarios or assumptions. All ARS for soil requests are to be developed on a site-specific or AOC-specific basis, using

[10] http://www.nj.gov/dep/srp/guidance/rs/index.html

exposure assumptions that can be justified with supporting information as illustrated in the examples below.

5.2.1.1. Active Recreational Land Use

This type of land use consists of sports playing fields, playgrounds, and motorcycle and all-terrain vehicle (ATV) use areas. Individuals using these areas could be actively engaging in sports or using playground equipment (e.g., slides, jungle gyms). During these activities, individuals would be expected to be in direct contact with surface soil. Disturbance of the surface soil would be expected given the nature of the activities.

These types of activities are typically limited to certain times of the year, time of day or particular sports seasons. The length of time spent in these areas will vary depending on the activity. For a given area, all potential activities that could take place should be considered when developing an ARS for soil. Exposure to surface soil for this type of land use would be expected to be greater than for other alternative land uses because the individual will be in direct contact with soil in a limited area. Motorcycle, mountain biking, and ATV land use areas will have unique exposure scenarios (e.g., vehicular traffic added to inhalation exposure pathway); these will be evaluated on a site or AOC-specific basis. Prior to development of an ARS for soil, technical consultation with the Department is advised for the exposure assumptions that could involve motorcycle/ATV recreational use.

> Contact information for technical consultations can be found at http://www.state.nj.us/dep/srp/srra/technical_consultation/.

The site-specific land use that is the basis of the ARS for soil must be monitored in the soil remedial action permit to ensure that the area continues to be utilized for its stated purpose and the use conditions do not change. In the event that the land use changes, the ARS for soil may no longer be valid and development and use of a new ARS for soil or the default soil remediation standard may be appropriate in order to determine if remedial action should be performed. The soil remedial action permit will also need to be modified as appropriate.

When considering what the RME will be for this type of land use, the following potential exposure assumptions should be considered:

- What are the expected age groups of the receptors that will be engaged in recreational activities in the area?
- How much time will each age group spend in the recreational area?
- Will parents/care givers bring other children to the recreational area? If so, how often?
- Will coaches, referees, etc. be present at the recreational area? If so, for what length of time?
- Are there spectators in addition to participants at the recreational area?
- Are there maintenance workers responsible for the recreational area (e.g., grooming field, trash removal)? If so, how many days and hours per week would they be expected to perform such maintenance activities? For the site-specific exposure, will the

maintenance worker be the more sensitive receptor (i.e., be subject to more exposure) than other expected receptors using the site/area?

Two examples of active recreational scenarios are provided below.

Example 1: Sports Playing Field

An example RME for this land use is represented by a young child (age zero to six years) who starts out watching their older sibling play soccer (games, practices) for 65 days per year (half of the player exposure frequency). At the age of six, this individual then is assumed to become a soccer player who participates in spring and fall leagues on the same field. During this period, they participate from age six to 18 years, for 130 days per year including practice (USEPA 2014b) for 12 years.

If an individual is expected to use this field more or less than two seasons per year, then 130 days may not be appropriate, and the exposure frequency should be adjusted based on site-specific or AOC-specific use and exposure factors. For this example, the child spectator and youth soccer player receptors were used to develop the ARS for soil, versus the adult spectator or adult soccer player, because they were determined to be the most sensitive receptors for this alternative land use exposure scenario.

Sports Playing Field

Child Spectator

- Exposure Frequency: 65 days/year
- Exposure Time: 2 hours/day for inhalation exposure pathway
- Exposure Duration: 6 years

Youth Soccer Player

- Exposure Frequency: 130 days/year
- Exposure Time: 2 hours/day for inhalation exposure pathway
- Exposure Duration: 12 years

Use the above exposure parameters along with the default parameters in the Department's calculators (http://www.nj.gov/dep/srp/guidance/rs/index.html)

Example 2: Playground

Another example RME for this land use is represented by a child using a playground in a park adjacent to or near their house. For preschool age (zero to six years), it is assumed the child visits the playground five days per week for two hours, when the average ambient high

temperature is above 50º F (200 days based on nine months i.e., 40 weeks x five days/week) based on information from the Office of the New Jersey State Climatologist. Starting at school age, the frequency of visiting the playground decreases and eventually the youth only meets with friends in the park a few days per week for two hours, when the average ambient high temperature is above 50º F (e.g., 120 days based on nine months, i.e., 40 weeks x three days/week).

If an individual is not expected to use this playground five days per week because the playground is remote (not in the vicinity of a residential area, school or child care facility), then it may be reasonable to adjust the exposure frequency downward. For this example, the child and youth receptors were used to develop the ARS for soil, versus the adult, because they were determined to be the most sensitive receptors for this alternative land use exposure scenario.

Playground

Child

- Exposure Frequency: 200 days/year
- Exposure Time: 2 hours/day for inhalation exposure pathway
- Exposure Duration: 6 years

Youth

- Exposure Frequency: 120 days/year
- Exposure Time: 2 hours/day for inhalation exposure pathway
- Exposure Duration: 12 years

Use the above exposure parameters along with the default parameters in the Department's calculators (http://www.nj.gov/dep/srp/guidance/rs/index.html)

Important Consideration:

A playground or sports field may have a worker who maintains these areas (e.g., grooming field, trash removal). The exposure of the maintenance worker to soil also needs to be quantified on a site-specific basis (days per year and hours per day), as determined using site-specific information provided by the entity owning/maintaining the recreational facility. In such cases, assume the worker exposure duration is 25 years, and assume outdoor worker default dermal parameters. If the maintenance worker is the more sensitive receptor based on exposure frequency and associated activities, then the ARS for soil should be based on the maintenance worker rather than on the recreator.

Useful Sources:

Exposure Factors Handbook (USEPA 2011 – with updates to individual chapters) that includes child-specific exposure factors: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

Child-Specific Exposure Scenarios Examples (EPA 600/R-14/217F) (Final Report). (USEPA 2014b): http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100LOGR.txt

Guidelines for Human Exposure Assessment (EPA/100/B-19/001) (October 2019): https://www.epa.gov/sites/production/files/2020-01/documents/guidelines_for_human_exposure_assessment_final2019.pdf

ExpoBox https://www.epa.gov/expobox

NOAA National Center for Environmental Information: http://www.ncdc.noaa.gov/

Office of the New Jersey State Climatologist: http://climate.rutgers.edu/stateclim/

Contact Local Recreation or other Officials as Appropriate

5.2.1.2. Passive Recreational Land Use

This type of land use consists of land and trails used for walking, cycling, and hunting. This land is largely undeveloped land or environmentally sensitive area with trails used for non-motorized activity. Individuals utilizing these areas would be passing through the area without spending concentrated time in one specific place, minimal facilities and services are provided. Due to limited disturbance of the soil during these activities, individuals would be expected to have minimal direct soil contact.

These types of activities can occur throughout the year and all potential activities (e.g., walking, hiking, biking, jogging) should be considered to determine the appropriate RME. Depending on location, topography, and activity, some areas may be more likely to have children accompanying an adult (as described in the two (2) examples below).

