

Connecticut Release Based Cleanup Regulations: DRAFT Proposal for New Risk-based Remediation Criteria for Managed Multifamily Residential and Passive Recreational Exposure Scenarios

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Contents

Table of Tables:	2
Overview: Problem Formulation	3
Managed Multifamily Residential Scenario	3
Scenario.....	3
Criteria Development.....	4
Passive Recreation Scenario	4
Scenario.....	4
Criteria Development.....	5
Hazard Identification and Dose Response	5
Toxicity Values.....	5
Mutagenicity	5
Trichloroethylene.....	6
Criteria Formulas: Analysis Plan.....	6
Exposure Assessment.....	6
Body Weight.....	6
Soil Ingestion Rates	7
Soil Ingestion Rates – Managed Multifamily Residential Scenario	7
Soil Ingestion Rates – Passive Recreation Scenario	8
Exposure Frequency.....	8
Exposure Frequency – Managed Multifamily Residential Scenario.....	8
Exposure Frequency – Passive Recreation Scenario	8
Exposure Duration & Averaging Time.....	9
Criteria Derivation: Analysis	10
Condensed Equations for Derivation of Managed Residential Direct Exposure Criteria.....	10
Condensed Equations for Derivation of Passive Recreation Direct Exposure Criteria	11
Bibliography	12
Tables.....	13
Appendix A: Equations for Soil Exposure within a Managed Multifamily Residential Setting	27

Appendix B: Equations for Soil Exposure within a Passive Recreation Setting	32
Appendix D: Criteria Values	37
Appendix E: Reference Materials	38
Body Weight	38
Updated Soil Ingestion Rates	39

Table of Tables:

Table 1: Passive Recreational Activities and Frequency for CT General Population	9
Table 2: EFH Table 8-1 Recommended Values for Body Weight	38
Table 3: EPA EFH Table 8-25 Estimated Body Weight of Typical Age Groups of Interest in U.S.EPA Risk Assessments.....	38
Table 4: Recommended Soil and Dust Ingestion Rates from 2011 EFH.....	39

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Overview: Problem Formulation

Two new exposure scenarios are being proposed for inclusion in updated Release Based Cleanup Regulations (RBCRs) that contain cleanup standards based off of the [Connecticut Remediation Standard Regulations](#) (RSRs). These scenarios are Managed Multifamily Residential Soil Exposures and Passive Recreational Soil Exposures. This document describes the derivation of risk-based criteria to support application of these scenarios within the RBCRs.

Derivation of these two proposed risk-based criteria will be based on updated toxicity values for existing substances listed in the RSRs, a consideration of the mutagenicity of each substance, updated exposure estimates and updated criteria formulas. Changes to the remaining exposure scenarios contained in the regulations are not being proposed at this time.

Managed Multifamily Residential Scenario

Scenario

A new exposure scenario applicable to a managed multifamily residential setting is being proposed for inclusion within the cleanup standards section of the RBCRs. This scenario will be available for use at certain managed multifamily housing settings such as apartment buildings or condominiums where rules and practices will be in place to limit access to soils by site residents. It is expected that these sites will be actively managed to support these provisions. Such management measures may include:

- Leasing agreements or condominium declarations and bylaws that will limit residents' access to soil by restricting active recreation only to areas with impervious cover, clearly prohibiting any activities that involve frequent and/or intense direct contact with soil, such as digging in the soil, gardening or activities that result in disturbing the dirt. These prohibitions do not apply to raised bed gardening as long as the soils being used are not from the property and that soils used within the raised beds are not contaminated from other sources. Guidance on how to properly use and construct raised bed gardens is available in the [CTDPH Growing and Eating Fruits and Vegetables Safely Fact Sheet](#).
- The property and grounds will be actively managed by an association or a professional property management company to make sure that open exposure areas of soil are repaired through maintenance activities such as making sure garden beds are properly mulched, maintaining lawns to ensure a dense grass cover of the soil is maintained, and general property maintenance tasks. Property maintenance workers would not engage in major construction or excavation activities that could result in significant soil exposures for an extended time period.
- Residents would be allowed to use well maintained lawn areas at the facility, other paved areas designated for activities (basketball, tennis, playgrounds, etc.)

Under this scenario, soil may be remediated to the Managed Multifamily Residential Direct Exposure Criteria instead of the Residential Direct Exposure Criteria. An Environmental Use Restriction would be required that prohibits: 1. Activities that would result in frequent and/or intense direct contact with soil by residents and 2. Active recreation on areas without impervious cover. There will be no requirements for a cover layer of clean fill or a barrier between contamination and upper soil layers.

Criteria Development

Derivation of the Managed Multifamily Direct Exposure Criteria are based on reduced exposure frequency and intensity of activity at the site, supporting reduced exposures to soils. This scenario is supported by requirements to reduce soil exposures to residents within a managed setting. However, this management approach may also result in additional soil exposures to groundskeepers and maintenance personnel at the site, as compared with the existing Industrial/Commercial Direct Exposure Criteria, which is based on exposures to indoor workers. As such, the proposed Direct Exposure Criteria for Managed Multifamily Residential sites will consider risks and exposure rates for both child residents, adult residents, and site workers. To support criteria development for this scenario, risks to all three exposure groups (child resident, adult resident, and site worker) are evaluated and are documented below.

Passive Recreation Scenario

Scenario

A new exposure scenario applicable to sites designated for passive recreational activities is being proposed for inclusion within the cleanup standards section of the RBCRs. This scenario will be available for use at certain sites designated solely for passive recreational uses. The following conditions form the basis for this exposure scenario:

- Passive recreation includes hiking, running, walking, and related activities, such as observing and photographing nature, geocaching, letterboxing, mobile app gaming, wildlife viewing, or other activities that do not involve active recreation requiring a dedicated playfield or activities that can result in more direct contact with soil or ground surfaces.
- Passive recreation does not include mountain biking, All Terrain Vehicle (ATV) use, sports activities on athletic fields, picnic areas, swimming areas, or any other recreational activities that may significantly increase a recreator's direct contact with soil.
- Signage is recommended to indicate acceptable and prohibited activities at the location.
- Activities at these locations may be monitored periodically (not required) but active management of on-site activities is not expected
- An Environmental Use Restriction or conservation easement held by a state, local or federal government would be used to limit activity on the parcel as described here.

In these settings, soil may be remediated to the Passive Recreation Exposure Criteria instead of the Residential Direct Exposure Criteria. There will be no requirements for a cover layer of clean fill or a barrier between contamination and upper soil layers.

Criteria Development

Derivation of the Passive Recreation Exposure Criteria are based on reduced exposure frequency and intensity of activity at the site, supporting reduced exposures to soils. This scenario is supported by restricting activities at a site through administrative processes such as Environmental Land Use Restrictions or Conservation Easements. Both children and adults are expected to participate in passive recreational activities, so the derivation of this criteria type will be based on the formulas for the existing Residential Direct Exposure Criteria. Limited maintenance of trails by adults is anticipated as part of this exposure scenario and is factored into derivation of the criteria.

Hazard Identification and Dose Response

Toxicity Values

Toxicity values used in criteria derivation were provided by the Connecticut Department of Public Health (CTDPH). CTDPH staff reviewed toxicity information from multiple sources, including the U.S. Environmental Protection Agency Integrated Risk Information System (IRIS), the Agency for Toxic Substances and Disease Registry, and the California Environmental Protection Agency Office of Environmental Health Hazard. The majority of the selected toxicity values (~75%) were taken from the IRIS database. The remaining values were taken from other sources.

Toxicity values used in calculating the risk-based criteria and supporting documentation is provided in Table 1.

Mutagenicity

EPA recommends considering the potential mutagenicity of each carcinogenic substance in risk analyses. Procedures recommended by EPA in the [Guidelines for Carcinogen Risk Assessment](#) (EPA 2005a) and the [Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens](#) (EPA 2005b) were used to incorporate consideration of mutagenicity in criteria derivation. Age dependent adjustment factors (ADAFs) recommended by EPA, and identified below, are used along with substance-specific cancer slope factors to account for mutagenicity as appropriate for each substance.

