Soil Reference Value (SRV) Technical Support Document

Remediation and Environmental Analysis and Outcomes Divisions
Minnesota Pollution Control Agency

Minnesota Pollution Control Agency

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Acronyms

95 UCL	95% Upper Confidence Level of the Mean
ADAF	Age Dependent Adjustment Factor
ATSDR	Agency for Toxic Substances and Disease Registry
B[a]P	Benzo[a]pyrene
BMD	Benchmark Dose
BTV	Background Threshold Value
CAEPA	California Environmental Protection Agency
CDC	Centers for Disease Control
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
cPAH	Carcinogenic Polycyclic Aromatic Hydrocarbon
Csat	Soil Saturation Limit
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
EAO	Environmental Analysis and Outcomes
ELCR	Excess Lifetime Cancer Risk
EPA	Environmental Protection Agency
EPA's SSG	Environmental Protection Agency's Soil Screening Guidance
HBV	Health Based Value
HEAST	Health Effects Assessment Summary
HI	Hazard Index
HQ	Hazard Quotient
HRL	Health Risk Limits
IRIS	Integrated Risk Information System
ISV	Intrusion Screening Value
IUR	Inhalation Unit Risk
LOAEL	Lowest Observed Adverse Effect Level
MERLA	Minnesota Environmental Response and Liability Act
MDH	Minnesota Department of Health
MOA	Mode of Action
MPCA	Minnesota Pollution Control Agency
MRL	Minimum Risk Limits
NOAEL	No Observed Adverse Effect Level

PAH	Polycyclic Aromatic Hydrocarbon
PEF	Potency Equivalency Factor
PF	Particulate Emission Factor
PPRTV	Provisional Peer Reviewed Toxicity Values
Q/C	Inverse Mean Concentration at the Center of a Source
QA/QC	Quality Assurance/Quality Control
RAA	Risk Assessment Advice
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RfC	Reference Concentration
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RPF	Relative Potency Factor
RSL	Regional Screening Level
LUC	Land Use Category
SLV	Soil Leaching Value
SRV	Soil Reference Value
SVOC	Semi-Volatile Organic Compound
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEF	Toxicity Equivalency Factors
UF	Uncertainty Factor
VF	Volatilization Factor
VIC	Voluntary Investigation and Cleanup
VOC	Volatile Organic Compound
WHO	World Health Organization

1.0 Introduction

This technical support document (TSD) provides the basis for derivation of the Soil Reference Values (SRVs) and lists the risk evaluation concepts that were considered. It is a foundation document intended to be used by the Minnesota Pollution Control Agency's (MPCA) Voluntary investigation and Cleanup (VIC), Superfund and Resource Conservation and Recovery Act (RCRA) programs (abbreviated as "MERLA and RCRA programs" in this guidance) to create program specific guidance for using SRVs in a soil pathway investigation. It may also be used by other programs or entities to understand how the SRVs were derived and what items should be included in a soil pathway investigation that uses the SRVs. It is not intended to be any program's specific soil pathway investigation guidance. Program specific guidance should be followed to conduct a soil pathway investigation.

SRVs are a screening tool that may be used to evaluate potential human health risks from soil exposure. They were derived based on EPA Superfund methodology to be used by MPCA's MERLA and RCRA programs. Exposure assumptions based on specific land use categories (LUC) depicting a specific soil land use scenario and set of receptors are used. SRVs are not appropriate to use as a screening tool in other situations unless a thorough evaluation has been conducted to ensure their applicability.

SRVs applicable to most sites in Minnesota were derived to be used as screening values. Exceedance of a SRV indicates further investigation should be conducted to determine if there is an actual risk present on site. In some cases, it may be appropriate to use site specific SRVs as clean up values. Refer to program specific guidance to determine appropriate clean up values.

SRVs do not assess risks associated with soil contaminants leaching into groundwater or intrusion of soil contaminant vapors into buildings. Risks associated with these pathways are evaluated using other risk based values: Soil Leaching Values (SLVs) and Intrusion Screening Values (ISVs).

This guidance includes a description of the LUCs, the methodology and exposure assumptions used to derive SRVs and recommendations on using SRVs to conduct risk evaluations and site specific risk assessments. It is not intended to replace program specific soil investigation guidance.

This guidance is intended to be used in conjunction with the SRV Spreadsheet.

2.0 Land use categories

To evaluate potential risks at remediation sites from soil contaminants, land use categories (LUC) have been developed depicting specific scenarios and receptors. LUCs characterize two things: 1) LUC specific exposure parameters used to derive LUC specific SRVs and 2) accessible and potentially accessible zone depths that a human receptor is expected to access. LUCs are summarized in Table 1 and depicted in Figures 1 through 6. There are two clauses that apply to all of the LUCs explained below: Impervious Surface and Utility Corridor.

There are two sets of LUC SRVs: Residential/Recreational and Commercial/Industrial. Although the Residential/Recreational LUC has three sub categories: Single Family Homes, Multi-Family Housing and Recreational, all three use the same Residential/Recreational SRVs.

Although the LUCs are intended to be appropriate to use at the majority of remediation sites, there may be cases where a project team may need to deviate from the maximum depths listed based on site specific characteristics, such as they type and extent of contamination present or a site used in a way that does not fit into the typical LUCs. In these cases, the MPCA project team may use professional judgment to determine an appropriate maximum depth. The SRV TSD is not intended to be used as

program specific guidance. The inclusion of the LUCs in the SRV TSD is to establish the exposure scenarios used to derive SRVs for each LUC and describe the rationale for the maximum depths. Please refer to program specific guidance to determine how to perform a soil investigation for that specific program, including how SRVs will be used. Appropriate institutional controls will be included in program specific guidance.

Impervious surface

The impervious surface clause refers to soil beneath a newly constructed impervious surface, defined as pavements (example: roads, parking lots, sidewalks, driveways, trails) or basements made of an impervious surface, such as asphalt, concrete, stone or brick (Figure 1). Two feet of soil that does not exceed either 1) the surrounding LUC SRVs or 2) program determined clean up values should be placed under all newly constructed impervious surfaces except where an impervious surfaces already exists. Two feet of soil that either does not exceed 1) the surrounding LUC SRVs or 2) program determined clean up values should also be placed under newly constructed buildings. MPCA project teams have the right to require 2 feet or greater depths of soil that does not exceed LUC SRVs or program determined clean up values when site specific conditions require it to ensure potential receptors are adequately protected.

Utility corridor

Soil used to backfill a utility corridor during development shall not exceed 1) the SRVs for the planned LUC or 2) clean up levels established by a specific program (Figure 2).

Table 1: Land use categories

Land Use Category (LUC)	SLU Sub-Category	Exposure	Examples	Accessible Zone Depth	Potentially Accessible Zone Depth
Residential/Recreational	Single Family Homes (Figure 3)	Used by all ages Receptors are expected to contact soil with significant digging	Lawns surrounding single family homes	4 feet	12 feet
	Multi-Family Housing and Other Areas (Figure 4)	Used by all ages Receptors are expected to contact soil with somewhat significant digging	Lawns, yards, or landscaping surrounding multi-family housing, and "other areas" - long-term care facilities; correctional housing; hospitals; child care centers; churches; schools	4 feet	12 feet
	Recreational (Figure 5)	Used by all ages Receptors are expected to contact soil with less significant digging	Wildlife areas; local, state or national forests; public or private erodible trails; playgrounds; sports fields; beaches; campgrounds Maximum soil depth for an erodible trails is 2 feet measured from the trail disturb zone determined by trail use *	4 feet	12 feet
Commercial/Industrial	(Figure 6)	Commercial - used by all ages, children are not expected to spend a significant amounts of time at site Industrial - used by adult worker Receptors are expected to contact soil with less significant digging	Lawns, yards, or landscaping surrounding warehouses; public utilities; rail storage; freight storage; manufacturing facilities; restaurants, shopping malls, retail stores, hotels	4 feet	12 feet

* Trail disturb zone is the depth the trail may erode during use. For example, if an all-terrain vehicle (ATV) trail has a 6 inch disturb zone the 2 feet would start from the end of that 6 inch disturb zone.

Impervious Surface Clause

Two feet of soil that does not exceed SRVs of the surrounding planned land use category (LUC) or program defined cleanup values is required under a newly constructed impervious surface (including basements). This is not required under an already existing impervious surface.