The site-specific land use that is the basis of the ARS for soil must be monitored in the soil remedial action permit to ensure that the area is still being utilized for its original purpose and that the land use conditions do not change. In the event that land use changes, the ARS for soil may no longer be valid, and development and use of a new ARS for soil may be appropriate or use of the default soil remediation standard may be applicable; the soil remedial action permit will also need to be modified as appropriate.

When considering what the RME will be for this type of land use, the following potential exposure assumptions should be considered:

- What are the expected age groups of the receptors who will be using the recreational area?
- How much time will each age group spend at the recreational area?
- Will parents/care givers bring other children to the recreational area? If so, how often?
- Are there maintenance workers responsible for the recreational area (e.g., grooming area, trash removal)? If so, how many days and hours per week? For the site-specific

exposure, will the maintenance worker be the more sensitive receptor than others using the site/area?

Two examples of passive recreational scenarios are provided below.

Example 1: Jogger

An example RME for this land use is represented by an individual adult who jogs on trails through a park. This individual is assumed to jog 200 days per year (based on 50 weeks at four times per week) for one hour over a 26-year period (based on the 90th percentile for residence time). For this example, the 26-year period does not include exposure to a child 6 years and younger because a young child would not be expected to be jogging on the trails.

If an individual representing an RME is expected to use this park more or less than four days per week for 26 years, then the exposure frequency may be adjusted if proper rationale can be provided, supported and approved.

Jogger

Adult

- Exposure Frequency: 200 days/year
- Exposure Time: 1 hour/day for inhalation exposure pathway
- Exposure Duration: 26 years

Use the above exposure parameters along with the default parameters in the Department's calculators (http://www.nj.gov/dep/srp/guidance/rs/index.html)

Example 2: Hiker/Biker

An example RME for this land use is represented by an individual adult who hikes or bikes (i.e., leisure, not mountain biking, which kicks up more soil and would present a greater exposure) on trails through a park, sometimes accompanied by a child (six years and younger). They visit the area two days per week for two hours at a time. The individual is assumed to hike or bike 100 days per year (based on 50 weeks at two times per week) for one hour over 26 years based on the 90th percentile for residence time.

If an individual is expected to use this park more or less than two days per week, then the exposure frequency may be adjusted as appropriate. For example, if the park is in the vicinity of a residential area, school or child care facility, it would be appropriate to consider more frequent use.

Hiker/Biker

Child

- Exposure Frequency: 50 days/year
- Exposure Time: 2 hours/day for inhalation exposure pathway
- Exposure Duration: 6 years

Adult

- Exposure Frequency: 100 days/year
- Exposure Time: 2 hours/day for inhalation exposure pathway
- Exposure Duration: 20 years

Use the above exposure parameters along with the default parameters in the Department's calculators (http://www.nj.gov/dep/srp/guidance/rs/index.html)

Important Consideration:

A trail may have a worker who maintains these areas (e.g., clearing brush, trash removal). The exposure of the maintenance worker to soil also needs to be quantified on a site-specific basis (days per year and hours per day) determined by the entity owning/maintaining the recreational facility. In such cases, assume the worker exposure duration is 25 years, and assume outdoor worker default dermal parameters. If the maintenance worker is the more sensitive receptor based on exposure frequency and activities, then the ARS for soil should be based on the maintenance worker rather than the recreator.

Useful Sources:

Exposure Factors Handbook (USEPA 2011 – with updates to individual chapters): http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

Child-Specific Exposure Scenarios Examples (EPA 600/R-14/217F) (Final Report). (USEPA 2014b): http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100LOGR.txt

Guidelines for Human Exposure Assessment (EPA/100/B-19/001) (October 2019): https://www.epa.gov/sites/production/files/2020-01/documents/guidelines_for_human_exposure_assessment_final2019.pdf

Contact Local Recreation or other Officials as Appropriate

5.2.1.3. Restricted Access Areas

This type of land use consists of right-of-way areas used for the inspection and repair of utilities. Individuals accessing such areas (right-of-way areas for utilities, transportation corridors or other similar uses) may be engaged in activities associated with the inspection and maintenance of these areas, working to assure that the land is clear and accessible, or perhaps installing and repairing the utilities in cases where damage has occurred, or upgrades are performed.

During such activities, individuals could be expected to have minimal direct contact with surface and subsurface soil; however, there may be situations with activities that could result in increased direct contact with surface and subsurface soil (e.g., clearance, repair of utilities, earthmoving, etc.). These types of activities are likely to be performed by small groups of workers throughout the year. All potential activities (e.g., inspection, maintenance and repair) should be considered in determining the appropriate RME.

The site-specific land use that is the basis of the ARS for soil must be monitored in the soil remedial action permit to ensure that the area continues to be utilized for its stated purpose and the use conditions do not change. In the event that the land use changes, the ARS for soil may no longer be valid and development and use of a new ARS for soil or the default soil remediation standard may be appropriate in order to determine if remedial action should be performed. The soil remedial action permit will also need to be modified as appropriate.

When considering what the RME will be for this type of land use, the following should be considered:

- How much time will a worker spend within the restricted access area? How many days and hours per week?
- Is the area owned/maintained by a single entity such that a worker would be expected to only come into contact with the area while working for that particular entity?
- Are there other receptors that will be in the area?
- Will other individuals be able to gain access to the restricted access area?

An example of a restricted access land use scenario is provided below.

Example: Utility Line Worker

In this hypothetical example, workers employed by The XYZ Company of New Jersey (XYZ) will be engaged in activities which involve the maintenance and repair of a utility line located in a right-of-way area owned by XYZ. The types of maintenance activities (i.e., inspection of utility line, as needed repairs/maintenance) in which these workers will be involved will be of limited size and duration. Since the area is owned by XYZ the workers are only expected to have the opportunity to be exposed to soil while employed by XYZ at this facility.

For this example, an exposure frequency of 30 days/year is assumed. This is based on the amount of time workers are expected to spend performing maintenance activities that could involve soil excavation (10 days/year) and performing other maintenance activities that do not involve soil excavation (20 days/year).

It is assumed that workers may be engaged in these activities on behalf of their employer for a duration of 10 years. A 10-year exposure duration can be supported by the analysis of Burmaster (2000), using data from the Bureau of Labor Statistics through February 1996, which indicated that the 95th and 90th percentile job tenure of workers in construction is approximately 12.48 years and 7.7 years, respectively. This analysis is also consistent with data from the Bureau of Labor Statistics from 2008 through 2018 which indicates that the median job tenure of workers in construction is approximately four (4) years. Overall, an exposure duration of 10 years is consistent with an RME for an individual working at a specific facility.

During these activities the potential routes of soil exposure would include incidental ingestion, dermal contact, and inhalation of soil vapor and airborne particulates. The "outdoor worker" soil ingestion rate of 100 mg/day from the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002) and OSWER Directive 9200.1-120 *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors* (USEPA 2014a) is consistent with an RME. The soil ingestion rate of 100 mg/day, used by USEPA reflects "the increased ingestion exposures experienced by workers during landscaping or other soil disturbing activities". For dermal contact with soil, a skin surface area of 3,527 cm^2 and soil adherence factor of 0.12 mg/cm^2 is assumed (USEPA 2014a). The skin surface area and soil adherence factor are the USEPA-recommended standard default assumptions for evaluating high-end contact with soil by workers in industrial settings (USEPA 2014a).