- An ADAF value of 10 is used for exposures during ages 0-2 years;
- An ADAF value of 3 is used for exposures during ages 2-6 years;
- An ADAF value of 3 is used for exposures during ages 6-16 years; and
- An ADAF value of 1 is used for exposure during ages beyond 16 years.

Trichloroethylene

Trichloroethylene causes toxicity to the liver and is associated with Non-Hodgkin's Lymphoma via a carcinogenic pathway. It also causes toxicity to the kidney through a mutagenic pathway. EPA recommends that analyses of the health impacts of trichloroethylene be conducted to account for both the carcinogenic and mutagenic modes of action (EPA 2011a).

Criteria Formulas: Analysis Plan

Criteria formulas for exposures to noncarcinogens are based on exposures to single population groups, such as child residents, adult residents, site workers, child recreators, and adult recreators. Risks to each group are evaluated separately and the exposure group/equation that is protective of all potential exposure groups within a scenario is selected as the basis for the proposed new criteria for noncarcinogens.

Criteria formulas for children and adult exposures to carcinogens within these new scenarios are evaluated using equations that calculate values over a combined exposure period. Criteria formulas for site worker exposures to carcinogens are calculated separately from exposure to residents in the Managed Multifamily Residential scenario.

The various formulas for each scenario are provided in Appendices A and B.

Exposure Assessment

Body Weight

Existing RSR criteria use body weights of 70 kilograms (kg) for adults and 15 kg for children (≤ 6 years). These values were based on the Standard Default Exposure Factors contained in Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual. (USEPA, 1991)

Subsequent to that guidance, EPA provided updated body weight data in the 2011 Exposure Factors Handbook (EFH) (USEPA 2011). The updated body weight recommendations are based on EPA's analysis of the National Health and Nutrition Examination Survey (NHANES) data collected for 1999-2006. This dataset contains newer information than was available when the original risk-based criteria for the RSRs were developed.

Based on data from the 2011 EFH, EPA recommends using 80 kg as the body weight for adults (Table 8-1, included as Table 2 in Appendix D of this document). This value is based on the various mean body weights for adults (male and female combined) and is consistent with the weight data reported for adult age groups from 21 to 80 years, which range from 76.4 kg to 83.6 kg, as presented in Table 8-3 in the report. EPA has incorporated this updated body

weight into the derivation of recommended national water quality criteria for the compounds updated in 2015. (USEPA 2015). Additionally, EPA uses this updated adult bodyweight in the Regional Screening Levels – Generic Tables (USEPA 2023). The Agency for Toxic Substances and Disease Registry (ATSDR) has also issued guidance recommending the use of 80 kg as the body weight for adults (ATSDR 2023). The updated adult body weight of 80 kg is selected for use in deriving risk-based criteria for the additional RSR exposure scenarios.

The 2011 EFH also provides updated body weight data for children. Table 8-25 (included as Table 3 in Appendix D of this document) presents the results from a study by Porter *et al*, presented in the 2011 EFH. That study re-analyzed the data from several NHANES studies and calculated the weight information for typical age ranges used in EPA risk assessment for each NHANES study. The most current data in that presentation is based on NHANES IV (1999-2002). The overall mean weight of 17.3 kg for children ages 1–6 from the Porter analysis (Table 8-25) is selected for use in deriving risk-based criteria for children ages 0–6 years within the additional RSR exposure scenarios.

These same sources are used to derive body weights for other age ranges, as follows:

Age Range	Body Weight (kilogram)	Basis
Adults	80	EPA EFH & ATSDR
Children (0–6 years)	17.3	EPA EFH Table 8-25, overall mean, ages 1–6
Children (0–2 years)	11.4	EPA EFH Table 8-1, value for 1–2-year-olds
Children (2–6 years)	17.3	EPA EFH Table 8-25, overall mean, ages 1–6
Children (6–16 years)	47.7	EPA EFH Table 8-25, overall mean, ages 7–16
People (16–30 years)	80	EPA EFH & ATSDR

Soil Ingestion Rates

Soil Ingestion Rates – Managed Multifamily Residential Scenario

Current RSR values for soil ingestion are 200 milligrams per day (mg/d) for children and 100 mg/d for adults in a residential setting. The current Industrial/Commercial setting includes a soil ingestion rate of 50 mg/d. These rates are consistent with the EPA Risk Assessment Guidance for Superfund (USEPA 1991). The 50 mg/d value is specified for the soil ingestion rate for an office worker.

Reduced soil ingestion rates for adult and child residents are proposed based on the 2017 updated recommendations for soil and dust ingestion in the EFH (EPA 2017). The data is presented in EFH Table 5-1 for total ingestion of soil and dust (included as Table 4 in Appendix D of this document). Total soil and dust ingestion rates include exposures to outdoor soil and dust and indoor dust. This total exposure is recommended since indoor dust is affected by outdoor soil and dust quality. The upper range of the mean exposure was selected for use in deriving exposures for this scenario, providing a central tendency-based exposure value. The use of the upper range of the central tendency distribution was selected since the proposed

criteria derivation does not take into consideration other soil-based exposures, such as dermal or inhalation exposures to soils or behaviors such as soil pica or geophagy, which can substantially increase soil ingestion rates. Soil pica is the recurrent ingestion of high amounts of soil and geophagy is the intentional ingestion of soil, often associated with cultural practices. Considering the soil ingestion rate data in the EFH Table 5-1 for age groups 1 to <2 years, 2 to <6 years and 6 to <12 years, a soil ingestion rate of 100 mg/d for a child of 1 to 6 years is recommended for use in deriving criteria for this scenario. Considering the data in Table 5-1 for age groups 6 to <12 years and 12 years through adult, a soil ingestion rate of 50 mg/d is recommended for use in deriving criteria for this scenario.

The 2017 update to the EFH does not have data on soil ingestion rates for worker scenarios. The EPA Risk Assessment Guidance for Superfund (EPA 1991) provides several soil recommendations: 50 mg/d (indoor workers), 100 mg/d (adult agricultural workers), and 480 mg/d (construction and landscape workers). A value of 100 mg/d is proposed for evaluating risks to maintenance workers within the managed residential setting based on the EPA 1991 estimates for agricultural workers. This value is also consistent with ATSDR's recommended soil ingestion rate of 100 mg/d for outdoor workers with low intensity soil contact (e.g., lawn maintenance workers; ATSDR Exposure Dose Guidance for Soil and Sediment Ingestion, 2018).

Soil Ingestion Rates – Passive Recreation Scenario

Adjustments to soil ingestion rates are proposed for this scenario. For children within the various age groups, the soil ingestion rates selected for the Managed Multifamily Residential Scenario are also proposed for the Passive Recreation Scenario.

For adults and people aged 16–30 years, a soil ingestion rate of 75 mg/d is recommended, based on the average of 50 mg/d (general adult exposures) and 100 mg/d (site-worker adult exposures), recognizing that some adults and older adolescents may participate in trail maintenance activities.

Exposure Frequency

Exposure Frequency – Managed Multifamily Residential Scenario

Exposure frequency is set at 365 days/year for residential settings, consistent with the exposure frequency for the Residential Direct Exposure Criteria within the current RSRs.

Exposure Frequency – Passive Recreation Scenario

To determine appropriate exposure frequency at passive recreational settings, the 2017–2022 Statewide Comprehensive Outdoor Recreation Plan Data (Cohen et al. 2017) for Connecticut was reviewed. This study is based on a three-part survey of municipal officials, general population, and avid recreational enthusiasts. Respondents were asked to identify activities

they participate in and the frequency of that participation. Responses related to frequency did not include an option to indicate daily participation in the activity. The highest frequency for participation was set at several times per week. The results for the general public indicate that a majority of respondents participate in passive recreational activities, with 20% to 44% of respondents indicating they participated in common passive recreational activities several times a week.

Table 1: Passive Recreational Activities and Frequency for CT General Population

Responses Representative of CT General Population			
Activity	Percentage of respondents that participate in the activity	Percentage of respondents that participate several times per week	Percentage of respondents that participate a few times per month
Walking/hiking	65	44	30
Geocaching, letterboxing, mobile gaming	18	41	20
Running	30	34	30
Bird Watching	26	26	29
Road biking	26	20	34

For avid outdoor enthusiasts who reported walking and hiking as their first-choice activity, 61% indicated that they engaged in that activity several times/week.