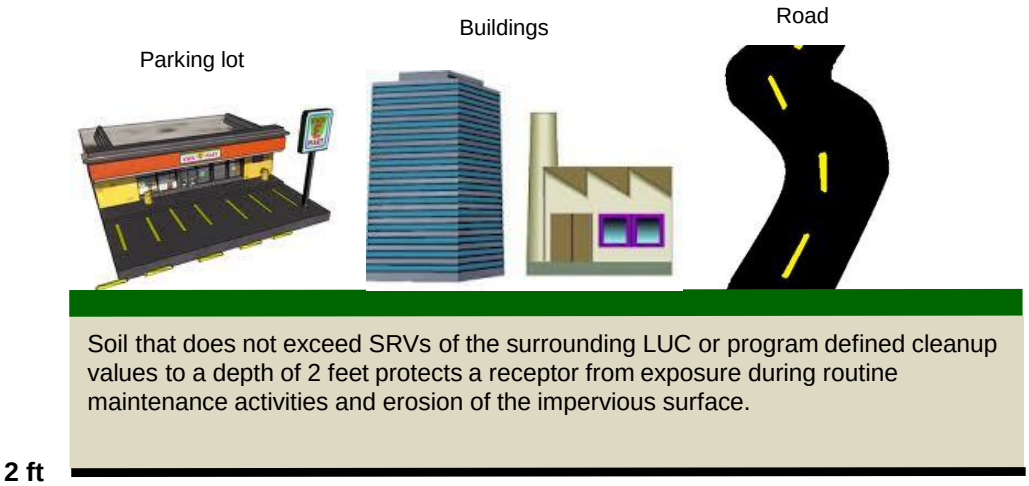


Figure 1. Impervious surface clause

Utility Corridor Clause

Soil used to backfill a utility corridor during development should not exceed SRVs for the planned land use category (LUC) or program defined cleanup values.

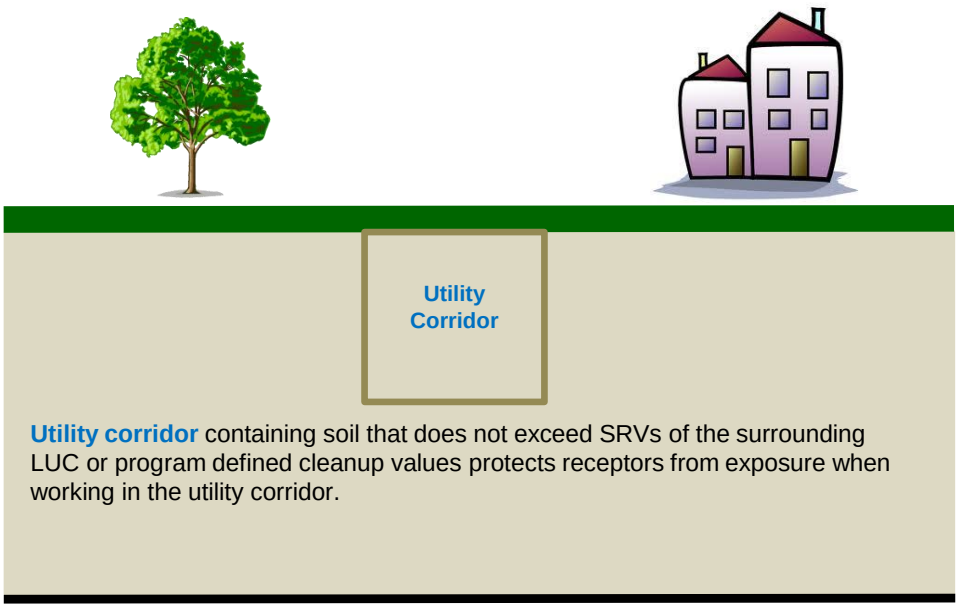


Figure 2. Utility corridor clause

Residential/Recreational – Single Family Homes

Land is used by all ages. Receptors are expected to contact soil with significant digging and may be exposed to soil while digging or to excavated soil that is left at the surface.

Soil that does not exceed Residential/Recreational SRVs or program defined cleanup values to a depth of 4 feet protects a receptor from exposure to soil at the surface and while digging during activities including planting trees and other vegetation, fence installation and gardening.

Although SRVs have **NOT been evaluated for any potential risks via plant uptake**, 4 feet is the maximum depth that garden grown produce roots are expected to grow.

Accessible Zone

4 ft

Soil that does not exceed Residential/Recreational SRVs or program defined cleanup values to a depth of 12 feet protects a receptor from exposure during utility work, excavation of soil during single family home construction activities and once the soil is brought to the surface and reused on site or another site.

Potentially Accessible Zone

12 ft

Figure 3. Residential/Recreational – Single family homes LUC

Residential/Recreational – Multi-Family Housing & Other Areas

Land is used by all ages. Receptors are expected to contact soil with somewhat significant digging and may be exposed to soil while digging or to excavated soil that is left at the surface.

Soil that does not exceed Residential/Recreational SRVs or program defined cleanup values to a depth of 4 feet protects a receptor from exposure to soil at the surface and while digging during activities including planting trees and other vegetation, fence installation and gardening.

Although SRVs have **NOT been evaluated for any potential risks via plant uptake**, 4 feet is the maximum depth that garden grown produce roots are expected to grow.

Accessible Zone

4 ft

Soil that does not exceed Residential/Recreational SRVs or program defined cleanup values to a depth of 12 feet protects a receptor from exposure during excavation of soil during utility work, most construction activities and once the soil is brought to the surface and reused on site or another site.

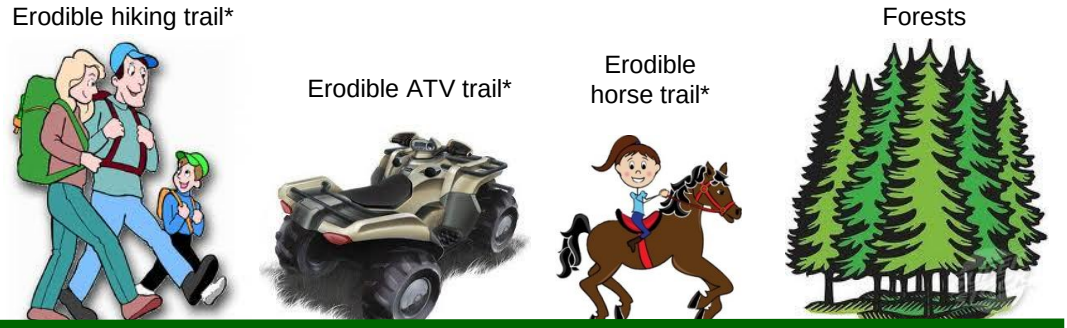
Potentially Accessible Zone

12 ft

Figure 4. Residential/Recreational – Multi-family housing & Other Areas LUC

Residential/Recreational – Recreational

Land is used by all ages. Receptors are expected to contact soil with less significant digging and may be exposed to soil while digging or to excavated soil that is left at the surface.



Soil that does not exceed Residential/Recreational SRVs or program defined cleanup values to a depth of 2 feet protects a receptor from exposure while participating in most recreational activities. 4 feet protects a receptor from exposure to soil at the surface and while digging during activities including planting trees and other vegetation and fence installation.

* For trails the 2 feet begins at the trails disturb zone determined by how much the soil is expected to erode based on the specific use of the trail. For example, if an ATV trail has a 6 inch disturb zone the 2 feet would start from the end of that 6 inch disturb zone.

Accessible Zone

4 ft

Soil that does not exceed Residential/Recreational SRVs or program defined cleanup values to a depth of 12 feet protects a receptor from exposure during excavation of soil during utility work, most construction activities and once the soil is brought to the surface and reused on site or another site.