For inhalation exposures, these workers are assumed to have a default exposure time of eight (8) hours/day.

Utility Worker

Adult

- Exposure Frequency: 30 days/year
- Exposure Time: 8 hours/day for inhalation exposure pathway
- Exposure Duration: 10 years

Use the above exposure parameters along with the default parameters in the Department's calculators (http://www.nj.gov/dep/srp/guidance/rs/index.html)

Useful Sources:

Exposure Factors Handbook (USEPA 2011 – with updates to individual chapters): https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. (USEPA 2014a) OSWER Directive 9200.1-120. https://www.epa.gov/sites/production/files/2015-11/documents/oswer_directive_9200.1-120_exposurefactors_corrected2.pdf

Utility Companies and Municipal Authorities – Contact Utility Company Public Relations or Local Officials as Appropriate

Distributions of total job tenure for men and women in selected industries and occupations in the United States. (Burmaster 2000)

Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002)
https://archive.epa.gov/region9/superfund/web/pdf/ssg_nonrad_supplemental.pdf

US Bureau of Labor Statistics, Economic News Release, Median Years of Tenure by Industry (2008-2018), https://www.bls.gov/news.release/tenure.t05.htm

5.2.1.4. Infrequent Access Areas

This type of land use consists of ecological preservation and conservation areas. Individuals utilizing these areas would be observing nature or hunting, if it is permitted. During these activities, individuals would be expected to walk into the area, then remain in one area for a long period, perhaps relocating once or twice during the day. No major disturbance of the soil would be expected given the land's preservation or conservation status; however, individuals may clear a small area, exposing or moving the surface soil in order to create a space where they can sit or stand.

These types of activities are typically limited to certain times of the year, time of day or aligned with the migration pattern of the species of interest. The length of time spent in the area may vary greatly depending on the activity. All activities that may take place in a given area must be considered in development of an ARS for soil.

The site-specific land use that is the basis of the ARS for soil must be monitored in the soil remedial action permit to ensure that the area continues to be utilized for its stated purpose and the use conditions do not change. In the event that the land use changes, the ARS for soil may no longer be valid and development and use of a new ARS for soil or the default soil remediation standard may be appropriate in order to determine if remedial action should be performed. The soil remedial action permit will also need to be modified as appropriate.

When considering what the RME will be for this type of land use, the following potential exposure assumptions should be considered:

- What are the expected age groups of the receptors who will be using the ecological preservation and conservation areas?
- How much time will each age group spend at the ecological preservation and conservation areas?
- Will parents/care givers bring children to the ecological preservation and conservation areas? If so, how often?
- Are the ecological preservation and conservation areas remotely located or are they associated with residential areas, which carries the potential for more frequent use?
- Is hunting permitted? Would hunters access the areas for multiple seasons (e.g., small game, archery, rifle, spring and fall turkey)?
- Are there maintenance workers at the ecological preservation and conservation areas (e.g., repairing fences, maintaining trails)? How many days and hours per week do they

engage in these activities? For the site-specific exposure, will the maintenance worker be the more sensitive receptor compared to others using the area?

Birding Example:

The example RME for this land use is represented by an individual adult birding or otherwise observing nature in a remote ecological preservation area with no trails, no hunting permitted and with birders/naturalists expected to use the area. The birder travels from their home to the remote preserve an average of 13 days per year (USFWS 2013), eight hours per event (New Jersey Audubon Society), for 26 years based on 90th percentile for residence time. When reviewing statistics on birding, the average number of days per year dramatically increases to 90 days per year (USFWS 2013) when travel is not required because the area is in the vicinity of a residence, school or child care facility (e.g., daycare).

The land use must be monitored in the soil remedial action permit to ensure that the area is still being utilized for its original purpose and the use conditions (e.g., increased use due to development of adjacent land) do not change.

Birding/Observing Nature in a Remote Ecological Preserve

Adult

- Exposure Frequency: 13 days/year
- Exposure Time: 8 hours/day for inhalation exposure pathway
- Exposure Duration: 26 years

Use the above exposure parameters along with the default parameters in the Department's calculators (http://www.nj.gov/dep/srp/guidance/rs/index.html)

Important Consideration:

The ecological preservation or conservation area may have a worker who maintains these areas (e.g., check on vegetation, repair fencing, maintaining trails). The exposure of the maintenance worker to soil also needs to be quantified on a site-specific basis (days per year and hours per day) determined using information provided by the entity owning/maintaining the ecological preservation or conservation area. In such cases, assume the worker exposure duration is 25 years, using outdoor worker default dermal parameters. If the maintenance worker is the more sensitive receptor based on exposure frequency and activities, then the ARS for soil should be based on the maintenance worker rather than the recreator.

Useful Sources:

Exposure Factors Handbook (USEPA 2011 – with updates to individual chapters): https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

Birding in the United States: A Demographic and Economic Analysis (USFWS 2013): https://www.fws.gov/southeast/pdf/report/birding-in-the-united-states-a-demographic-and-economic-analysis.pdf

2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (USFWS 2018): https://wsfrprograms.fws.gov/subpages/nationalsurvey/nat_survey2016.pdf

New Jersey Audubon Society: http://www.njaudubon.org/

New Jersey Fish and Wildlife Service: http://www.njfishandwildlife.com/

Cornell Lab of Ornithology and National Audubon Society eBird: http://ebird.org/content/ebird/

5.2.1.5. Summary of Alternative Remediation Standard for Soil Example Results Based on Alternative Land Use

This section presents a table of ARS for soil numerical results for the six (6) alternative land use examples discussed in Sections 5.2.1.1 through 5.2.1.4. A comparison to the default residential and nonresidential soil remediation standards for the ingestion-dermal and inhalation exposure pathways is also provided. These examples demonstrate how different activities associated with alternative land use can affect the remediation goals for several contaminants listed in Table 2. They should not be considered the only possible scenarios that may be relevant under a given alternative land use. They also should not be considered default ARS for soil values. All ARS for soil submissions should be based on site or AOC-specific information, which may differ from those presented in the previous examples. Table 2 shows the values derived using the Department's calculators for each example scenario.

Table 2 shows the calculated ARS for soil values for the ingestion-dermal and inhalation exposure pathways, and the most restrictive value for the two pathways incorporating the reporting limit (RL) and State background level where applicable. The individual contaminants presented represent both ingestion-dermal and inhalation exposure pathway driven chemicals with cancer and non-cancer endpoints. While the health-based values may be derived for all contaminants, the final standard or ARS for soil may be based on the RL or State background as appropriate. For example, as shown in Table 2, the soil remediation standard for arsenic defaults to the State background of 19 mg/kg, which is greater than the ARS for soil values for four of the six examples, making an ARS unnecessary for those scenarios.

Even though an exposure pathway may be the driver for the default soil remediation standard for a given contaminant, a different exposure pathway may be the driver for a specific ARS for soil, particularly where toxicity values are similar for both exposure pathways. For example, the benzene residential soil remediation standard for the inhalation exposure pathway is 2.2 mg/kg and the residential soil remediation standard for the ingestion-dermal exposure pathway is 3.0 mg/kg. As demonstrated in Table 2, the ARS for soil values are driven by the ingestion-dermal pathway for four of the six examples, while the inhalation exposure pathway is the driver for only two of the examples.