Based on this data, an Exposure Frequency of 4 days/week x 52 weeks/year, equal to 208 days/year is selected for calculating risk-based criteria for passive recreational exposures.

Exposure Duration & Averaging Time

A total exposure duration of 30 years is used for both the Managed Multifamily Residential Scenario and the Passive Recreation Scenario. For Site Workers, the exposure duration of 25 years is used.

Exposure Durations and Averaging Times used in the calculations are provided in the table below. Note the averaging time is equal to the exposure duration multiplied by 365 days/year.

Age Ranges	Exposure Duration (years)	Averaging Time (days)
For Exposures to Carcinogens and Mutagens:		
Lifetime Total Exposure	70	25,550
Children (0–2 years)	2	
Children (2–6 years)	4	
Children (6–16 years)	10	
People (16–30 years)	14	

For Exposures to Non-Carcinogens:		
Adults	24	8,760
Children (0–6 years)	6	2,190
Site Worker (Managed Multifamily Setting)	25	9125

Criteria Derivation: Analysis

Criteria calculated using the scenarios, equations, and inputs described above are presented in tables in Appendix D.

Condensed Equations for Derivation of Managed Residential Direct Exposure Criteria

Using the risk-based equations for each scenario and the associated exposure parameters, the equations can be condensed to the following equations to simplify calculations:

Abbreviations:

RfD = Reference Dose

CSF = Cancer Slope Factor

CSF_{tce-m} = CSF for mutagenic effects for Trichloroethylene

CSF_{tce-c} = CSF for carcinogenic effects for Trichloroethylene

Noncarcinogens:

Child Residents: RfD x 173,000

Adult Residents: RfD x 1,600,000

Site Workers: RfD x 1,168,000

Carcinogens (Not mutagenic):

Child & Adult: 1.41 / CSF

Site Workers: 3.27 / CSF

Mutagens:

Child & Adult: 0.24

Trichloroethylene:

Child & Adult: $0.02555 / ((CSF_{tce-m} \times 0.106320) + (CSF_{tce-c} \times 0.018134))$

Condensed Equations for Derivation of Passive Recreation Direct Exposure Criteria

RfD = Reference Dose

CSF = Cancer Slope Factor

CSF_{tce-m} = CSF for mutagenic effects for Trichloroethylene

CSF_{tce-c} = CSF for carcinogenic effects for Trichloroethylene

Noncarcinogens:

Child Recreators: RfD x 303,581.73

Adult Recreators: RfD x 1,871,794.87

Carcinogens (Not mutagenic):

Child & Adult: 2.15 / CSF

Mutagens:

Child & Adult: 0.42

Trichloroethylene:

Child & Adult: $0.02555 / ((\text{CSF}_{\text{tce-m}} \times 0.061498) + (\text{CSF}_{\text{tce-c}} \times 0.011894))$

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USEPA Regional Screening Levels (RSLs) – Generic Tables. November 2023. Available at: [Regional Screening Levels \(RSLs\) - Generic Tables | US EPA](#) (Default Exposure Factors for these Screening Levels are available at: [Table 1 Standard Default Factors November 2023 PDF \(epa.gov\)](#))

Tables

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
208968	Acenaphthylene		6.0E-02	surrogate	see note	none	none		RfD is based on analogy to acenaphthene (IRIS 1990) and listed in CT DEEP (2018). CSF : Acenaphthylene has not been classified as a carcinogen by EPA, NTP or IARC at this time.
67641	Acetone		9.0E-01	IRIS	2003	none	none		CSF : Acetone has not been classified as a carcinogen by EPA and has not be reviewed for carcinogenicity by NTP or IARC.
107131	Acrylonitrile	Yes	9.0E-05	ATSDR	2023	0.54	IRIS	1987	RfD from draft ATSDR (2023) provisional chronic MRL for GI affects in lifetime drinking water study in rats is selected over RfD of 1E-03 from HEAST (1993) for testicular effects in short-term (60-d) gavage study in mice.
15972608	Alachlor		5.0E-04	Cal-OEHHA	1997	see note			RfD from Cal PHG for alachlor (Cal EPA 1997) is protective of cancer and non-cancer effects and similar to IRIS RfD modified by additional UF of 10 for possible cancer (RfD: 0.001 mg/kg-d). A CSF is available from (Cal EPA1997) but was not

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
									used for PHG because it was derived using a linear approach that is not supported by animal toxicity data which indicate cancer induced by threshold mechanism.
116063	Aldicarb		1.0E-03	IRIS	1993	none	none		CSF: Aldicarb has not been classified as a carcinogen by EPA, NTP or IARC.
120127	Anthracene		3.0E-01	IRIS	1990	none	none		IARC (2023) classified anthracene as possible human carcinogen (2B). There is no CSF and IRIS RfD based on total UF of 3,000 precludes adding additional UF to address possible carcinogenicity. Use ATSDR intermediate MRL with mod for chronic (UF 10) and possible cancer (UF 3) would result in RfD of 0.3 that is identical to IRIS value. EPA and NTP have not classified anthracene as a carcinogen by EPA or NTP as of 12/2023.

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
7440360	Antimony		2.0E-04	ATSDR w/mod	2019	none	none		RfD: derived from ATSDR intermediate MRL of 0.0006 with the addition of UF v10 (i.e., 3) for chronic exposure. The RfD from modified MRL is similar to the non-cancer tox value from Cal OEHHA (1.4E-04) based on different effect but derived from the same study (Cal OEHHA, 2016). CSF: Antimony has not been classified as a carcinogen by EPA, NTP or IARC.
7440382	Arsenic	Yes	3.0E-04	IRIS	1991	1.5E+00	IRIS	1995	
1912249	Atrazine		3.0E-04	ATSDR w/mod	2003	See note			RfD from ATSDR intermediate MRL lowered by 3x for chronic and 3x for possible carcinogenicity; a CSF of 0.23/mg-kg-d from Cal EPA (1999) exists but relevance of mammary tumors has been questioned by EPA, ATSDR and other researchers. Atrazine has not been classified as a carcinogen by EPA, NTP or IARC.
7440393	Barium		2.0E-01	IRIS	2005	none	none		CSF: Barium has not been classified as a carcinogen by EPA, NTP or IARC.

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
71432	Benzene	Yes	4.0E-03	IRIS	2003	5.5E-02	IRIS	2000	Lower tox values are available but not recommended because findings may not be generalizable to U.S. general population and may overstate risk from benzene due to co-exposures to other VOCs in addition to benzene
56553	Benzo[a]anthracene	Yes	3.0E-02	DPH	2018	1.0E-01	RPF, see note	2017; 1993	RfD: Use 0.03 mg/kg-d as per DPH PAH memo to DEEP dated 4.4.2018. CSF based on EPA IRIS (2017) value for BAP; adjusted to RPF for benzo(a)anthracene (EPA 1993).
50328	Benzo(a)pyrene	Yes	3.0E-04	IRIS	2017	1.0E+00	IRIS	2017	
205992	Benzo(b)fluoranthene	Yes	3.0E-02	DPH	2018	1.0E-01	RPF, see note	2017; 1993	RfD: Use 0.03 mg/kg-d as per DPH PAH memo to DEEP dated 4.4.2018. CSF is based EPA IRIS (2017) value for BAP; adjusted to RPF for benzo(b)fluoranthene (EPA 1993).
207089	Benzo(k)fluoranthene	Yes	3.0E-02	DPH	2018	1.0E-02	RPF, see note	2017; 1993	RfD: Use 0.03 mg/kg-d as per DPH PAH memo to DEEP dated 4.4.2018. CSF is based EPA IRIS (2017) value for BAP; adjusted to RPF for benzo(k)fluoranthene (EPA 1993)