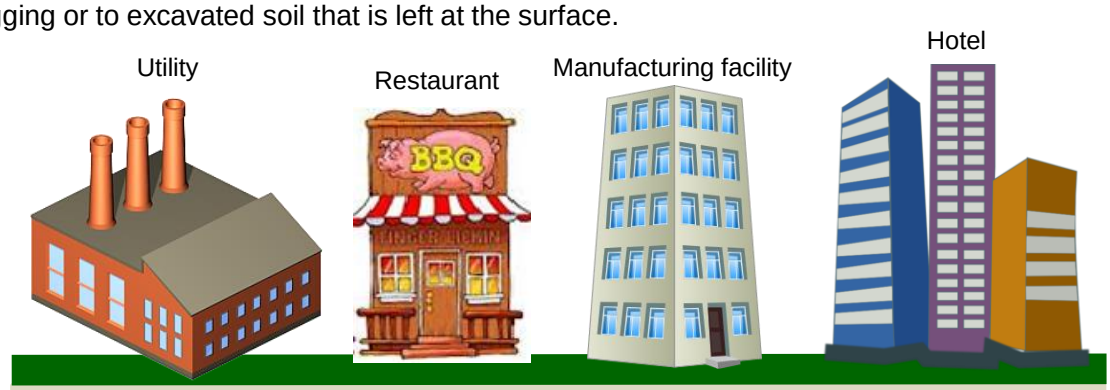
Potentially Accessible Zone

12 ft

Figure 5. Residential/Recreational – Recreational LUC

Commercial/Industrial

Commercial land is used by all ages. Industrial land is used by adult workers. Receptors are expected to contact soil with less significant digging and may be exposed to soil while digging or to excavated soil that is left at the surface.



Soil that does not exceed Commercial/Industrial SRVs or program defined cleanup values to a depth of 4 feet protects a receptor from exposure to soil at the surface and during routine maintenance activities such as planting trees and other vegetation and fence installation.

Accessible Zone

4 ft

Soil that does not exceed Residential/Recreational SRVs or program defined cleanup values to a depth of 12 feet protects a receptor from exposure during excavation of soil during utility work, most construction activities and once the soil is brought to the surface and reused on site or another site.

Potentially Accessible Zone

12 ft

Figure 6. Commercial/Industrial LUC

3.0 Derivation of soil reference values

SRVs are intended to be screening values. They were derived using the following:

- **Methodology** from the United States Environmental Protection Agency's (EPA) Superfund program for assessing risks associated with soil contamination
- **Exposure parameters** depicting a human receptor's exposure to contaminated soil in a specific LUC
- **Toxicity values** reflecting the potential toxicity of contaminants in soil
- **Chemical specific parameters** characterizing a contaminant's chemical and physical properties

Details regarding the derivation of SRVs for each LUC including methodology, exposure parameters, toxicity values and chemical specific parameters are in the SRV spreadsheet. This section provides general information regarding the derivation of the SRVs and refers to the SRV spreadsheet whenever possible. Therefore, this guidance is intended to be used in conjunction with the SRV spreadsheet. For additional information not covered in this guidance or the SRV spreadsheet please refer to the following United States Environmental Protection Agency's (EPA) guidance:

- EPA's 1996 Soil Screening Guidance: User's Guide
- EPA's 2002 Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites
- EPA's 2004 Risk Assessment Guidance for Superfund, Part E
- EPA's 2005 Supplemental Guidance for Assessing Susceptibility from Early-Life Exposures to Carcinogens
- EPA's 2008 Children's Specific Exposure Factor Handbook
- EPA's 2011 Exposure Factor Handbook
- EPA's 2014 Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Parameters memo

3.1 Methodology

SRVs were derived using the EPA's Superfund methodology for deriving EPA's regional screening levels (RSLs) for evaluating potential risks from contaminated soils at remediation sites (EPA 1996, EPA 2002). EPA's methodology is based on the reasonable maximum exposure (RME) concept which uses upper-bound estimates for the most sensitive exposure parameters and central tendency estimates for less sensitive exposure parameters to derive soil screening values. Upper bound estimates of the average exposure point concentrations are compared to the soil screening levels. RME is intended to be protective of the entire population, including sensitive individuals, while still being reasonable.

SRVs were derived to represent chronic, long term exposures to a contaminant. Acute, one-time event exposure SRVs have been developed for a small number of contaminants where acute exposure is of concern.

Chronic, long term exposures are evaluated by deriving two SRVs: one to assess cancer risks and one to assess noncancer chronic risks. Acute, shorter term exposures are evaluated by deriving one noncancer acute SRV.

Soil saturation concentration (Csat) is derived for any contaminant that is present as a liquid at ambient soil temperatures. It is not derived for contaminants that are present as solids at ambient temperature. Csat represents the concentration of a contaminant in soil at which soil pore water and pore air are

saturated with the chemical and the absorptive limit of the soil particles has been reached. Above Csat a contaminant may be present in free phase.

EPA has also established a maximum contaminant limit of 100,000 mg/kg which represents 10% by weight of a soil sample. Concentrations at the maximum contaminant limit and higher may violate the assumptions used to derive SRVs.

Final chronic SRVs are set at the lowest of the following values:

- Cancer SRV
- Noncancer Chronic SRV
- Soil Saturation Concentration (Csat)
- Maximum Contaminant Limit

Methodologies used to derive cancer, noncancer chronic and noncancer acute SRVs are described below. Equations and specific exposure parameters used to derive cancer SRVs, noncancer chronic SRVs, noncancer acute SRVs and Csat are provided in the SRV spreadsheet.

3.1.1 Cancer SRV methodology

Cancer SRVs include three routes of human exposure to soil:

- Incidental soil ingestion
- Dermal contact with soil
- Inhalation of fugitive soil dust and soil vapors

They do not include plant uptake of contaminants.

Consistent with EPA's Superfund methodology cancer SRVs were derived assuming a lifetime daily dose over 70 years and an exposure duration associated with receptors of a specific LUC. Age specific exposure parameters (such as body weight and surface area) were used for the following age brackets: 0 to 2 years, 2 to 16 years and 16 to 30 years.

Two methods can be used to account for early life sensitivity: 1) chemical specific adjustment factors and 2) default age dependent adjustment factors (ADAFs). Chemical specific adjustment factors are used if they are available. Default ADAFs are applied to contaminants determined to be a linear carcinogen per Minnesota Department of Health (MDH) guidance. Although EPA only applies default ADAFs to linear carcinogens with mutagenic mode of actions (MOAs), MDH has determined that it is more appropriate to apply ADAFs to all linear carcinogens regardless of the MOA.

Risks are characterized by using an excess lifetime cancer risk (ELCR) representing the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a carcinogen. An ELCR of 1E-05 or 1 additional case of cancer in 100,000 has been established as an acceptable risk level.

Contaminant soil concentrations resulting in cancer risk estimates less than an ELCR of 1E-05 are considered to be at acceptable risks levels and generally do not require risk management.

To assess additivity of cancer risks, individual contaminant cancer risks are summed regardless of cancer type. Additive cancer risks less than 1E-05 are considered acceptable and generally do not require risk management.

LUC specific cancer equations, exposure parameters and ADAFs are provided in the SRV spreadsheet.

3.1.2 Noncancer chronic SRV methodology

Noncancer chronic SRVs include three routes of human exposure to soil:

- Incidental soil ingestion
- Dermal contact with soil
- Inhalation of fugitive soil dust and soil vapors

They do not include plant uptake of contaminants.

Consistent with EPA's methodology noncancer chronic SRVs were derived based on exposure parameters applicable to specific LUCs.

A combined hazard quotient (HQ)/relative source contribution (RSC) of 0.2 is used to derive the SRVs applicable to the majority of sites in Minnesota. The use of a combined HQ/RSC accounts for the following:

- A receptors exposure to the same contaminant in other media such as groundwater, surface water or air
  - Using 0.2 assumes 20% of a receptors exposure to a specific contaminant will come from soil and the rest of their exposure from other media
- A receptors exposure to the same contaminant in different LUCs they may frequent such as school, home and work
- Potential additive risks from multiple contaminants present at a site

Individual contaminant soil concentrations resulting in noncancer risks less than a HQ of 1.0 are considered to be at acceptable levels and generally do not require risk management.

LUC specific noncancer chronic equations and exposure parameters are provided in the SRV spreadsheet.

3.1.3 Noncancer acute SRV methodology

Noncancer acute SRVs include one route of human exposure to soil:

- Deliberate soil ingestion by a child occurring in one event

They do not include dermal contact, inhalation of fugitive dust and soil vapors or plant uptake of contaminants.

Noncancer acute SRVs were only derived for the Residential/Recreational LUC based on a child age 1 to 3 years deliberately ingesting a bolus of soil during a single event. Soil pica behavior is common for children 1 to 3 years in age. The one time ingestion rate of 10,000 mg/event is based on a 1995 study by Stanek and Calabrese (also referenced by EPA 2011a and ATSDR 2011) that found 33% of children will ingest greater than 10,000 mg of soil 1 to 2 days per year.