Table 2 does not include exposure assumptions for a site or AOC-specific maintenance worker; however, exposure to this maintenance worker must be quantified, using information provided by the owner of the facility in question and compared to the values developed for the other receptors for the ARS for soil. The site or AOC-specific maintenance worker is not expected to have the same exposure assumptions as the default outdoor worker used in development of the nonresidential soil remediation standards. There may be circumstances where the maintenance worker is the more sensitive receptor (e.g., a large sports complex where a maintenance worker is engaged in activities at the complex several days per week). In this case, the ARS for soil may be based on the site or AOC-specific maintenance worker.

The example scenarios presented above and in Table 2, only address alternative land use scenarios, and do not consider the additional options based on physical parameters that may be used for the inhalation exposure pathway as presented in Sections 5.3.1 through 5.3.3, below. These additional options may be used separately or in conjunction with the alternative land use scenarios, which would change the numeric values derived for the inhalation exposure pathway in Table 2.

Table 2 - Summary of Example Alternative Remediation Standards for Soil Based on Site-Specific Exposure Variables

Chemical	CAS	Default Values				Active Recreation				Passive Recreation				Restricted Access Area		Infrequent Access Area	
		Residential	Footnote	Nonresidential	Footnote	Sports Playing Field	Footnote	Playground	Footnote	Jogger	Footnote	Hiker-Biker	Footnote	Utility Worker	Footnote	Birder	Footnote
Soil Remediation Standards for the Ingestion-Dermal Exposure Pathway (mg/kg)																	
Arsenic	7440-38-2	19	Bkg[11]	19	Bkg[11]	19	Bkg[11]	19	Bkg[11]	19	Bkg[11]	19	Bkg[11]	40	ING-C	36	ING-C
Benzene	71-43-2	3.0	ING-C	16	ING-C	16	ING-C	6.2	ING-C	17	ING-C	17	ING-C	300	ING-C	260	ING-C
Benzo(a)pyrene[12]	50-32-8	0.51	ING-C	2.3	ING-C	2.6	ING-C	1.1	ING-C	2.5	ING-C	2.8	ING-C	44	ING-C	39	ING-C
Cadmium	7440-43-9	71	ING-N	1,100	ING-N	380	ING-N	130	ING-N	1,200	ING-N	500	ING-N	8,300	ING-N	19,000	ING-N
4,4'-DDT	50-29-3	1.9	ING-C	9.5	ING-C	9.7	ING-C	3.9	ING-C	10	ING-C	11	ING-C	180	ING-C	160	ING-C
Manganese	7439-96-5	1,900	ING-N	31,000	ING-N	10,000	ING-N	3,300	ING-N	35,000	ING-N	13,000	ING-N	230,000	ING-N	540,000	ING-N
Mercury	7439-97-6	23	ING-N	390	ING-N	130	ING-N	41	ING-N	440	ING-N	160	ING-N	2,900	ING-N	6,700	ING-N
Naphthalene	91-20-3	2,500	ING-N	34,000	ING-N	13,000	ING-N	4,300	ING-N	39,000	ING-N	17,000	ING-N	260,000	ING-N	590,000	ING-N
Vinyl Chloride	75-01-4	0.97	ING-C	5.0	ING-C	5.0	ING-C	2.0	ING-C	5.5	ING-C	5.5	ING-C	95	ING-C	84	ING-C
Xylenes	1330-20-7	12,000	ING-N	190,000	ING-N	63,000	ING-N	21,000	ING-N	220,000	ING-N	82,000	ING-N	NA	a	NA	a
Soil Remediation Standards for the Inhalation Exposure Pathway (mg/kg)																	
Arsenic	7440-38-2	1,100	INH-C	5,200	INH-C	61,000	INH-C	45,000	INH-C	46,000	INH-C	52,000	INH-C	99,000	INH-C	88,000	INH-C
Benzene	71-43-2	2.2	INH-C	11	INH-C	120	INH-C	92	INH-C	93	INH-C	110	INH-C	200	INH-C	180	INH-C
Benzo(a)pyrene[12]	50-32-8	3,500	INH-C	16,000	INH-C	110,000	INH-C	73,000	INH-C	150,000	INH-C	150,000	INH-C	120,000	INH-C	280,000	INH-C
Cadmium	7440-43-9	2,600	INH-C	12,000	INH-C	150,000	INH-C	110,000	INH-C	110,000	INH-C	120,000	INH-C	240,000	INH-C	210,000	INH-C
4,4'-DDT	50-29-3	NA	b	NA	b	NA	b	NA	b	NA	b	NA	b	NA	b	NA	b
Manganese	7439-96-5	87,000	INH-N	400,000	INH-N	NA	a	NA	a	NA	a	NA	a	NA	a	NA	a
Mercury	7439-97-6	520,000	INH-N	NA	a,c	NA	a,c	NA	a,c	NA	a,c	NA	a,c	NA	a,c	NA	a,c
Naphthalene	91-20-3	5.7	INH-C	27	INH-C	NA	a,c	NA	a,c	NA	a,c	NA	a,c	NA	a,c	NA	a,c
Vinyl Chloride	75-01-4	1.4	INH-C	6.4	INH-C	76	INH-C	56	INH-C	57	INH-C	64	INH-C	120	INH-C	110	INH-C
Xylenes	1330-20-7	NA	a,c	NA	a,c	NA	a,c	NA	a,c	NA	a,c	NA	a,c	NA	a,c	NA	a,c
More Restrictive Soil Remediation Standards for the Ingestion-Dermal and Inhalation Exposure Pathways (mg/kg)[d]																	
Arsenic	7440-38-2	19	Bkg[11]	19	Bkg[11]	19	Bkg[11]	19	Bkg[11]	19	Bkg[11]	19	Bkg[11]	40	ING-C	36	ING-C
Benzene	71-43-2	2.2	INH-C	11	INH-C	16	ING-C	6.2	ING-C	17	ING-C	17	ING-C	200	INH-C	180	INH-C
Benzo(a)pyrene[12]	50-32-8	0.51	ING-C	2.3	ING-C	2.6	ING-C	1.1	ING-C	2.5	ING-C	2.8	ING-C	44	ING-C	39	ING-C
Cadmium	7440-43-9	71	ING-N	1,100	ING-N	380	ING-N	130	ING-N	1,200	ING-N	500	ING-N	8,300	ING-N	19,000	ING-N
4,4'-DDT	50-29-3	1.9	ING-C	9.5	ING-C	9.7	ING-C	3.9	ING-C	10	ING-C	11	ING-C	180	ING-C	160	ING-C
Manganese	7439-96-5	1,900	ING-N	31,000	ING-N	10,000	ING-N	3,300	ING-N	35,000	ING-N	13,000	ING-N	230,000	ING-N	540,000	ING-N
Mercury	7439-97-6	23	ING-N	390	ING-N	130	ING-N	41	ING-N	440	ING-N	160	ING-N	2,900	ING-N	6,700	ING-N
Naphthalene	91-20-3	5.7	INH-C	27	INH-C	13,000	ING-N	4,300	ING-N	39,000	ING-N	17,000	ING-N	260,000	ING-N	590,000	ING-N
Vinyl Chloride	75-01-4	0.97	ING-C	5.0	ING-C	5.0	ING-C	2.0	ING-C	5.5	ING-C	5.5	ING-C	95	ING-C	84	ING-C
Xylenes	1330-20-7	12,000	ING-N	190,000	ING-N	63,000	ING-N	21,000	ING-N	220,000	ING-N	82,000	ING-N	NA	a	NA	a

[11] Calculated ARS for soil value is below the State determined background. Therefore, by policy, the value is changed to the State background value.