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
7440417	Beryllium		2.0E-04	IRIS w/mod	1998	none	none		IRIS RfD modified by additional UF of 10 for possible sensitization via dermal exposure (ATSDR 2023). CSF: none. NTP and IARC have classified Beryllium as a human carcinogen based on lung cancer via inhalation; evidence is limited for cancer following ingestion (EPA Group D carcinogen by oral route), therefore DPH did not modify oral RfD for possible carcinogenicity.
111444	Bis(2-chloroethyl)ether [BCEE]		none	none		1.1E+00	IRIS	1987	RfD: no appropriate toxicological data available
108601	Bis(2-Chloroisopropyl)ether [BCMEE]		1.0E-02	IRIS w/mod	1989	none	none		RfD: IRIS RfD with additional UF of 3 for possible carcinogenicity as per DPH memo to DEEP dated 5.8.18. CSF: No appropriate toxicological data are available; former HEAST cancer toxicity values are obsolete (EPA PPRTV 2011)
117817	Bis(2-ethylhexyl)phthalate [DEHP]		1.0E-04	ATSDR	2022	1.4E-02	IRIS	1988	
75252	Bromoform	Yes	2.0E-02	IRIS	1987	7.9E-03	IRIS	1990	Tox values are from DPH Memo (5.8.2018) to DEEP

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
78933	Butanone, 2- [MEK]		6.0E-01	IRIS	2003	none	none		
85687	Benzyl butyl phthalate		5.0E-02	IRIS w/mod	1989	none	none		RfD is modified by additional UF of 3 to address the possible carcinogenicity of BBP; A provisional CSF exists from PPRTV (2002) that is based on limited evidence and a linear approach that likely overestimates cancer risk as experimental data suggest a threshold mechanism
7440439	Cadmium		1.0E-04	ATSDR	2012	none	none		No CSF is available b/c evidence is insufficient for cancer from exposure to cadmium via ingestion (ATSDR 2012; EPA 1989). DPH did not modify RfD for potential carcinogenicity because Cd does not appear to be carcinogenic by the oral route.
56235	Carbon Tetrachloride		4.0E-03	IRIS	2010	7.0E-02	IRIS	2010	
12789036	Chlordane		5.0E-04	IRIS	1998	3.5E-01	IRIS	1998	
108907	Chlorobenzene		2.0E-02	IRIS	1989	none	none		CSF: chlorobenzene has not been classified as a carcinogen by EPA, NTP or IARC.

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
67663	Chloroform		1.0E-02	IRIS	2001	none	none		CSF: EPA considers the RfD of 0.01mg/kg/d adequately protective against cancer effect.
95578	Chlorophenol, 2-		5.0E-03	IRIS	1988	none	none		CSF: 2-Chlorophenol has not been classified as a carcinogen by EPA, NTP or IARC.
18540299	Chromium, hexavalent	Yes	9.0E-04	ATSDR	2012	5.0E-01	OEHHA	2011	
16065831	Chromium, trivalent		1.5E+00	IRIS	1998	none	none		CSF: trivalent chromium has not been classified as a carcinogen by EPA, NTP or IARC.
7440508	Copper		3.0E-03	ATSDR w/mod	2004	none	none		RfD: based on ATSDR (2004) intermediate MRL of 0.01 with an additional UF=3 to account for chronic duration. CSF: copper has not been classified as a carcinogen by EPA, NTP or IARC.
57125	Cyanide, free		6.3E-04	IRIS	2010	none	none		CSF: cyanide has not been classified as a carcinogen by EPA, NTP or IARC.
94757	Dichlorophenoxyacetic Acid, 2,4- [D, 2,4-]		1.0E-03	IRIS w/mod	1987	none	none		RfD: IRIS RfD with additional UF of 10 to account for possible carcinogenicity
124481	Dibromochloromethane	Yes	2.0E-02	IRIS	1987	8.4E-02	IRIS	1987; rev1992	
95501	Dichlorobenzene, 1,2-		9.0E-02	IRIS	1989	none	none		CSF: 1,2-dichlorobenzene has not been classified as a carcinogen by EPA, NTP or IARC.

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
541731	Dichlorobenzene, 1,3-		2.0E-03	ATSDR w/mod	2006	none	none		RfD is ATSDR intermediate oral MRL with additional UF=10 to account for exposure duration
106467	Dichlorobenzene, 1,4-		7.0E-02	ATSDR	2006	5.4E-03	OEHHA	1997	
75343	Dichloroethane, 1,1-		1.0E-02	HEAST w/mod	1997	none	none		
107062	Dichloroethane, 1,2-	Yes	2.0E-02	ATSDR w/mod	2022	9.1E-02	IRIS	1987	RfD is ATSDR draft int MRL with additional UF=10 to account for duration, also supported by PPRTV subchronic RfD
75354	Dichloroethylene, 1,1-		5.0E-03	IRIS w/mod	2002	none	none		RfD: IRIS RfD with additional UF of 10 to account for possible carcinogenicity
156592	Dichloroethylene, cis-1,2-		2.0E-03	IRIS	2010	none	none		CSF: Cis-1,2-dichloroethylene has not been classified as a carcinogen by EPA, IARC, or NTP
156605	Dichloroethylene, trans-1,2-		2.0E-02	IRIS	2010	none	none		CSF: Trans-1,2-DCE has not been classified as a carcinogen by EPA, IARC, or NTP.
120832	Dichlorophenol, 2,4-		3.0E-03	IRIS	1987	none	none		CSF: 2,4-dichlorophenol has not been classified as a carcinogen by EPA, NTP or IARC.
78875	Dichloropropane, 1,2-		2.0E-02	ATSDR w/mod	2021	3.6E-02	OEHHA	1999	RfD is based on ATSDR intermediate oral MRL with additional UF=3 (instead of 10 because cumulative UF would be 10000) to account for exposure duration

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
542756	Dichloropropene, 1,3-	Yes	3.0E-02	IRIS	2000	1.0E-01	IRIS	2000	
60571	Dieldrin		5.0E-05	IRIS	1988	1.6E+01	IRIS	1988	
84742	Di-n-butyl phthalate		1.5E-03	DPH	2018	none	none		RfD is from CalEPA Proposition 65 (MADL 2007) as per DPH memo to DEEP dated 5.8.18. CSF: Di-n-butyl phthalate has not been classified as a carcinogen by EPA, NTP or IARC.
117840	Di-n-octyl phthalate		1.0E-02	ATSDR w/mod	1997	none	none		RfD is from ATSDR intermediate MRL (1997) with additional UF of 10 for chronic exposure and UF of 3 for antiandrogenic effect of phthalates; CSF: Di-n-octyl phthalate has not been classified as a carcinogen by EPA, NTP or IARC.
72208	Endrin		3.0E-04	IRIS	1988	none	none		CSF: endrin has not been classified as a carcinogen by EPA, NTP or IARC.
100414	Ethylbenzene		1.0E-01	IRIS	1987	1.1E-02	OEHHA	2007	
106934	Ethylene dibromide	Yes	9.0E-03	IRIS	2004	2.0E+00	IRIS	2004	
206440	Fluoranthene		4.0E-02	IRIS	1990	none	none		CSF: fluoranthene has not been classified as a carcinogen by EPA, NTP or IARC.

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
86737	Fluorene		4.0E-02	IRIS	1990	none	none		CSF: fluorene has not been classified as a carcinogen by EPA, NTP or IARC.
76448	Heptachlor		5.0E-04	IRIS	1987	4.5E+00	IRIS	1987	
1024573	Heptachlor epoxide		1.3E-05	IRIS	1987	9.1E+00	IRIS	1987	
118741	Hexachlorobenzene		1.0E-05	DPH	2018	1.6E+00	IRIS	1991	RfD from DPH memo (5.8.2018) sent to DEEP.
67721	Hexachloroethane		7.0E-04	IRIS	2011	4.0E-02	IRIS	2011	
7439921	Lead		none			none			There is no RfD or CSF available. There is no threshold of effect for lead, therefore no RfD can be calculated. Lead exposure and health effects are assessed using EPA's toxicokinetic models (EPA 2003).
58899	Lindane		3.0E-04	IRIS	1987	1.1	OEHHA	2005	
7487947	Mercury - inorganic		3.0E-04	IRIS	1995	none	none		CSF: mercury has not been classified as a carcinogen by EPA, NTP or IARC.
72435	Methoxychlor		2.0E-03	IRIS w/mod	1990	none	none		RfD from IRIS with additional UF of 3 to address possible carcinogenicity.
108101	Methyl isobutyl ketone		8.6E-02	IRIS w/mod	2003	none	none		RfD from R-2-R extrapolation IRIS RfC based on systemic

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
									effects and modified by UF of 10 for possible carcinogenicity.
1634044	Methyl tert butyl ether		1.0E-02	ATSDR w/mod	2023	none	none		RfD is ATSDR intermediate oral MRL with additional UF=10 to account for exposure duration and UF of 3 for possible carcinogenicity. A CSF from Cal OEHHA exists based on low-dose linear extrapolation
75092	Methylene chloride	Yes	6.0E-03	IRIS	2011	2.0E-03	IRIS	2011	
91203	Naphthalene		2.0E-02	IRIS	1998	none	none		RfD value from DPH 4.4.2018 memo to DEEP.
7440020	Nickel		2.0E-03	IRIS w/mod	1991	none	none		IRIS RfD (1996) with additional UF of 10 to account for allergic sensitization potential which may cause low doses to be a risk for dermal reactions after initial exposure, and due to potential for more sensitive reproductive toxicity and possible oral cancer.
87865	Pentachlorophenol	Yes	2.5E-03	DPH	2018	4.0E-01	IRIS	2010	RfD value from DPH 5.8.2018 memo to DEEP.
85018	Phenanthrene		3.0E-02	DPH	2018	none	none		RfD value from DPH 4.4.2018 memo to DEEP; CSF : Phenanthrene has not been classified as a carcinogen by EPA, NTP or IARC.