Risks are characterized using a hazard quotient (HQ) of 1.0 for individual contaminants. Additivity is not assessed for noncancer acute risks.

The Residential/Recreational noncancer acute equation and exposure parameters are provided in the SRV spreadsheet.

3.2 Exposure parameters

LUC specific SRVs were derived using exposure parameters specific to the LUC. Exposure parameters were chosen based on the type of human receptor expected to be present at a LUC and their likely activities. Consistent with the RME concept, upper-bound estimates were used for the most sensitive exposure parameters and central tendency for those less sensitive. The majority of the exposure parameters used are those recommended in EPA's February 2014 Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Parameters memo (2014 memo) and EPA's 1996 Soil Screening Guidance: User's Guide and 2002 Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA's SSG). The different types of exposure parameters used in the SRVs are discussed below. A detailed list of the specific exposure parameters used for each LUC is provided in the SRV spreadsheet.

3.2.1 Exposure duration

Exposure duration depicts the number of years a human receptor is likely to be exposed to soil at a specific LUC. Since it is a sensitive exposure parameter it is appropriate to use an upper bound estimate. The appropriate estimate to use depends on the receptor type specific to the LUC. For example, for the Commercial/Industrial LUC the upper bound estimate of exposure duration is 25 years since it is possible there will be workers who will work for the same employer for 25 years. All exposure durations for LUCs included in EPA's 2014 memo were used as recommended. Exposure duration values used for each LUC category are listed in the SRV spreadsheet.

3.2.2 Exposure frequency

Exposure frequency depicts how often a human receptor may be exposed to soil via the following routes of exposure: ingestion, dermal contact and inhalation of fugitive dust and volatiles. It is intended to estimate how many times per year a human receptor may be exposed via these different routes. Since it is a sensitive exposure parameter it is appropriate to use an upper bound estimate. Exposure frequencies for LUC included in EPA's SSG were modified to reflect the climate in Minnesota.

The appropriate exposure frequency depends on the following:

- Type of human receptor specific to the LUC
- Exposure route
  - Ingestion
  - Dermal contact
  - Inhalation via fugitive dust
  - Inhalation via vapors
- Type of contaminant present
  - Volatile organic compounds (VOCs)
  - Non-VOCs

According to frost data from the Minnesota Department of Transportation and snow cover data from the Minnesota Office of Climatology, there are an average of 100 days per year in Minnesota when the ground is frozen and covered by 1 inch or more of snow. During these days it is not likely a human receptor will be exposed to outdoor soil via ingestion, dermal contact or inhalation of fugitive dust or vapors. However, a receptor may still be exposed to soil via ingestion of soil present in indoor dust during this 100 day time period.

Whether the contaminant is a VOC or non-VOC determines whether it is appropriate to include the dermal exposure route. Dermal exposure to VOCs will not occur unless a receptor is digging in the soil since VOCs will be depleted from the first 2 cm of the soil surface. If digging does occur, in most cases, it is likely that dermal exposure will not be significant since the VOCs will quickly evaporate from the soil and the receptor's skin. There are three chemicals where the dermal pathway is included even though the chemical is considered a VOC since the dermal pathway has been determined to be a significant route of exposure: chlordane, polychlorinated biphenyls (PCBs) and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) equivalents.

Table 2 provides the rationale used to determine when the 100 days should be eliminated from the exposure frequency and whether the dermal exposure routes should be included for VOCs and non-VOCs. Since the 100 days per year is representative of a human receptor that frequents the LUC year round, this number needs to be modified to account for the number of days per year a receptor of a specific LUC frequents that LUC. For example, workers are estimated to work 5 days per week. The 100 days of frozen and snow covered ground would need to be reduced to represent only the frozen and snow covered days that occur during the time the worker spends at work. Specific exposure frequencies for each LUC are listed in the SRV spreadsheet.

Table 2. Exposure frequency modifications

Exposure Route	VOC	Non-VOC
Ingestion	*Eliminate 100 days/year* Although ingestion exposure will occur both indoor and outdoor, VOCs will not be present in indoor dust due to their volatile nature	*Do NOT eliminate 100 days/year* Ingestion exposure will occur both indoor and outdoor and non-VOCs will be present in indoor dust
Dermal Contact	*NOT included for VOCs* Dermal contact is not considered to be a significant route of exposure for VOCs due to their volatile nature	*Eliminate 100 days/year* Dermal contact is considered to only be a significant route of exposure outdoors and will not occur when the ground is frozen and snow cover greater than 1 inch
Inhalation – Fugitive Dust	*NOT included for VOCs* Inhalation of fugitive dust is not considered to be a significant route for exposure for VOCs due to their volatile nature	*Eliminate 100 days/year* Fugitive dust is not expected to be present outdoors when the ground is frozen and snow cover greater than 1 inch
Inhalation – Vapors	*Eliminate 100 days/year* Vapors are not expected to be present outdoors when the ground is frozen and snow cover greater than 1 inch	*Eliminate 100 days/year* Vapors are not expected to be present outdoors when the ground is frozen and snow cover greater than 1 inch

3.2.3 Body weight

Body weight depicts the weight of the receptor that is likely to be present in a specific LUC. Since it is a less sensitive exposure parameter it is appropriate to use a central tendency estimate. All body weights were calculated using the same data used by EPA in the 2014 memo. Specific body weights and the calculations for each LUC are listed in the SRV spreadsheet.

3.2.4 Ingestion rate

Ingestion rate is the amount of soil a receptor is expected to incidentally ingest when participating in activities associated with the LUC. Since this is a sensitive exposure parameter it is appropriate to use an upper bound

estimate. All ingestion rates for LUCs included in EPA's 2014 memo used as recommended. Specific ingestion rate values used for each LUC are listed in the SRV spreadsheet.

3.2.5 Surface area

Surface area is the amount of a receptor's exposed skin during dermal contact with the soil. Since this is a less sensitive exposure parameter it is appropriate to use a central tendency estimate. Surface area estimates were calculated using the same data used by EPA in the 2014 memo. Specific surface areas and the calculations used are listed in the SRV spreadsheet.

3.2.6 Adherence factor

Adherence factor is the amount of soil expected to adhere to a receptor's exposed skin during dermal contact with the soil. The adherence factor is a sensitive exposure parameter that depends significantly on the type of activity a receptor is engaging in. To fit with the RME scenario, EPA recommends using a central tendency value from an activity that is likely to result in more soil adherence such as an adult gardening or a child playing in wet soil. Adherence factor estimates for receptors of all LUCs included in EPA's 2014 memo were used as recommended. Specific adherence factor values for each LUC are listed in the SRV spreadsheet.

3.2.7 Volatilization factor

The volatilization factor (VF) estimates the amount of a contaminant present in vapor that may be inhaled by a receptor. It relates the amount of contamination present in the soil to the amount that may be present in vapors released from subsurface soil. There is no consideration for vapors that may be present in the first 2 cm of the soil since any vapor in this area of the soil would be released to the air rapidly. EPA includes two different VFs that can be used to derive SRVs: standard VF and mass limit VF, both based on the same model. The standard VF uses chemical specific parameters but continues to include vapor exposure even after the starting material has been depleted, violating mass balance laws. The mass limit VF includes a thickness parameter that prevents mass balance violations but does not use any chemical specific parameters. EPA recommends deriving two SRVs: one using the standard VF and one using the mass limit VF. The final SRV is set to whichever value is greater. Both methods are upper end estimates of the potential vapor exposure a receptor may experience. Therefore, use of both VFs results in a more realistic but yet still conservative estimate of potential vapor inhalation risk.

Standard VF

All of the default parameters recommended in EPA's SSG were used to calculate the standard VF. The chemical specific parameters used in the calculation are discussed in Section 3.4 – Chemical Specific Parameters. The inverse of the mean concentration at the center of a 0.5 acre square source (Q/C) was used.

Mass limit VF

All of the default parameters recommended in EPA's SSG were used to calculate the mass limit VF. A default contamination thickness (average depth of source) parameter is not given since EPA recommends this be determined according to the site. MPCA has established a standard default thickness of 12 feet based on the following rationale:

- The average thickness of contamination present at most remediation sites is not greater than 12 feet.
- Setting a thickness parameter close to the greatest depth that a receptor is expected to access (Residential/Recreational LUC) will adequately protect a receptor that is accessing the soil as well as a receptor located above the soil surface in most cases.