[12] By policy, the SRWMP does not consider mutagenic mode of action when calculating carcinogenic soil remediation standards for the ingestion-dermal and inhalation exposure pathways.

Bkg	State Background Level	**INH-C**	Inhalation Cancer Endpoint
ING-C	Ingestion-Dermal Cancer Endpoint	**INH-N**	Inhalation Non-Cancer Endpoint
RL	Reporting Limit	a	Value Greater Than 1,000,000 mg/kg
ING-N	Ingestion-Dermal Non-Cancer Endpoint	b	No Toxicological Information Available
NA	Value Not Applicable	c	Value Greater Than the Soil Saturation Concentration (CSAT)
		d	**All exposure pathways need to be considered for remedial decisions**

5.2.2. Alternative Remediation Standards for Lead

Lead contamination is a known threat to human health, especially when lead is ingested or inhaled by children under the age of seven. In accordance with N.J.A.C. 7:26D, Appendix 6, Section III (b), consultation with the Department is required prior to the development and submission of an ARS for lead. The Department has adopted USEPA's risk assessment tools for lead, which are different than those used for other contaminants. Lead toxicity data indicate that adverse effects occur at very low exposure levels and no reference dose can be derived. Therefore, lead is assessed differently, based on a blood lead concentration in a child using the Integrated Exposure Uptake Biokinetic (IEUBK) model; or for adults in a nonresidential setting, using the Adult Lead Methodology[13] (ALM) to derive an acceptable exposure level based on the fetal blood lead concentration of a pregnant woman, considered to be protective of the most sensitive receptor (the fetus/neonate). The IEUBK and ALM software and user's manuals can be found at: https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals.

For the residential scenario, the *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK)* (USEPA 1994a) and updates is used by the Department to develop the default residential soil remediation standard for lead. The IEUBK model generates a distribution of blood lead concentrations that predicts the probability of elevated blood lead levels in children (under the age of seven) that are exposed to environmental lead from multiple sources, including soil. It also predicts the probability that a child exposed to specified media lead concentrations will have a blood lead level greater than or equal to a specified reference value. The IEUBK model is the primary tool used in determining health-based remediation levels at lead contaminated residential sites.

The Adult Lead Methodology (ALM) is used by the Department to develop the default nonresidential soil remediation standard for lead. The ALM describes a process for assessing risks associated with nonresidential adult exposures to lead in soil by relating soil lead intake to blood lead concentrations in women of child-bearing age. The Technical Review Workgroup (TRW) for lead developed an interim ALM guidance (USEPA, 1996b), followed by *Recommendations of the TRW for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil* (USEPA 2003a).

The Centers for Disease Control and Prevention (CDC) previously determined that childhood blood lead levels at or above 10 micrograms of lead per deciliter of blood (µg Pb/dL) (1991) resulted in adverse effects to children's health and would be used as the level of concern. In the *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*, USEPA adopted 10 µg Pb/dL as the blood lead level of concern for use in the risk assessment process and to derive a residential lead soil screening level in an attempt to limit exposure to soil lead levels such that a typical (or hypothetical) child or group of similarly exposed children would have an estimated risk of no more than 5% exceeding the 10 µg/dL BLL (USEPA 1994b). In 2012, CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended lowering the level that triggers intervention to a childhood blood lead level based

[13] The ALM describes a process for assessing risks associated with nonresidential adult exposures to lead in soil by relating soil lead intake to blood lead concentrations in women of child-bearing age to derive an acceptable exposure level based on the fetal blood lead concentration of a pregnant woman.

on the 97.5th percentile (5 µg/dL) of the population blood lead level in children ages one-six (CDC 2012). The ACCLPP also recommended that this value should be updated by CDC every four years, based on the most recent population-based blood lead surveys among children (National Health and Nutrition Examination Survey [NHANES]) (CDC 2012). These recommendations were based on a growing body of evidence concluding that there was no measurable blood lead level that wasn't associated with cognitive deficits; and, blood lead levels less than 10 µg/dL resulted in deficits beyond cognitive function to include cardiovascular, immunological, and endocrine effects.

At this time, the Department is evaluating ACCLPP's recommendation of 5µg/dL that triggers intervention and, in the interim, the current policy has not been changed. There is uncertainty in regard to the use of the 5 µg/dL blood lead level and whether it should actually be lower or higher, and because of this uncertainty, the recommended blood lead level target may change in the future. USEPA is also continuing to evaluate the IEUBK model and may propose updates to model variables.

The Department's current residential soil remediation standard for lead is 400 mg/kg, based on a 10 µg/dL blood lead level and use of the IEUBK model. The Department's nonresidential soil remediation standard for lead is 800 mg/kg (N.J.A.C. 7:26D), based on a 10 µg/dL blood lead level, the combined phases of the National Health and Nutrition Examination Survey (NHANES III) data and use of the ALM model. The Department will continue to use these standards until USEPA updates its policy regarding lead including the ACCLPP's recommendation and the Department will determine if any revisions are necessary at that juncture.

Requests for an ARS for lead for alternative land use scenarios (see Section 5.2.1) or site-specific changes to IEUBK model and ALM default values are allowable if site-specific data (e.g., bioavailability/bioaccessibility – see https://www.epa.gov/superfund/soil-bioavailability-superfund-sites-guidance) are more representative than the default values and there is sufficient data to characterize site-specific conditions. Because IEUBK and ALM are pseudo-steady state models, intermittent exposure scenarios should meet a minimum frequency of one day per week and a duration of three consecutive months. Detailed information and applications of this approach are found in USEPA's *Assessing Intermittent or Variable Exposures at Lead Sites* (USEPA 2003b).