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
108952	Phenol	Yes	3.0E-02	IRIS w/mod	2002	none	none		RfD is from IRIS (2002) with additional UF=10 to account for evidence on positive mutagenicity but limited evidence on carcinogenicity as per DPH memo to DEEP dated 5.8.18.
1336363	Polychlorinated biphenyls		2.0E-05	IRIS	1994	2	IRIS	1996	RfD from IRIS (1994) for Aroclor 1254 (11097-69-1) is most health protective value; CSF from IRIS (1996) for higher chlorinated "high risk" congeners. Evaluation on congener profile is recommended if criterion is exceeded.
129000	Pyrene		3.0E-02	IRIS	1990	none	none		CSF: pyrene has not been classified as a carcinogen by EPA, NTP or IARC.
7782492	Selenium		5.0E-03	IRIS	1991	none	none		CSF: selenium has not been classified as a carcinogen by EPA, NTP or IARC.
7440224	Silver		5.0E-03	IRIS	1991	none	none		CSF: silver has not been classified as a carcinogen by EPA, NTP or IARC.
122349	Simazine		5.0E-03	IRIS w/mod	1993	none	none		RfD from IRIS with additional UF of 10 for possible carcinogenicity - mammary tumors in rats; mixed genotoxic results (IARC, Vol 73, 1999).

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
100425	Styrene	Yes	7.0E-02	IRIS w/mod	1987	none	none		RfD from IRIS with additional UF of 3 to account for possible carcinogenicity (total UF =3000)
630206	Tetrachloroethane, 1,1,1,2-	Yes	3.0E-02	IRIS	1987	2.6E-02	IRIS	1987	
79345	Tetrachloroethane, 1,1,2,2-	Yes	2.0E-02	IRIS	2010	2.0E-01	IRIS	2010	
127184	Tetrachloroethylene		6.0E-03	IRIS	2012	2.1E-03	IRIS	2012	
7791120	Thallium		1.0E-05	Cal OEHHA	2004	none	none		RfD is from Cal OEHHA PHG (1999, update 2004)
108883	Toluene		2.0E-03	ATSDR	2017	none	none		
8001352	Toxaphene	Yes	2.0E-04	ATSDR w/mod	2014	1.1	IRIS	1988	RfD is ATSDR intermediate MRL (2014) with additional UF of 10 to account for chronic exposure.
71556	Trichloroethane, 1,1,1-		7.6E-02	CalPHG	2006	none	none		CSF: 1,1,1-Trichloroethane has not been classified as a carcinogen by EPA, NTP or IARC.
79005	Trichloroethane, 1,1,2-		4.0E-03	IRIS	1988	5.7E-02	IRIS	1987	
79016	Trichloroethylene	Yes	5.0E-04	IRIS	2011	9.3E-03 (kidney); 3.7E-02 (NHL + Liver)	IRIS	2011	CSFs are presented separately for kidney (which occurs through a known mutagenic MOA), and for liver and NHL combined (MOA unknown). Thus, ADAFs are only applied to the CSF for kidney cancer.

CASRN	Chemical Name	Mutagen	RfD (mg/kg-d)	Source of RfD Toxicity Value	RfD Date	Cancer Slope Factor (mg/kg/d) ⁻¹	Source of CSF Toxicity Value	CSF Date	Comment
1314621	Vanadium		9.0E-04	IRIS w/mod	1988	none	none		IRIS RfD modified by additional UF of 10 for potential increased toxicity from vanadium compounds other than vanadium pentoxide (PPRTV 2009)
75014	Vinyl chloride	Yes	3.0E-03	IRIS	2000	0.72	IRIS	2000	CSF is IRIS (2000) CSF for continuous lifetime exposure during adulthood using LMS method.
1330207	Xylenes		2.0E-01	IRIS	2003	none	none		
7440666	Zinc		3.0E-01	IRIS	2005	none	none		

Appendix A: Equations for Soil Exposure within a Managed Multifamily Residential Setting

Managed Multifamily Direct Exposure Criteria Formulas for Soil Exposures to Residents

Note: Default RSR criteria for non-carcinogens for this exposure scenario will be based on the Child Managed Multifamily Residential Exposures. The other equations are included for use in the TSD.

Equations for carcinogens, mutagens and Trichloroethylene also need to be provided within RSRs.

For Non-carcinogenic substances:

Child Resident Exposures

$$DEC_{C_MF_NC} \text{ (mg/kg)} = (RfD \times HI \times BW_{(0-6)} \times AT_{c_res}) / (SIR_{(0-6)_mf} \times EF_{res} \times ED_{(0-6)} \times CF_{soil})$$

Adult Resident Exposures (not needed in RSRs)

$$DEC_{A_MF_NC} \text{ (mg/kg)} = (RfD \times HI \times BW_a \times AT_{a_es}) / (SIR_{a_mf} \times EF_{res} \times ED_a \times CF_{soil})$$

Site Worker Exposures (not needed in RSRs)

$$DEC_{SW_MF_NC} \text{ (mg/kg)} = (RfD \times HI \times BW_a \times AT_{sw_mf}) / (SIR_{sw_mf} \times EF_{sw_mf} \times ED_{sw_mf} \times CF_{soil})$$

For substances that are carcinogenic:

Exposure to Site Workers: (not needed in RSRs)

$$DEC_{SW_MF_C} \text{ (mg/kg)} = (RL \times BW_a \times AT) / (CSF \times SIR_{sw_mf} \times EF_{sw_mf} \times ED_{sw_mf} \times CF_{soil})$$

Exposure to Child and Adult Residents:

$$DEC_{MFres_Cnm} \text{ (mg/kg)} = (RL \times AT) / (CSF \times CF_{soil} \times TSD_{mf})$$

$$TSD_{mf} \text{ (mg/kg)} = SD_{0-6mf} + SD_{amf}$$

$$SD_{0-6mf} \text{ (mg/kg)} = (SIR_{(0-6)mf} \times ED_{(0-6)} \times EF_{res}) / BW_{(0-6)}$$

$$SD_{amf} \text{ (mg/kg)} = (SIR_{amf} \times ED_a \times EF_{res}) / BW_a$$

For mutagenic substances:

Exposure to Child and Adult Residents:

$$DEC_{MFres_Cm} = (RL \times AT) / (CSF \times CF_{soil} \times TSDM_{mf})$$

Where:

$$TSDM_{mf} \text{ (mg/kg)} = SD_{0-2mf} + SD_{2-6mf} + SD_{6-16mf} + SD_{16-30mf}$$

$$SD_{0-2mf} \text{ (mg/kg)} = (SIR_{(0-2)_mf} \times ADAF_{(0-2)} \times ED_{(0-2)} \times EF_{res}) / BW_{(0-2)}$$

$$SD_{2-6mf} \text{ (mg/kg)} = (SIR_{(2-6)} \times ADAF_{(2-6)} \times ED_{(2-6)} \times EF_{res}) / BW_{(2-6)}$$

$$SD_{6-16mf} \text{ (mg/kg)} = (IR_{(6-16)} \times ADAF_{(6-16)} \times ED_{(6-16)} \times EF_{res}) / BW_{(6-16)}$$

$$SD_{16-30mf} \text{ (mg/kg)} = (IR_{(16-30)} \times ADAF_{(16-30)} \times ED_{(16-30)} \times EF_{res}) / BW_{(16-30)}$$