- There are additional methods available to assess potential risks including: Vapor Intrusion Investigation using Intrusion Screening Values (ISVs), Soil Leaching Investigation using Soil Leaching Values (SLVs) and Groundwater Investigation using Health Risk Limits (HRLs) and other applicable groundwater values.
- MPCA MERLA and RCRA project teams are responsible to know if their specific site fits within the exposure parameters used to derive the SRVs applicable to the majority of sites in Minnesota listed on the SRV spreadsheet. If there is a potential volatilization issue at the site based on site specific data that does not fit these SRVs, such as the presence of a specific type of contaminant, especially high concentration of a contaminant or current and potential site use, the risk manager will deem the generic SRVs inappropriate for use.

T parameter

The T parameter in both volatilization factors has been determined to represent the time interval over which the contaminant present in the soil volatilizes. An estimate of the flux from the volatilized contaminant that reaches the air above the soil is averaged over T. This parameter does not represent the receptors exposure duration. Thirty years has been used for all volatilization factor T parameters as a reasonable estimate of the contaminants volatilization time interval. If this T does not appear reasonable for the specific contaminants at a site, the Remediation project team may request the assistance of the MPCA risk assessor to establish a reasonable site specific T parameter.

3.2.8 Particulate emission factor

The particulate emission factor (PF) estimates the concentration of a contaminant in fugitive dust that may be inhaled by a receptor. It relates the amount of a contaminant present in soil to the amount that may be present in fugitive dust. Only wind borne dust is included in the PF. Emissions from traffic and mechanical disturbances are not included. All of the default parameters provided in EPA's SSG were used to calculate the PF except for the fraction of vegetative cover for the Commercial/Industrial LUC. A value of zero was used for vegetative cover for the Commercial/Industrial LUC based on the potential for the lack of vegetative cover at this type of site. The inverse of the mean concentration at the center of a 0.5 acre square source (Q/C) was used.

3.3 Toxicity values

Toxicity values provide an estimate of a contaminant's toxicity which is used to determine an acceptable level of contamination in soil. SRVs use three types of toxicity values: cancer toxicity values to derive cancer SRVs, noncancer chronic toxicity values to derive noncancer chronic SRVs and acute toxicity values used to derive acute noncancer SRVs. Specific types of toxicity values used in SRVs are listed below.

- Cancer Toxicity Values – estimate of an increased cancer risk from a lifetime of exposure to a contaminant via the oral or inhalation routes of exposure
  - **Cancer Slope Factor** (CSF) – used to estimate cancer risks from oral and dermal routes (since there are typically no dermal toxicity values) of exposures
  - **Inhalation Unit Risk** (IUR) – used to estimate cancer risks from inhalation route of exposure
- Noncancer Chronic Toxicity Values – estimate of a continuous oral or inhalation exposure to the human population that is likely to not result in an appreciable risk
  - **Chronic Reference Dose (RfD)** – used to estimate noncancer risks from oral and dermal (since there are typically no dermal toxicity values) routes of exposures

    - **Chronic Reference Concentration (RfC)** – used to estimate noncancer risks from inhalation route of exposure
- Noncancer Acute Toxicity Values – estimate of an acceptable exposure to a child deliberately ingesting soil during a single event
    - **Acute Reference Dose** – used to estimate noncancer risks from oral exposures

Cancer, noncancer chronic and noncancer acute toxicity values used for specific contaminants are listed in the SRV spreadsheet.

3.3.1 Toxicity value hierarchy

The following hierarchy is generally followed to determine appropriate toxicity values to use for deriving cancer and noncancer chronic SRVs. In some cases the hierarchy is not followed if rationale exists to support a deviation from it for a specific contaminant. Noncancer acute toxicity value sources are discussed in Section 3.3.2 – Acute Toxicity Values.

- Minnesota Department of Health's Health Risk Values (HRV), Health Risk Limits (HRL), Health Based Values (HBV) or Risk Assessment Advice (RAA)
- EPA's Integrated Risk Information System's (IRIS) Reference Dose (RfD), Reference Concentration (RfC), Cancer Slope Factor (CSF) and Inhalation Unit Risk (IUR)
- EPA's Superfund Provisional Peer Reviewed Toxicity Values (PPRTVs) Reference Dose (RfD), Reference Concentration (RfC), Cancer Slope Factor (CSF) and Inhalation Unit Risk (IUR)
- Agency for Toxic Substances and Disease Registry's (ATSDR) Minimal Risk Levels (MRLs)
- California Environmental Protection Agency Office of Environmental Health Hazard Assessment's (OEHHA) Reference Exposure Levels and Cancer Potency Values
- EPA's Superfund Provisional Peer Reviewed Toxicity Values (PPRTV) Appendix Reference Dose (RfD), Reference Concentration (RfC), Cancer Slope Factor (CSF) and Inhalation Unit Risk (IUR)
- EPA's Superfund Health Effects Assessment Summary (HEAST) Reference Dose (RfD), Reference Concentration (RfC), Cancer Slope Factor (CSF) and Inhalation Unit Risk (IUR)
- Other sources such as other states that derive their own toxicity values may be used if 1) an appropriate dataset was used, 2) the derivation was based on current methodologies and 3) it was subject to peer review.

3.3.2 Acute toxicity values

Acute noncancer SRVs based on ingestion were derived for chemicals that are known historically to pose an acute risk from soil exposure. Since acute noncancer RfDs are not as readily available as chronic RfDs, an evaluation was conducted to determine the most appropriate toxicity value to use. In most cases the acute toxicity values were derived from effect levels. Evaluations conducted are summarized in Appendix A. Acute noncancer RfDs are listed in Table 3.

Table 3. Acute RfDs

Chemical	Acute RfD (mg/kg-event)
Arsenic	0.005
Barium	0.2 (Ch)
Cadmium	0.007
Copper	0.09
Cyanide	0.0056
Fluoride	0.5
Nickel	0.2
Pentachlorophenol	0.005
Phenol	1.0

Ch = Chronic RfD used since acute was less than chronic RfD

3.3.3 Benzo[a]Pyrene equivalents

On August 15, 2013, the Minnesota Department of Health (MDH) released "Guidance for Evaluating the Cancer Potency of Polycyclic Aromatic Hydrocarbon (PAH) Mixtures in Environmental Samples." This guidance was revised on October 31, 2014. MDH guidance recommends a revised method to evaluate carcinogenic PAHs (cPAHs) using relative potency factors (RPF) instead of potency equivalency factors (PEF) and an alternative surrogate mixture method using 7X the concentration of benzo[a]pyrene (B[a]P). Six new cPAHs have been added to the list to analyze and ten have been removed. Although it is MPCA's practice to adopt MDH's guidance, since laboratory analytical methods are not available to analyze the six additional cPAH compounds added to the RPF list, it is not feasible at this time. MPCA and MDH are working together to develop soil analytical methods for the new cPAH compounds. Once analytical methods have been established MPCA will re-evaluate the feasibility of implementing this guidance. Until then, MPCA will continue to use the PEF method (MDH's previous guidance) to evaluate human health risks from cPAHs as described below.

Previous guidance issued by MDH recommends evaluating 25 cPAHs that the California Environmental Protection Agency (CAEPA) has identified as being probable or possible human carcinogens (MDH 2001, CA EPA 1999). Since toxicity data does not exist for all individual cPAHs, they are evaluated according to how potent they are in relation to a reference contaminant, benzo[a]pyrene (B[a]P).

Assuming B[a]P has a toxicity of 1, other cPAHs are assigned a potency equivalency factor (PEF) to indicate how toxic they are in comparison to B[a]P. A list of PEFs for the 25 cPAHs is provided in the SRV spreadsheet.

Site soil concentrations of individual cPAHs are multiplied by the corresponding PEF values to obtain an individual B[a]P equivalent concentration. These individual B[a]P equivalent concentrations are summed for all cPAHs to arrive at a total B[a]P equivalent concentration that is compared to the appropriate SRV.

Based on the following factors, MPCA's MERLA and RCRA programs recommend evaluating only the "short list" of seven cPAHs provided on the SRV spreadsheet at the majority of sites.

- Source of extended list of cPAHs is only present at a minority of MERLA and RCRA sites
- Limitations of soil analytical methods for extended list of cPAHs
- Consistency with EPA and other states

MPCA's MERLA and RCRA programs do recommend evaluating the extended list of 25 cPAHs at the specific types of sites listed below.