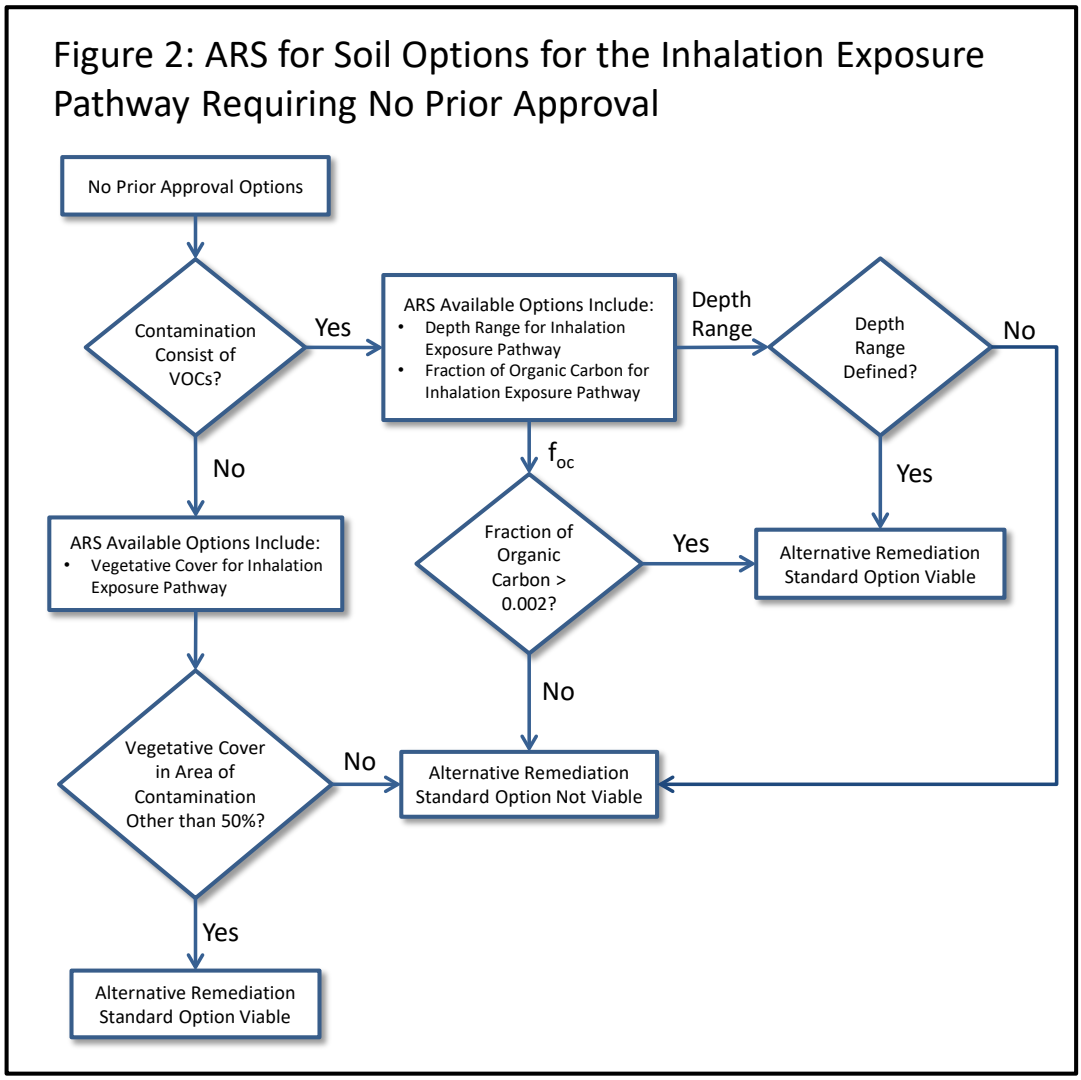
All requests for an ARS for lead will be handled on a case-specific basis until the new USEPA policy becomes available and the Department determines what action it will take in response. Prior to the development and submission of an ARS for lead, it is required that the investigator consult with the Department to discuss the nature and site-specific basis for the ARS request (N.J.A.C. 7:26D, Appendix 6, Section III (b)). The Department will first review the ARS for lead request and then collaborate with the USEPA Region 2 lead TRW contact on cases where additional expertise is needed.

Contact information for technical consultations can be found at http://www.state.nj.us/dep/srp/srra/technical_consultation/.

5.3. Alternative Remediation Standard for Soil Requests Requiring No Prior Approval by the Department

All ARS for soil options for the ingestion-dermal exposure pathway require prior approval from the Department; however, the following options may be used for the inhalation exposure pathway without prior Department approval. The ARS for soil options for the inhalation exposure pathway are found in N.J.A.C. 7:26D, Appendix 7, Section II (see Figure 2, below).

Figure 2: ARS for Soil Options for the Inhalation Exposure Pathway Requiring No Prior Approval



5.3.1. Depth Range of Contamination for Inhalation Exposure Pathway

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 deriving an ARS for soil for contaminants controlled by the volatile component of the equation.

The inhalation exposure pathway assumes the contamination starts at the ground surface and extends to an infinite depth (USEPA 1996a). However, 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 soil remediation standard for the inhalation exposure pathway 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 Inhalation Exposure Pathway Calculator, located on the Department's website,[14] to develop an ARS for soil.

An assumption of finite depth range reduces the modeled average volatilization flux in comparison to what is modeled assuming infinite depth. Use of a finite depth range assumption results in a greater remediation standard. An ARS for soil based on finite depth range may be used in support of a remedial action decision at a site or an AOC 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.

The following information will be required to be submitted to the Department:

- A printout of the Department's calculator showing the modified input parameters and the resultant ARS;
- A description of how the input parameters were selected (i.e., vertical contaminant delineation), including all related laboratory results, sample location maps and boring logs; and
- A description of how the standards were used in the remediation of the site or AOC, including institutional controls, if appropriate.

The Department requires 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 feet 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 alter 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 the ground surface.

Contact information for technical consultations can be found at http://www.state.nj.us/dep/srp/srra/technical_consultation/.

[14] http://www.nj.gov/dep/srp/guidance/rs/index.html

5.3.2. Organic Carbon Content of Soil for Inhalation Exposure Pathway

The organic carbon content of soil (f_{oc}) may be used to develop an ARS for soil only for the inhalation exposure pathway. This parameter will only have an effect on deriving an ARS for soil for contaminants controlled by the volatile component of the equation.

The inhalation exposure pathway assumes that f_{oc} in soil is 0.002 $g_{(oc)}/g_{(soil)}$ based on USEPA (1996a) and Carsel et al. (1988). If the f_{oc} is measured in soil in accordance with the *Alternative Remediation Standards Technical Guidance for Soil and Soil Leachate for the Migration to Ground Water Exposure Pathway* (NJDEP 2021c), the f_{oc} value may be entered into the Department's Inhalation Exposure Pathway Calculator, located on the Department's website,[15] to develop an ARS for soil. The Department's calculator will develop an appropriate f_{oc} from values entered.

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. Increasing the organic carbon content of the soil will increase the calculated remediation standard. An ARS for soil developed using this methodology may be used to remediate a site or AOC 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.

The following information will be required to be submitted to the Department:

- A printout of the Department's calculator showing the modified input parameters and the resultant alternative remediation standard;
- A description of how the input parameters were selected (i.e., average or lowest f_{oc} concentration), including all related laboratory results and the Department's calculator output for f_{oc}; and
- A description of how the standards were used in the remediation of the site or AOC.

The Department does 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}.

> Contact information for technical consultations can be found at http://www.state.nj.us/dep/srp/srra/technical_consultation/.

5.3.3. Fraction of Vegetative Cover for Inhalation Exposure Pathway

The fraction of vegetative cover (V) may be used to develop an ARS for soil only for the inhalation exposure pathway and only has an effect on derivation of an ARS for non-volatile contaminants. The calculator for the inhalation exposure pathway assumes 50% vegetative cover for the site or AOC because it represents a reasonable compromise between no cover and a

[15] http://www.nj.gov/dep/srp/guidance/rs/index.html

totally vegetated site (USEPA 1996a). This parameter can be varied to reflect a site-specific condition and to allow for an appropriate ARS to be 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 may 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 and the site or AOC area is also measured, then V can be determined by dividing the area of vegetative cover by the area of 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. The value for V (as a decimal) may be entered into the Department's Inhalation Exposure Pathway Calculator, located on the Department's website,[16] to develop an ARS for soil. The ARS for soil may be used 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.