For Trichloroethylene

Exposure to Child and Adult Residents:

$$DEC_{mfTCE} = (RL \times AT) / ((CSF_{TCE-M} \times CF_{soil} \times TSDM_{mf}) + (CSF_{TCE-C} \times CF_{soil} \times TSD_{mf}))$$

$$TSDM_{mf} \text{ (mg/kg)} = SD_{0-2mf} + SD_{2-6mf} + SD_{6-16mf} + SD_{16-30mf}$$

$$SD_{0-2mf} \text{ (mg/kg)} = (SIR_{(0-2)_mf} \times ADAF_{(0-2)} \times ED_{(0-2)} \times EF_{res}) / BW_{(0-2)}$$

$$SD_{2-6mf} \text{ (mg/kg)} = (SIR_{(2-6)} \times ADAF_{(2-6)} \times ED_{(2-6)} \times EF_{res}) / BW_{(2-6)}$$

$$SD_{6-16mf} \text{ (mg/kg)} = (IR_{(6-16)} \times ADAF_{(6-16)} \times ED_{(6-16)} \times EF_{res}) / BW_{(6-16)}$$

$$SD_{16-30mf} \text{ (mg/kg)} = (IR_{(16-30)} \times ADAF_{(16-30)} \times ED_{(16-30)} \times EF_{res}) / BW_{(16-30)}$$

$$TSD_{mf} \text{ (mg/kg)} = SD_{0-6mf} + SD_{amf}$$

$$SD_{0-6mf} \text{ (mg/kg)} = (SIR_{(0-6)_mf} \times ED_{(0-6)} \times EF_{res}) / BW_{(0-6)}$$

$$SD_{amf} \text{ (mg/kg)} = (SIR_a \times ED_a \times EF_{res}) / BW_a$$

Exposure Values for Soil Exposures at Managed Multifamily Residential Sites			
Terms	Description	Value	Units
Criteria Types			
DEC _{C_MF_NC}	Direct Exposure Criteria for Soil Exposures to Child Residents in a Managed Multifamily Residential Setting	Chemical Specific	mg/kg
DEC _{A_MF_NC}	Direct Exposure Criteria for Soil Exposures to Adult Residents in a Managed Multifamily Residential Setting	Chemical Specific	mg/kg
DEC _{SW_MF_NC}	Direct Exposure Criteria for Soil Exposures to Site Workers in a Managed Multifamily Residential Setting Non Cancer	Chemical Specific	mg/kg
DEC _{SW_MF_C}	Direct Exposure Criteria for Soil Exposures to Site Workers in a Managed Multifamily Residential Setting (Carcinogen)	Chemical Specific	mg/kg
DEC _{MFres_Cnm}	Direct Exposure Criteria for Soil Exposures to Child and Adult Residents in a Managed Multifamily Residential Setting (Carcinogens)	Chemical Specific	mg/kg
DEC _{MFres_Cm}	Direct Exposure Criteria for Soil Exposures to Child and Adult Residents in a Managed Multifamily Residential Setting (Mutagens)	Chemical Specific	mg/kg
DEC _{mf.TCE}	Direct Exposure Criteria for Soil Exposures to Child and Adult Residents in a Managed Multifamily Residential Setting (Trichloroethylene)	Chemical Specific	mg/kg
Variables			
ADAF(0-2)	Age Dependent Adjustment Factor for mutagenic cancer risk - 0–2 years	10	unitless
ADAF(16-30)	Age Dependent Adjustment Factor for mutagenic cancer risk - ages 16–30 years	1	unitless

ADAF(2-6)	Age Dependent Adjustment Factor for mutagenic cancer risk - ages 2–6 years	3	unitless
ADAF(6-16)	Age Dependent Adjustment Factor for mutagenic cancer risk - ages 6–16 years	3	unitless
SDa_mf	Soil dose for adult residents in Multifamily Residential setting	5475	mg/kg
SD(0-6)_mf	Soil dose for ages 0–6 in Multifamily Residential setting	12658.95954	mg/kg
SD(0-2)_mf	Soil dose for ages 0–2 in Multifamily Residential setting	64,035.09	mg/kg
SD(2-6)_mf	Soil dose for ages 2–6 in Multifamily Residential setting	25,317.92	mg/kg
SD(6-16)_mf	Soil dose for ages 6–16 in Multifamily Residential setting	22,955.97	mg/kg
SD(16-30)_mf	Soil dose for ages 16–30 in Multifamily Residential setting	3,421.88	mg/kg
AT	Averaging Time - Carcinogens	25,550	days
ATa_PRec	Averaging Time - Adult Non-carcinogen (passive recreation exposure)	8,760	days
ATa_res	Averaging Time - Adult Non-carcinogen (residential exposure)	8,760	days
ATc_PRec	Averaging Time - Child Non-carcinogen (passive recreation exposure)	2,190	days
ATc_res	Averaging Time - Child Non-carcinogen (residential exposure)	2,190	days
ATsw_mf	Averaging Time Adult site worker non-carcinogen Multi-Family Residential Exposure Scenario	9,125	days
BW(0-2)	Body Weight - ages 0–2 years	11.4	kg
BW(0-6)	Body Weight - ages 0–6 years	17.3	kg
BW(16-30)	Body Weight - ages 16–30 years	80	kg
BW(2-6)	Body Weight - ages 2–6 years	17.3	kg
BW(6-16)	Body Weight - ages 6–16 years	47.7	kg
BWa	Body Weight - Adult	80	kg
CFsoil	Conversion Factor (kg/mg) for soil	0.000001	kg/mg
CSF	Cancer Slope Factor	chem specific	chem specific
CSF _{TCE-C}	Cancer Slope Factor for Trichloroethylene carcinogenic risks	chem specific	chem specific
CSF _{TCE-M}	Cancer Slope Factor for Trichloroethylene for mutagenic risks	chem specific	chem specific
ED(0-2)	Exposure Duration - ages 0–2 years	2	years
ED(0-6)	Exposure Duration - ages 0–6 years	6	years
ED(16-30)	Exposure Duration - ages 16–30 years	15	years

ED(2-6)	Exposure Duration - ages 2–6 years	4	years
ED(6-16)	Exposure Duration - ages 6–16 years	10	years
EDa	Exposure Duration - Adult	24	years
EDsw_mf	Exposure Duration site worker residential multifamily	25	years
EFres	Exposure Frequency Residential	365	days/year
EFsw_mf	Exposure Frequency site worker residential multifamily	250	days/year
HI	Hazard Index	1	unitless
TSDmf	Total Soil Dose for children and adults in a Multifamily Residential setting for exposures carcinogens	18,134.0	mg/kg
TSDMmf	Total Soil Dose for children and adults in a Multifamily Residential setting for exposures to mutagens	115,730.9	mg/kg
RfD	Reference Dose	chem specific	mg/kg/d
RL	Risk Level	0.000001	unitless
SIR(0-2)_mf	Soil Ingestion Rate - Residential Multifamily (ages 0–2 years)	100	mg/day
SIR(0-6)_mf	Soil Ingestion Rate - (ages 0–6 years) Residential Multifamily	100	mg/day
SIR(16-30)_mf	Soil Ingestion Rate - Residential Multifamily (age 16–30)	50	mg/day
SIR(2-6)_mf	Soil Ingestion Rate - Residential Multifamily (ages 2–6 years)	100	mg/day
SIR(6-16)_mf	Soil Ingestion Rate - (ages 6–16 years)	100	mg/day
SIRa_mf	Soil Ingestion Rate - Adult Residential Multifamily	50	mg/day
SIRsw_mf	Soil Ingestion Rate - Site Worker Residential Multifamily	100	mg/day

Appendix B: Equations for Soil Exposure within a Passive Recreation Setting

Note: Default RSR criteria for non-carcinogens for this exposure scenario will be based on the Child Passive Recreation Exposures. The adult non-cancer equation is included for use in the TSD.