- Source of contamination was from a combustion process such as an incinerator or open burning
- Environmental fingerprinting or forensics will be used to identify sources or waste streams
- Extended list of 25 cPAHs are a concern or have been previously identified
    - In this case contact the MPCA project team and the MPCA or MDH risk assessor to determine whether it necessary to evaluate the extended list of 25 cPAHs

Note: This section only pertains to cPAHs, which are evaluated by using B[a]P equivalents. Noncarcinogenic PAHs are evaluated individually and are not included in the total B[a]P equivalent concentration.

3.3.4 2,3,7,8 - Tetrachlorodibenzo-p-dioxin equivalents

MDH's dioxin policy recommends using the World Health Organization's (WHO) toxicity equivalency factors (TEFs) to evaluate dioxin-like compounds (MDH 2009). Since toxicity data does not exist for all individual dioxin-like compounds, they are evaluated according to how potent they are in relation to a reference contaminant, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).

Assuming TCDD has a toxicity of 1, other dioxin-like compounds are assigned a toxicity equivalency factor (TEFs) to indicate how toxic they are in comparison to TCDD. A list of TEFs for dioxin-like compounds is provided in the SRV spreadsheet.

Site soil concentrations of individual dioxin-like compounds are multiplied by the corresponding TEF value to obtain an individual TCDD equivalent concentration. These individual TCDD equivalent concentrations are summed for all dioxin-like compounds to arrive at a total TCDD equivalent concentration that is compared to the appropriate SRV.

3.4 Chemical specific parameters

The following chemical specific parameters were used in the derivation of the SRVs. Please refer to the SRV spreadsheet for a detailed list of the specific parameters that were used for a specific chemical. Table 4 lists the hierarchies for the chemical specific parameters which are modeled after the hierarchies EPA uses for their Regional Screening Values (RSLs).

- **Dermal Absorption Factor** – Estimates amount of a chemical that will be absorbed through the skin
- **Gastrointestinal Absorption Factor** – Estimates amount of a chemical that will be absorbed by the gastrointestinal system
- **Relative Bioavailability** – Estimates amount of a chemical that will be available inside an organism to cause an adverse effect
    - Generally limited to site specific risk assessments except in cases where there is sufficient data to provide a reasonable value to be used that would apply to all sites in Minnesota
- **Diffusivity in Air** – Estimates diffusion of a chemical into air
- **Diffusivity in Water** – Estimates diffusion of a chemical into water
- **Soil Organic Carbon Partition Coefficient** – Estimates to what degree a chemical will bind to the organic fraction of soil
- **Henry's Law** – Estimates vapor release from chemicals in soil
- **Solubility** – Estimate amount of chemical that can be dissolved in water

Table 4. Chemical specific parameter hierarchies

Priority	Dermal Absorption	Relative Bioavailability	Gastrointestinal Absorption	Air Diffusion	Water Diffusion	Koc[1]	Henrys Law	Solubility
1	EPA 2004	CSR	EPA 2004	WATER9	WATER9	EPI Suite - Est[2]	EPI Suite - Exp	EPI Suite - Exp
2	EPA 2012	EPA 1996		SSSG	SSSG	SSSG	SSSG	SSSG
3						YAWS - Est	YAWS - Exp	CRC
4						EPI Suite - Exp	EPI Suite - Est[3]	Perry
5						YAWS - Exp	PHYSPROP	Lange
6								YAWS - Exp
7								YAWS - Est
8								EPI Suite - Est
9								PHYSPROP

[1] - Not applicable to inorganics

[2] - For estimated Koc use the MCI method first, then the log Kow method.

[3] - For estimated Henry's Law use the GROUP method first, then the BOND method.

EPA 2004 - EPA's 2004 RAGS E, Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E: Supplemental Guidance for Dermal Risk Assessment): http://www.epa.gov/oswer/riskassessment/ragse/index.htm.

EPA 2012 - EPA's 2012 RSL Tables: http://www.epa.gov/region9/superfund/prg/.

CSR – Chemical specific reference that specifies a relative bioavailability (ex. ATSDR profile).

EPA 1996 - EPA's Soil Screening Guidance: User's Manual: http://www.epa.gov/superfund/health/conmedia/soil/index.htm.

EPI Suite Exp - Experimental Values, US EPA and Toxics and Syracuse Research Corporation (SRC), Estimation Interface (EPI) Suite: http://www.epa.gov/opptintr/exposure/pubs/episuite.htm.

SSSG - EPA, 2002, Supplemental Soil Screening Guidance: http://www.epa.gov/superfund/health/conmedia/soil/index.htm.

YAWS Exp - Knovel, 2003, Experimental Values, YAWS Handbook of Thermodynamic and Physical Properties of Chemical Compounds: http://why.knovel.com.

EPI Suite Est - Estimated Values, US EPA and Toxics and Syracuse Research Corporation (SRC), Estimation Interface (EPI) Suite: http://www.epa.gov/opptintr/exposure/pubs/episuite.htm.

PHYSPROP - Syracuse Research Corporation (SRC), 2005, PHYSPROP Database: http://www.syrres.com/what-we-do/product.aspx?id=133.

YAWS Est - Estimated Values, Knovel, 2003, YAWS Handbook of Thermodynamic and Physical Properties of Chemical Compounds: http://why.knovel.com/.

Baes - Baes, C.F., Oak Ridge National Laboratory, 1984, A Review and Analysis of Parameters for Asessing Transport of environmentally Released Radionucleotides through Agriculture: http://homer.ornl.gov/baes/documents/ornl5786.html. Values are also found in Superfund Chemical Data Matrix: http://www.epa.gov/superfund/sites/npl/hrsres/tools/scdm.htm.

CRC - CRC Handbook of Chemistry and Physics: http://www.hbcpnetbase.com/.

Perry - Green, Don W., Perry, Robert H., 2008, Perry's Chemical Engineer's Handbook: http://www.knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=2203&VerticalID=0.

Lange - Speight, James G., 2005, Lange's Handbook of Chemistry: http://www.knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=1347&VerticalID=0.

WATER9 - EPA's WATER9 software, available at http://www.epa.gov/ttn/chief/software/water/index.html.

4.0 Risk evaluation – Minimum requirements

This section includes the minimum requirements for using the SRVs in a risk evaluation but is not intended to replace program specific guidance. Risk evaluations use information obtained through site investigation to evaluate whether a human health risk exists at a site. There are two options: 1) conduct a **risk evaluation** explained in this section using SRVs derived to be applicable to a LUC for the majority of sites in Minnesota or 2) conduct a **site specific risk assessment** (Appendix B) using site specific SRVs derived using site specific information. Generally, it is more efficient to first conduct the risk evaluation before considering whether it is appropriate to conduct a site specific risk assessment.

SRVs evaluate chronic noncancer and cancer risks and acute noncancer risks for a limited number of chemicals (listed in Section 3.3.2). Any other potential subchronic, short-term or acute risks associated with a site should be evaluated using a site specific risk assessment (Appendix B).

4.1 Identify LUC and contaminants of potential concern

Site uses should be clearly identified to determine which LUC is appropriate for the site and identify the contaminants of potential concern (COPC). Table 1 and Figures 1 through 6 should be used to determine the appropriate LUC for the site. Any contaminants associated with site uses or that have been detected at the site should be included as COPCs.

4.2 Exposure pathways and receptors

All potential exposure pathways and receptors must be identified. For an exposure pathway to be complete, the following three conditions must exist:

- Source of contamination
- Exposure route
- Potential receptor

Possible routes of human health exposure to contaminants in soil include:

- Incidental soil ingestion
- Ingestion via produce
- Ingestion via food chain
- Dermal contact with soil
- Inhalation via fugitive dust
- Inhalation via volatilization - outdoor air
- Inhalation via volatilization - indoor air

Routes of exposure included in the derivation of SRVs are bolded. The inhalation via volatilization - indoor air route of exposure is evaluated during the vapor intrusion investigation. If any of the routes of exposure that are not bolded in the list apply to a site (except for the inhalation of volatilization – indoor air), a site specific risk assessment may be required (Appendix B).

Potential receptors on or off site that may be exposed to site soil contamination should be identified. It is also important to identify the most sensitive receptor that may be exposed.

In general, if there is no completed exposure pathway for a COPC then it can be eliminated.