The following information will be required to be submitted to the Department:

- A printout of the Department's calculator showing the modified input parameters and the resultant alternative remediation standard;
- A description of how the input parameters were selected (i.e., figures, photos, etc.), including all measurements and calculations; and
- A description of how the standards were used in the remediation of the site or AOC, including appropriate institutional controls.

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

Contact information for technical consultations can be found at http://www.state.nj.us/dep/srp/srra/technical_consultation/.

[16] http://www.nj.gov/dep/srp/guidance/rs/index.html

6. SUBMITTAL OF ALTERNATIVE REMEDIATION STANDARDS FOR SOIL

The LSRP must complete the Alternative or Interim Remediation Standard and/or Screening Level Application Form to request Departmental prior approval of an ARS for soil for the ingestion-dermal and/or inhalation exposure pathways or to notify the Department of the implementation of an ARS for soil that does not require prior approval. These forms and instructions are found in the Forms Library (under General Forms) located on the SRWMP website at http://www.state.nj.us/dep/srp/srra/forms/.

Forms are periodically updated and it is important to check the website to ensure that the latest version of these forms and instructions is being used. Information on completing the form and submitting the necessary documentation is provided in the instructions and further detailed in this guidance. The Department requires the use of an institutional control and a soil remedial action permit pursuant to N.J.A.C. 7:26C-7, as well as N.J.A.C. 7:26D Appendices 6 and 7, for an ARS for soil based on an alternative land use scenario, depth range (for contamination starting at a depth greater than zero feet below ground surface) and vegetative cover to ensure that the continued use of the ARS remains valid.

Questions regarding the completion of the form may be directed to the appropriate contact person identified at: http://www.nj.gov/dep/srp/srra/srra_contacts.htm. Request for a site-specific technical consultation may be directed to the contact listed at: http://www.state.nj.us/dep/srp/srra/technical_consultation/.

The following information is required to be submitted with the applicable form found on the Department's website with the appropriate remedial phase report (see specific sections of this guidance for requirements):

- A printout of the Department's calculator, located on the Department's SRWMP Remediation Standards website (http://www.nj.gov/dep/srp/guidance/rs/index.html), showing the modified input parameters and the resultant ARS for soil;
- A description and justification for the selected input parameters;
- A description of how the ARS for soil will be used in the remediation of the site or AOC, including institutional controls and remediation permits (where appropriate); and
- A comparison of the ARS for soil with the appropriate default soil remediation standard or ARS from each of the other exposure pathways for soil (e.g., ingestion-dermal, inhalation and migration to groundwater exposure pathways). In addition to the ARS process, ecological remediation goals must be considered where environmentally sensitive natural resources are present in accordance with N.J.A.C. 7:26E-1.16 and -4.8 and as addressed in the *Ecological Evaluation Technical Guidance* (NJDEP 2018).

The ARS information provided in this guidance may be used in the development and submittal of a site-specific ARS for soil request. An ARS for soil is applicable to the site or AOC for which the request was submitted, but is not applicable at any other site or AOC (N.J.A.C. 7:26D-8.2). An ARS for soil may incorporate elements from both the prior approval and no prior approval options; however, an ARS using this combination will require prior approval by the Department.

The development and use of an ARS for soil, in itself, is not justification for the extension of any regulatory or mandatory timeframes (Administrative Requirements for the Remediation of Contaminated Sites, N.J.A.C. 7:26C-3).

7. REFERENCES

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Appendices

Appendix A

GLOSSARY

GLOSSARY

Alternative remediation standard or ARS is defined in N.J.A.C. 7:26D-1.5 (https://www.nj.gov/dep/rules/rules/njac7_26d.pdf).

Area of Concern or AOC is defined in N.J.A.C. 7:26E-1.8 (https://www.nj.gov/dep/rules/rules/njac7_26e.pdf).

Contaminated site is defined in N.J.A.C. 7:26E-1.8 (https://www.nj.gov/dep/rules/rules/njac7_26e.pdf).

Contamination or contaminant is defined in N.J.A.C. 7:26E-1.8 (https://www.nj.gov/dep/rules/rules/njac7_26e.pdf).

Department means "the New Jersey Department of Environmental Protection."

Ingestion-dermal exposure pathway is defined in N.J.A.C. 7:26D-1.5 (https://www.nj.gov/dep/rules/rules/njac7_26d.pdf).

Inhalation exposure pathway is defined in N.J.A.C. 7:26D-1.5 (https://www.nj.gov/dep/rules/rules/njac7_26d.pdf).

Outdoor Worker means "a long-term receptor exposed during the work day who is a full-time employee of the company operating on-site and who spends most of the workday conducting maintenance activities outdoors."

Nonresidential is defined in N.J.A.C. 7:26D-1.5 (https://www.nj.gov/dep/rules/rules/njac7_26d.pdf).

Reasonable Maximum Exposure (RME) means "a reasonably conservative exposure (well above the average case) that is a product of factors, such as concentration, exposure frequency and duration that reflect an appropriate mix of average and upper–bound values."

Remediation Standard is defined in N.J.A.C. 7:26D-1.5 (https://www.nj.gov/dep/rules/rules/njac7_26d.pdf).

Residential is defined in N.J.A.C 7:26D-1.5 (https://www.nj.gov/dep/rules/rules/njac7_26d.pdf).

Appendix B

ACRONYMS

ACRONYMS

ACCLPP	Advisory Committee on Childhood Lead Poisoning Prevention
ALM	Adult Lead Methodology
AOC	Area of Concern
ARS	Alternative Remediation Standard
ATV	All Terrain Vehicle
CDC	Centers for Disease Control and Prevention
COC	Contaminant of Concern
C_{sat}	Soil Saturation Concentration
d1	Initial depth to contamination exceeding inhalation exposure pathway soil remediation standard
d2	Final depth to contamination exceeding inhalation exposure pathway soil remediation standard
Department	New Jersey Department of Environmental Protection
EPH	Extractable Petroleum Hydrocarbons
f_{oc}	Organic Carbon Content of Soil
IEUBK	Integrated Exposure Uptake Biokinetic Model
LSRP	Licensed Site Remediation Professional
NHANES	National Health and Nutrition Examination Survey
N.J.A.C.	New Jersey Administrative Code
N.J.S.A.	New Jersey Statutes Annotated
NJDEP	New Jersey Department of Environmental Protection
PAH	Polycyclic Aromatic Hydrocarbon
Q/C	Inverse Concentration at the Center of the Source
RL	Reporting Limit
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SRWMP	Site Remediation and Waste Management Program
TRW	Technical Review Workgroup for Lead
USEPA	United States Environmental Protection Agency
V	Fraction of Vegetative Cover
VIT	Vapor Intrusion Technical Guidance
VF	Soil-to-Air Volatilization Factor