Equations for carcinogens, mutagens and Trichloroethylene also need to be provided within RSRs.

For non-carcinogenic substances:

Child Passive Recreation Exposures

$$DEC_{C_PRec_NC} \text{ (mg/kg)} = (RfD \times HI \times BW_{(0-6)} \times AT_{c_PRec}) / (SIR_{(0-6)_PRec} \times EF_{PRec} \times ED_{(0-6)} \times CF_{soil})$$

Adult Resident Exposures (not needed in RSRs)

$$DEC_{A_PRec_NC} \text{ (mg/kg)} = (RfD \times HI \times BW_a \times AT_{a_PRec}) / (SIR_{a_PRec} \times EF_{PRec} \times ED_a \times CF_{soil})$$

For Carcinogenic substances:

Exposure to Child and Adult Passive Recreators:

$$DEC_{PRec_Cnm} \text{ (mg/kg)} = (RL \times AT) / (CSF \times CF_{soil} \times TSD_{PRec})$$

$$TSD_{PRec} \text{ (mg/kg)} = SD_{0-6PRec} + SD_{aPRec}$$

$$SD_{0-6PRec} \text{ (mg/kg)} = (SIR_{(0-6)_PRec} \times ED_{(0-6)} \times EF_{PRec}) / BW_{(0-6)}$$

$$SD_{aPRec} \text{ (mg/kg)} = (SIR_{aPRec} \times ED_a \times EF_{PRec}) / BW_a$$

For Mutagenic substances:

Exposure to Child and Adult Passive Recreators:

$$DEC_{\text{PRec_Cm}} = (\text{RL} \times \text{AT}) / (\text{CSF} \times \text{CF} \times \text{TSDM}_{\text{PRec}})$$

Where:

$$\text{TSDM}_{\text{PRec}} (\text{mg/kg}) = \text{SD}_{0-2\text{PRec}} + \text{SD}_{2-6\text{PRec}} + \text{SD}_{6-16\text{PRec}} + \text{SD}_{16-30\text{PRec}}$$

$$\text{SD}_{0-2\text{PRec}} (\text{mg/kg}) = (\text{SIR}_{(0-2)\text{PRec}} \times \text{ADAF}_{(0-2)} \times \text{ED}_{(0-2)} \times \text{EF}_{\text{PRec}}) / \text{BW}_{(0-2)}$$

$$\text{SD}_{2-6\text{PRec}} (\text{mg/kg}) = (\text{SIR}_{(2-6)\text{PRec}} \times \text{ADAF}_{(2-6)} \times \text{ED}_{(2-6)} \times \text{EF}_{\text{PRec}}) / \text{BW}_{(2-6)}$$

$$\text{SD}_{6-16\text{PRec}} (\text{mg/kg}) = (\text{SIR}_{(6-16)\text{PRec}} \times \text{ADAF}_{(6-16)} \times \text{ED}_{(6-16)} \times \text{EF}_{\text{PRec}}) / \text{BW}_{(6-16)}$$

$$\text{SD}_{16-30\text{PRec}} (\text{mg/kg}) = (\text{SIR}_{(16-30)\text{PRec}} \times \text{ADAF}_{(16-30)} \times \text{ED}_{(16-30)} \times \text{EF}_{\text{PRec}}) / \text{BW}_{(16-30)}$$

For Trichloroethylene – Carcinogenic and Mutagenic Risks

Exposure to Child and Adult Residents:

$$DEC_{PRecTCE} = (RL \times AT) / ((CSF_{TCE-M} \times CF_{soil} \times TSDM_{PRec}) + (CSF_{TCE-C} \times CF_{soil} \times TSD_{PRec}))$$

$$TSDM_{PRec} \text{ (mg/kg)} = SD_{0-2PRec} + SD_{2-6PRec} + SD_{6-16PRec} + SD_{16-30PRec}$$

$$SD_{0-2PRec} \text{ (mg/kg)} = (SIR_{(0-2)_{PRec}} \times ADAF_{(0-2)} \times ED_{(0-2)} \times EF_{PRec}) / BW_{(0-2)}$$

$$SD_{2-6PRec} \text{ (mg/kg)} = (SIR_{(2-6)_{PRec}} \times ADAF_{(2-6)} \times ED_{(2-6)} \times EF_{PRec}) / BW_{(2-6)}$$

$$SD_{6-16PRec} \text{ (mg/kg)} = (SIR_{(6-16)_{PRec}} \times ADAF_{(6-16)} \times ED_{(6-16)} \times EF_{PRec}) / BW_{(6-16)}$$

$$SD_{16-30PRec} \text{ (mg/kg)} = (SIR_{(16-30)_{PRec}} \times ADAF_{(16-30)} \times ED_{(16-30)} \times EF_{PRec}) / BW_{(16-30)}$$

$$TSD_{PRec} \text{ (mg/kg)} = SD_{0-6PRec} + SD_{aPRec}$$

$$SD_{0-6PRec} \text{ (mg/kg)} = (SIR_{(0-6)_{PRec}} \times ED_{(0-6)} \times EF_{PRec}) / BW_{(0-6)}$$

$$SD_{aPRec} \text{ (mg/kg)} = (SIR_{aPRec} \times ED_a \times EF_{PRec}) / BW_a$$

Exposure Values for Soil Exposures at Passive Recreational Sites			
Terms	Description	Value	Units
Criteria Types			
DEC _{C_PRec_NC}	Direct Exposure Criteria for Soil Exposures to Children aged 0-6 years in a Passive Recreation Setting (Non-cancer)	Chemical Specific	mg/kg
DEC _{A_PRec_NC}	Direct Exposure Criteria for Soil Exposures to Adult Residents in a Passive Recreation Setting (Non-cancer)	Chemical Specific	mg/kg
DEC _{PRec_Cnm}	Direct Exposure Criteria for Soil Exposures to Children and Adults in a Passive Recreation Setting (carcinogens)	Chemical Specific	mg/kg

DEC _{PRec_Cm}	Direct Exposure Criteria for Soil Exposures to Children and Adults in a Passive Recreation Setting (Mutagens)	Chemical Specific	mg/kg
DEC _{PRec_TCE}	Direct Exposure Criteria for Soil Exposures to Children and Adults in a Passive Recreation Setting (Trichloroethylene)	Chemical Specific	mg/kg
Variables			
ADAF(0-2)	Age Dependent Adjustment Factor for mutagenic cancer risk - 0–2 years	10	unitless
ADAF(16-30)	Age Dependent Adjustment Factor for mutagenic cancer risk - ages 16–30 years	1	unitless
ADAF(2-6)	Age Dependent Adjustment Factor for mutagenic cancer risk - ages 2–6 years	3	unitless
ADAF(6-16)	Age Dependent Adjustment Factor for mutagenic cancer risk - ages 6–16 years	3	unitless
SDa_Prec	Soil dose for adult residents in Multifamily Residential setting	4680	mg/kg
SD(0-6)_PRec	Soil dose for ages 0–6 in Multifamily Residential setting	7213.872832	mg/kg
SD(0-2)_PRec	Soil dose for ages 0–2 in Multifamily Residential setting	36,491.23	mg/kg
SD(2-6)_PRec	Soil dose for ages 2–6 in Multifamily Residential setting	14,427.75	mg/kg
SD(6-16)_PRec	Soil dose for ages 6–16 in Multifamily Residential setting	13,081.76	mg/kg
SD(16-30)_PRec	Soil dose for ages 16–30 in Multifamily Residential setting	2,925.00	mg/kg
AT	Averaging Time - Carcinogens	25,550	days
ATa_PRec	Averaging Time - Adult Non-carcinogen (passive recreation exposure)	8,760	days
ATc_PRec	Averaging Time - Child Non-carcinogen (passive recreation exposure)	2,190	days
BW(0-2)	Body Weight - ages 0–2 years	11.4	kg
BW(0-6)	Body Weight - ages 0–6 years	17.3	kg
BW(16-30)	Body Weight - ages 16–30 years	80	kg
BW(2-6)	Body Weight - ages 2–6 years	17.3	kg
BW(6-16)	Body Weight - ages 6–16 years	47.7	kg
BWa	Body Weight - Adult	80	kg
CFsoil	Conversion Factor (kg/mg) for soil	0.000001	kg/mg
CSF	Cancer Slope Factor	chem specific	chem specific
CSF _{TCE-C}	Cancer Slope Factor for Trichloroethylene non- mutagenic risks	chem specific	chem specific