4.3 Risk evaluation conceptual site model

A conceptual site model (CSM) used in a risk evaluation should clearly demonstrate site conditions impacting human health soil exposures and risks. At a minimum, the following items should be clearly illustrated in the CSM:

- Site geological and hydrogeological settings
- Location, concentration and volume of contamination
- Contaminant migration pathways
- Exposure pathways
- Potential receptors on and off site

4.4 Exposure area/point and exposure concentrations

An exposure area or exposure point is where a receptor contacts contaminated soil. Chronic, subchronic and short-term exposures typically occur in an exposure area, whereas acute exposure occurs at an exposure point. Due to the possible transport of contamination off site, exposure areas or points may be located on or off site. Site use should be taken into consideration when determining appropriate exposure areas and exposure points.

Samples from an exposure area may be averaged over the entire exposure area to arrive at an exposure area concentration. Exposure areas should be defined to include areas of contaminated soil only and should not contain uncontaminated soil. Including uncontaminated areas in the exposure area results in an underestimate of the actual exposure area concentration.

Exposure points should be defined by discrete samples with one exposure concentration.

Samples used to represent an exposure area or exposure point concentration should be representative of the area and depth to which the potential receptor may be exposed.

Areas containing significantly higher concentrations of contamination than surrounding areas are referred to as hot spots. These areas may have been subject to larger releases or contaminated in different ways than other areas of the site. All hot spots should be defined as distinct exposure areas and evaluated separately.

4.5 Sampling

Data obtained from sampling is used to estimate an exposure concentration used to evaluate potential risks. Appropriately designed sampling accomplishes the following:

- Determines presence or absence of contamination
- Identifies contaminants present
- Delineates both lateral and vertical extent of contamination
- Identifies hot spots
- Provides background concentrations

Two types of sampling designs commonly used are target (judgmental) and probabilistic sampling. In target sample locations are selected based on site information and professional judgment. In probabilistic sample locations are selected based on a random statistical model. Probabilistic models commonly used are: simple random, systematic/grid and stratified sampling.

Simple random is used when the population being sampled is homogeneous without potential hot spots. Sample locations are selected on a random basis so they are not necessarily uniformly distributed across the site. Systematic/grid is often used when little information is available about a site or to fully characterize a site. Sample locations are evenly distributed throughout the site using a grid. Stratified sampling separates a site into homogeneous groups or strata based on soil characteristics, site knowledge and professional judgment. Each strata is sampled independently using an appropriate method, most commonly systematic/grid. These sampling designs are discussed in greater detail in EPA's 2002 Guidance on Choosing a Sampling Design for Environmental Data Collection.

The type of sampling that will be most effective to adequately characterize a site will depend on sampling objectives, how much information is available regarding contaminant releases and site specific characteristics. For most situations a combination of two sampling methods, target and stratified, are recommended. Sites are typically divided into units that share common soil and COPC release characteristics and then sampled appropriately.

The default soil depth a receptor is likely to be directly exposed to will vary by LUC. Exposure concentrations to evaluate any potential risks from ingestion, dermal or inhalation via fugitive dust should be calculated from samples obtained from the surface to the depth a receptor is likely to have direct exposure to (Table 1 and Figures 1 through 6). If a situation exists on site that does not meet the assumptions used to establish the applicable LUC depth of exposure, the exposure concentration is required to be obtained from the site specific depth the receptor is likely to have direct exposure to.

When VOCs or semi-VOCs (SVOCs) are present, exposure concentrations to evaluate potential outdoor inhalation risk from vapor should be calculated from subsurface samples obtained from 2 cm below the soil surface to an appropriate depth based on the specific contaminant present and site characteristics.

Composite sampling

Composite sampling must be approved by the MPCA project team. If any of the following conditions apply, composite sampling should not be conducted:

- VOCs are being analyzed
- Soil samples that are not homogeneous
- Contaminant pattern is unknown or variable
- Matrix interference among contaminants is likely
- Acute risks are being evaluated (includes cases where the SRV is based on acute risks)

Maximum contaminant concentrations should be used to evaluate risks when using results from composite sampling.

Laboratory analysis

Analysis should be conducted for all COPCs and calculated on a total, dry weight basis. Appropriate quality assurance and quality control (QA/QC) procedures and methods with detection limits below the SRVs should be used.

For general considerations when designing a sampling plan please refer to Minnesota Pollution Control Agency Quality Assurance Project Plan Guidance and MPCA's Data Quality Objectives. Additional information can be found in EPA's SW-846 On-line.

Non-detects

The Kaplan Meier method available in EPA's ProUCL software should be used to evaluate non-detect data including calculations of 2,3,7,8-TCDD and Benzo[a]pyrene equivalents (please refer to the Soil Investigation Guidance for additional information.

Background concentrations

For some soil contaminants, existing published background concentrations may lack a sufficient number of samples, be based on outdated QA/QC procedures and/or may not accurately represent background concentrations. In these cases, site specific background data are preferred. The following items apply when obtaining background samples:

- Samples should be collected in areas that have not been impacted by environmental contamination from the site and must be representative of natural background concentrations
- Background samples should be of similar soil characteristics, geologic origin, hydrogeologic situation and depth bgs as the samples obtained from the site

Published background concentrations that are based on a sufficient number of samples, up to date QA/QC procedures and are expected to accurately represent background concentrations will be considered when appropriate.

4.6 Risk characterization

Risk characterization determines if there is a possibility that human health risks may exist at a site. The risk evaluation (screening evaluation) is performed by comparing site contaminant concentration to their LUC SRVs using the SRV spreadsheet. Based on the methodology used to derive the SRVs, the following sections recommend specific contaminant concentrations, such as 95% upper confidence level of the mean (95 UCL) or maximum, to use in specific situations. In some cases it may not be possible or appropriate to use these recommendations. For example, if data sets are small it may not be possible to calculate a 95 UCL. If it is not possible to calculate the 95UCL, reference program specific guidance and/or contact the MPCA project team.

Individual contaminant risks

The SRV spreadsheet applicable to all sites in Minnesota should be used for this evaluation. For discrete samples or to evaluate chronic noncancer or cancer risks the 95% upper confidence level of the mean (95 UCL) contaminant concentration should be used. If the 95 UCL is greater than the maximum concentration too few samples may have been obtained. In this case, if additional samples are not an option, the maximum concentration should be used. For composite samples or to evaluate acute noncancer risks the maximum contaminant concentration should be used.

Discrete samples or to evaluate ***chronic risks*****:**

- If 95 UCL contaminant concentration is equal to or less than applicable LUC chronic SRV, contaminant does not present an unacceptable human health risk and is not considered a contaminant of concern (COC)
- If 95 UCL contaminant concentration is equal to or less than site background, contaminant does not present an unacceptable human health risk and is not considered a COC
- If 95 UCL contaminant concentration is greater than applicable LUC chronic SRV, contaminant may present an unacceptable human health risk and is considered a COC
    - Exceedance of a chronic SRV indicates the need for further investigation to determine if a chronic risk exists – it does NOT indicate that a risk exists

- If 95 UCL contaminant concentration is greater than site background, contaminant may present an unacceptable human health risk and is considered a COC

Composite samples or to evaluate ***acute risks*****:**

- If maximum contaminant concentration is equal to or less than applicable LUC chronic SRV (composite samples) or acute SRV (acute risks), contaminant does not present a potential human health risk and is not considered a COC
- If maximum contaminant concentration is equal to or less than site background, contaminant does not present a potential human health risk and is not considered a COC
- If maximum contaminant concentration is greater than applicable LUC chronic SRV (composite samples) or acute SRV (acute risks), contaminant may present an unacceptable human health risk and is considered a COC
  - Exceedance of an acute SRV indicates the need for further investigation to determine if an acute risk exists – it does NOT indicate that a risk exists
- If maximum contaminant concentration is greater than site background, contaminant may present an unacceptable human health risk and is considered a COC

In general, if background concentrations exceed the LUC SRVs, it is appropriate to use the site background concentration as the SRV.

To determine the 95 UCL software such as EPA's ProUCL, R or Minitab should be used.

Potential risks for contaminants that are not listed in the SRV spreadsheet and lack sufficient toxicity data to derive a site specific SRV should be evaluated qualitatively (Appendix B).

Background threshold values (BTVs)

Ten of the soil reference values (SRVs) derived based on exposure parameters and toxicity values resulted in SRVs that were estimated as being potentially below background soil concentrations. An evaluation was conducted to determine if the health based SRV was below background concentrations and if necessary establish appropriate background values (Background Threshold Values or BTVs) that could be used instead of the health based SRV in MPCA's MERLA and RCRA programs.