Appendix C

TABLES

Table C-1 Default Exposure Assumptions for the Residential Ingestion-Dermal Scenario for Carcinogens				
Parameters		**Default**	**Units**	**Source**
TR	Target Cancer Risk	1.00E-06	unitless	N.J.S.A. 58:10B-12
AT	Averaging Time	365	days/year	USEPA (2014a)
LT	Lifetime	70	years	USEPA (2014a)
EF	Exposure Frequency	350	days/year	USEPA (2014a)
ED	Exposure Duration	Total: 26	years	USEPA (2014a)
		Adult: 20	years	USEPA (2014a)
		Child: 6	years	USEPA (2014a)
BW	Body Weight	Adult: 80	Kg	USEPA (2014a)
		Child: 15	Kg	USEPA (2014a)
CSF_O	Oral Cancer Slope Factor	Chemical Specific	$(mg/kg\text{-}day)^{-1}$	N.J.A.C. 7:26D
IFS_{adj}	Age-Adjusted Soil Ingestion Rate	36,750[a]	mg/kg	USEPA (2018)
CSF_D	Dermal Cancer Slope Factor	Chemical Specific	$(mg/kg\text{-}day)^{-1}$	NJDEP (2021a)
DFS_{adj}	Age-Adjusted Soil Dermal Contact Factor	103,390[b]	mg/kg	USEPA (2018)
ABS_d	Dermal Absorption Fraction	Chemical Specific	unitless	NJDEP (2021a)
IR	Soil Ingestion Rate	Adult: 100	mg/day	USEPA (2014a)
		Child: 200	mg/day	USEPA (2014a)
SA	Skin Surface Area	Adult: 6032	cm^2/day	USEPA (2014a)
		Child: 2373	cm^2/day	USEPA (2014a)
AF	Soil Adherence Factor	Adult: 0.07	mg/cm^2	USEPA (2014a)
		Child: 0.2	mg/cm^2	USEPA (2014a)

a Incorporates EF, ED, IR and BW b Incorporates EF, ED, SA, AF and BW

Table C-2 Default Exposure Assumptions for the Residential Ingestion-Dermal Scenario for Non-Carcinogens				
Parameters		**Default**	**Units**	**Source**
THQ	Target Hazard Quotient	1	unitless	N.J.S.A. 58:10B-12
AT	Averaging Time	365	days/year	USEPA (2014a)
ED	Exposure Duration	6	years	USEPA (2014a)
BW	Body Weight-child	15	kg	USEPA (2014a)
EF	Exposure Frequency	350	days/year	USEPA (2014a)
RfD_O	Oral Reference Dose	Chemical Specific	mg/kg-day	N.J.A.C. 7:26D
IR	Soil Ingestion Rate-child	200	mg/day	USEPA (2014a)
RfD_D	Dermal Reference Dose	Chemical Specific	mg/kg-day	NJDEP (2021a)
SA	Skin Surface Area-child	2,373	cm^2/day	USEPA (2014a)
AF	Soil Adherence Factor-child	0.2	mg/cm^2	USEPA (2014a)
ABS_d	Dermal Absorption Fraction	Chemical Specific	unitless	NJDEP (2021a)

Table C-3 Default Exposure Assumptions for the Nonresidential Ingestion-Dermal Scenario for Carcinogens				
Parameters		**Default**	**Units**	**Source**
TR	Target Cancer Risk	1.00E-06	unitless	N.J.S.A. 58:10B-12
AT	Averaging Time	365	days/year	USEPA (2014a)
LT	Lifetime	70	years	USEPA (2014a)
BW	Body Weight-adult	80	kg	USEPA (2014a)
EF	Exposure Frequency-Outdoor Worker	225	days/year	USEPA (2014a)
ED	Exposure Duration	25	years	USEPA (2014a)
CSF_O	Oral Cancer Slope Factor	Chemical Specific	$(mg/kg\text{-}day)^{-1}$	N.J.A.C. 7:26D
IR	Soil Ingestion Rate-outdoor worker	100	mg/day	USEPA (2014a)
CSF_D	Dermal Cancer Slope Factor	Chemical Specific	$(mg/kg\text{-}day)^{-1}$	NJDEP (2021a)
SA	Skin Surface Area-outdoor worker	3,527	cm^2/day	USEPA (2014a)
AF	Soil Adherence Factor-outdoor worker	0.12	mg/cm^2	USEPA (2014a)
ABS_d	Dermal Absorption Fraction	Chemical Specific	unitless	NJDEP (2021a)

Table C-4 Default Exposure Assumptions for the Nonresidential Ingestion-Dermal Scenario for Non-Carcinogens				
Parameters		**Default**	**Units**	**Source**
THQ	Target Hazard Quotient	1	unitless	N.J.S.A. 58:10B-12
AT	Averaging Time	365	days/year	USEPA (2014a)
ED	Exposure Duration	25	years	USEPA (2014a)
BW	Body Weight-adult	80	kg	USEPA (2014a)
EF	Exposure Frequency-Outdoor Worker	225	days/year	USEPA (2014a)
RfD_O	Oral Reference Dose	Chemical Specific	mg/kg-day	N.J.A.C. 7:26D
IR	Soil Ingestion Rate-outdoor worker	100	mg/day	USEPA (2014a)
RfD_D	Dermal Reference Dose	Chemical Specific	mg/kg-day	NJDEP (2021a)
SA	Skin Surface Area-outdoor worker	3,527	cm^2/day	USEPA (2014a)
AF	Soil Adherence Factor-outdoor worker	0.12	mg/cm^2	USEPA (2014a)
ABS_d	Dermal Absorption Fraction	Chemical Specific	unitless	NJDEP (2021a)

Table C-5 Default Exposure Assumptions 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	1.00E-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)
		Nonresidential: 8	hours	USEPA (2014a)
EF	Exposure Frequency	Residential: 350	days/year	USEPA (2014a)
		Nonresidential: 225 (outdoor worker)	days/year	USEPA (2014a)
ED	Exposure Duration	Residential: 26 (child: 6, adult: 20)	years	USEPA (2014a)
		Nonresidential: 25	years	USEPA (2014a)
IUR	Inhalation Unit Risk	Chemical Specific	$(\mu g/m^3)^{-1}$	N.J.A.C. 7:26D
RfC	Reference Concentration	Chemical Specific	$(\mu g/m^3)$	N.J.A.C. 7:26D

Table C-6 Physical Input Parameters for the Inhalation Exposure Pathway				
Parameters		**Default**	**Units**	**Source**
Q/C	Inverse Concentration at Center of Source	Residential: 86.6 Nonresidential: 85	$(g/m^2\text{-}s)/(kg/m^3)$	NJDEP (2021b)
T	Exposure Interval	8.2×10^8	seconds	USEPA (2014a)
ρ_b	Dry Soil Bulk Density	1.5	g/cm^3	USEPA (1996a)
θ_a	Air -Filled Soil Porosity	0.18	L_{air}/L_{soil}	NJDEP (2021b)
θ_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)
V	Fraction of Vegetative Cover	50	Percent	USEPA (1996a)
Um	Mean Annual Wind Speed	4.56	m/s	NOAA (2002)
Ut	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	None	NJDEP (2021b)

Table C-7 Comparison of Input Parameters for the Inhalation Exposure Pathway			
Parameters		**NJDEP Default[1]**	**USEPA Default[2]**
θ_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}
θ_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

1- NJDEP (2021b)
2-USEPA (1996a)