CSF _{TCE-M}	Cancer Slope Factor for Trichloroethylene for mutagenic risks	chem specific	chem specific
ED(0-2)	Exposure Duration - ages 0–2 years	2	years
ED(0-6)	Exposure Duration - ages 0–6 years	6	years
ED(16-30)	Exposure Duration - ages 16–30 years	15	years
ED(2-6)	Exposure Duration - ages 2–6 years	4	years
ED(6-16)	Exposure Duration - ages 6–16 years	10	years
ED _a	Exposure Duration - Adult	24	years
EF_PRec	Exposure Frequency Recreation	208	days/year
HI	Hazard Index	1	unitless
TSDMPRec	Total Soil Dose for children and adults in a Passive Recreation setting for exposures to mutagens	66,925.7	mg/kg
TSDPRec	Total Soil Dose for children and adults in a Passive Recreation setting for exposures to Carcinogens	11,893.9	mg/kg
RfD	Reference Dose	chem specific	mg/kg/d
RL	Risk Level	0.000001	unitless
SIR _{(0-2)_PRec}	Soil Ingestion Rate - Passive Recreation ages 0–2 years	100	mg/day
SIR _{(0-6)_PRec}	Soil Ingestion Rate - Passive Recreation ages 0–6 years	100	mg/day
SIR _{(16-30)_PRec}	Soil Ingestion Rate - Passive Recreation ages 16–30 years	75	mg/day
SIR _{(2-6)_PRec}	Soil Ingestion Rate - Passive Recreation ages 2–6 years	100	mg/day
SIR _{a_PRec}	Soil Ingestion Rate - Passive Recreation Adult	75	mg/day
SIRC _{(6-16)_PRec}	Soil Ingestion Rate - Passive Recreation Ages 6–16 years	100	mg/day

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Appendix E: Reference Materials

Body Weight

Table 2: EFH Table 8-1 Recommended Values for Body Weight

Age Group	Mean (kg)	Multiple Percentiles	Source
Birth to <1 month	4.8		
1 to <3 months	5.9		
3 to <6 months	7.4		
6 to <11 months	9.2		
1 to <2 years	11.4	Table 8-3 through Table 8-5	U.S. EPA analysis of NHANES, 1999–2006 data
2 to <3 years	13.8		
3 to <6 years	18.6		
6 to <11 years	31.8		
11 to <16 years	56.8		
16 to <21 years	71.6		
Adults	80.0		

Table 3: EPA EFH Table 8-25 Estimated Body Weight of Typical Age Groups of Interest in U.S. EPA Risk Assessments

Age Group (years)	NHANES	Males (kg)			Females (kg)			Overall (kg)		
		Mean	SD	N	Mean	SD	N	Mean	SD	N
1 to 6	II	17.0	4.6	2,097	16.3	4.7	1,933	16.7	4.5	4,030
	III	16.9	4.7	3,149	16.5	4.9	3,221	16.8	5.0	6,370
	IV	17.1	4.9	633	17.5	5.0	541	17.3	5.0	1,174
7 to 16	II	45.2	17.6	1,618	43.9	15.9	1,507	44.8	17.5	3,125
	III	49.3	20.9	2,549	46.8	18.0	2,640	47.8	18.4	5,189
	IV	47.9	20.1	1,203	47.9	19.2	1,178	47.7	19.1	2,381
18 to 65	II	78.65	13.23	4,711	65.47	13.77	5,187	71.23	11.97	9,898
	III	82.19	16.18	6,250	69.45	16.55	7,182	75.61	18.02	13,462
	IV	85.47	19.03	1,908	74.55	19.32	2,202	79.96	20.73	4,110
65+	II	74.45	13.05	1,041	66.26	13.25	1,231	69.56	12.20	2,272
	III	79.42	14.66	1,857	66.76	14.52	1,986	72.25	15.71	3,843
	IV	83.50	16.35	547	69.59	14.63	535	75.54	15.88	1,082

^a Estimates were weighted using the sample weights provided with each survey.
SD = Standard deviation.
N = Number of individuals.

Source: Portier et al. (2007).

Updated Soil Ingestion Rates

Table 4: Recommended Soil and Dust Ingestion Rates from 2011 EFH

Table 5-1. Recommended Values for Daily Soil, Dust, and Soil + Dust Ingestion (mg/day) ^a								
Age Group	Soil + Dust		Soil ^b				Dust ^c	
	General Population Central Tendency ^d	General Population Upper Percentile ^e	General Population Central Tendency ^f	General Population Upper Percentile ^f	Soil Pica ^g	Geophagy ^h	General Population Central Tendency ^f	General Population Upper Percentile ^f
<6 months	40	100	20	50			20	60
6 months to <1 year	70 (60-80)	200	30	90			40	100
1 to <2 years	90	200	40	90	1,000	50,000	50	100
2 to <6 years	60	200	30	90	1,000	50,000	30	100
1 to <6 years	80 (60-100)	200	40	90	1,000	50,000	40	100
6 to <12 years	60 (60-60) ⁱ	200	30	90	1,000	50,000	30	100
12 years through adult	30 (4-50) ^j	100 ^j	10	50		50,000	20	60

^a Ranges are provided in parentheses, when applicable, and represent the range of means from the various studies. Ranges are not provided for age groups for which the recommendations are based on a single study.

^b Includes soil and outdoor settled dust.

^c Includes indoor settled dust only.

^d Based on the average of the central tendency values from the various studies for each of the three methodologies (tracer, biokinetic modeling, activity pattern), averaged over the three methods. Recommendation for <6 months of age based on Wilson et al. (2013) (note that data for 0 to <7 months in Wilson et al. [2013] were used to represent the 0 to <6 months age group). Recommendations for children 6 months to <1 year based on the average of values from Hogan et al. (1998) and von Lindern et al. (2016). Recommendations for 1- to 2 year-olds and 2- to <6-year-olds based on von Lindern et al. (2016). Recommendations for children ages 1 to <6 years based on the average of values from Calabrese et al. (1989) as reanalyzed in Stanek and Calabrese 1995a (mean of the median values for the best 4 tracers for each child); Calabrese et al. (1997a) (average of the best tracer for each child); Calabrese et al. (1997b) (average of aluminum and silicon); Davis et al. (1990) as reanalyzed by Stanek and Calabrese, 1995a (mean of the median values for 3 tracers for each child); Hogan et al. (1998); Özkaynak et al. (2011); von Lindern et al. (2016); and Wilson et al. (2013). The recommendations for ages 12 years to adults are based on the average of data for teens (ages 12 to <20 years), adults, and seniors from Wilson et al. (2013) and on adults from Davis and Mirick (2006). All recommended values were rounded to one significant figure. See Table 5-34 for additional details.

^e Based on the average of the 95th percentile values from the various studies for each of the three methodologies (tracer, biokinetic modeling, activity pattern), averaged over the three methods. Based on the 95th percentile values for the same studies as used for the central tendency estimates except for age 12 years through adults. Upper percentile recommendation for 12 years of age through adults based on the assumption that the ratio of the 95th percentile to the mean value for adults is the same as the average of the ratios of 95th percentiles to means for all other age groups (i.e., average ratio of the 95th percentile to mean recommendations = 3.2). See Table 5-34 for additional details.

^f Estimates of soil and dust were derived from the soil + dust values assuming 45% soil and 55% dust, rounded to one significant figure.

^g Professional judgement based on: ATSDR (2001); Barnes (1990); Calabrese et al. (1997b, 1991, 1989); Stanek et al. (1998).

^h Vermeer and Frate (1979).

ⁱ Range based on two studies with estimates of 55 and 56 mg/day; both of these estimates round to 60 mg/day.

^j Soil + dust ingestion rates may be higher for adults following a traditional rural or wilderness lifestyle. Based on Doyle et al. (2012) and Irvine et al. (2014) the central tendency adult soil + dust ingestion rates is 50 mg/day (20 mg/day soil and 30 mg/day dust) and the upper percentile rate is 200 mg/day (90 mg/day soil and 100 mg/day dust).

— = No data.

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