MPCA's Remediation and Environmental Analysis and Outcome Divisions (EAO) conducted the evaluation to determine how the SRVs or BTVs for these 10 contaminants could be used at Remediation cleanup sites. Please refer to the "Background Threshold (BTV) Evaluation" document for additional information regarding that evaluation (MPCA 2015a).

If a BTV was established for a specific chemical, it will be listed in the SRV spreadsheet in place of the health based SRV. It is not appropriate to include BTVs in calculations of additive risk.

Additive risks

It is generally not necessary to perform a separate evaluation for additive risks when conducting a risk evaluation using the SRVs spreadsheet containing SRVs derived to be applicable to the majority of sites in Minnesota. These SRVs are derived using a combined hazard quotient (HQ)/relative source contribution (RSC) of 0.2 and an excess lifetime cancer risk (ELCR) of 1E-05 making them reasonably protective of potential additive noncancer and cancer risks at the majority of MERLA and RCRA sites. If there is a site specific characteristic that a MPCA project team identifies as being a potential additive risk concern, an additive risk evaluation may be required as part of a risk evaluation.

4.7 Uncertainty

Uncertainties that could have a significant effect on the outcome of the risk evaluation (either an under or over estimate of risks) may exist for two reasons:

- Lack of knowledge of the site which can be reduced by additional research or knowledge
  - Site specific data or information
  - Scientific information
- Natural variability which cannot be reduced by additional research or knowledge

There are many uncertainties involved in the risk evaluation. Some examples are exposure assumptions, sampling, laboratory analysis, toxicity information, contaminant speciation and professional judgment.

4.8 Conclusion

The results from a risk evaluation may include:

- Quantitative results from the SRV spreadsheet
  - Whether contaminant concentrations exceed their respective SRVs
  - Whether the additive risk evaluations exceed the target noncancer and cancer risk levels (when necessary to evaluate)
- Qualitative discussion of potential risks associated with contaminants lacking toxicity data
- Quantitative and/or qualitative discussion of uncertainty and how it may impact the quantitative results

If all contaminant concentrations are below the appropriate LUC SRVs and both noncancer and cancer additive risks are below target risks, it can be concluded that unacceptable human health risks do not exist at the site. If there are contaminant concentrations in exceedance of the appropriate LUC SRVs and/or noncancer or cancer additive risks are above target risks, this does not indicate there is an actual human health risk at the site. It indicates a need for further investigation by the specific program to determine if there may be an actual human health risk at the site.

5.0 References

ATSDR 2011. Agency for Toxic Substances and Disease Registry. Summary Report for the STSDR Soil Pica Workshop. July 5, 2011. http://www.atsdr.cdc.gov/child/soilpica.html.

CA EPA 1999. California Environmental Protection Agency. Air Toxics Hot Spot Program Risk Assessment Guidelines. http://oehha.ca.gov/air/hot_spots/.

EPA 1996. U.S. Environmental Protection Agency. Soil Screening Guidance: User's Guide. July 1996. http://www.epa.gov/superfund/health/conmedia/soil/index.htm.

EPA 2002. U.S. Environmental Protection Agency. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. December 2002. http://www.epa.gov/superfund/health/conmedia/soil/index.htm.

EPA 2002b. U.S. Environmental Protection Agency. Guidance on Choosing a Sampling Design for Environmental Data Collection. http://www.epa.gov/QUALITY/qs-docs/g5s-final.pdf.

EPA 2004. U.S. Environmental Protection Agency. Risk Assessment Guidance for Superfund, Part E. July 2004. https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e.

EPA 2005. U.S. Environmental Protection Agency. Supplemental Guidance for Assessing Susceptibility from Early Life Exposures to Carcinogens. March 2005. http://epa.gov/cancerguidelines/guidelines-carcinogen-supplement.htm.

EPA 2007. U.S. Environmental Protection Agency. SW-846 On-line. http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

EPA 2008. U.S. Environmental Protection Agency. Children's Specific Exposure Factor Handbook. September 2008. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=199243.

EPA 2011a. U.S. Environmental Protection Agency. Exposure Factor Handbook. September 2011. http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252.

EPA 2011b. U.S. Environmental Protection Agency. ProUCL Version 4.1.0, July 12, 2011. http://www.epa.gov/osp/hstl/tsc/software.htm.

EPA 2013. U.S. Environmental Protection Agency. Test Method Collection Website. http://www.epa.gov/osa/fem/methcollectns.htm.

EPA 2014. U.S. Environmental Protection Agency. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February, 2014. https://rais.ornl.gov/documents/OSWER-Directive-9200-1-120-Exposure-Factors_corrected.pdf.

MDH 2001. Minnesota Department of Health. 2001. Polycyclic Aromatic Hydrocarbons: Methods for Estimating Health Risks from Carcinogenic PAHs. http://www.health.state.mn.us/divs/eh/risk/guidance/pahmemo.html.

MDH 2009. Minnesota Department of Health. June 2009. Guidance for Dioxins – Methods for Estimating the Carcinogenic Health Risks from Dioxin-Like Compounds. http://www.health.state.mn.us/divs/eh/risk/guidance/dioxinmemo1.pdf.

MPCA 1998. Minnesota Pollution Control Agency. Remedy Selection Guidance. http://www.pca.state.mn.us/enzq83d.

MPCA 2011. Minnesota Pollution Control Agency. MPCA's Laboratory Quality Control and Data Policy. July 2011. https://www.pca.state.mn.us/about-mpca/mpca-quality-system. MPCA 2011a. Minnesota

Pollution Control Agency. MPCA's Laboratory Data Review Checklist Guidance. September 2011. https://www.pca.state.mn.us/about-mpca/mpca-quality-system. MPCA 2012. Minnesota Pollution Control Agency. Minnesota Pollution Control Agency Quality Assurance Project Plan Guidance. February 2012. http://www.pca.state.mn.us/ktqh3d9.

MPCA 2012a. Minnesota Pollution Control Agency. Data Quality Objectives. March 2012. http://www.pca.state.mn.us/ktqh3d9.

MPCA 2015. Minnesota Pollution Control Agency. Soil Reference Value (SRV) Spreadsheet. http://www.pca.state.mn.us/enzq83d.

MPCA 2015a. Minnesota Pollution control Agency. Background Threshold Value (BTV) Evaluation. http://www.pca.state.mn.us/enzq83d.

Appendix A: Derivation of acute RfDs

A.1 Arsenic

Acute arsenic toxicity results in gastrointestinal symptoms including nausea, vomiting and diarrhea and facial edema as the critical effects. Both symptoms subside when exposure is removed. Acute exposure may also result in the following other effects: respiratory effects including respiratory distress, hemorrhagic bronchitis and pulmonary edema; cardiac effects including altered myocardial depolarization (prolonged QT interval, nonspecific ST segment changes), cardiac arrhythmias and ischemic heart disease; and neurological effects including headache, lethargy, mental confusion, hallucination, seizures and coma (ATSDR 2007).

It is appropriate to use ATSDR's acute MRL of 5E-03 mg/kg-day based on gastrointestinal effects from poisoning to humans from contaminated soy sauce. Exposure lasted two to three weeks and the dose was estimated at 0.05 mg/kg-day. An uncertainty factor of 10 was used to account for the use of a lowest observed adverse effect level (LOAEL) instead of a no observed adverse effect level (NOAEL). This results in an *acute RfD of 5E-02 mg/kg-day*.

References

ATSDR 2007. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Arsenic. August 2007. http://www.atsdr.cdc.gov/toxprofiles/index.asp.

A.2 Barium

Acute barium toxicity usually begins with gastrointestinal symptoms including: abdominal pain, vomiting, diarrhea and weakness. Toxicity may progress to include more severe symptoms including: severe gastrointestinal hemorrhage, decreased blood potassium levels, cardiac arrhythmias, abnormal sensations that may begin in the mouth and spread to the extremities, muscle paralysis, complete quadriplegia, respiratory paralysis and death (Norberg et al. 2007, ATSDR 2007, IPCS 1991). It is not clear from the literature whether gastrointestinal effects always occur prior to the more severe effects (Lewi 1964, ATSDR 2007).

Several cases of accidental and intentional barium poisoning have been reported but do not have an associated effect level. Norberg et al. 2007 reports a lowest effect level of 3 mg/kg based on a dose of 200 to 500 mg of barium and an adult weight of 70 kg.

It is appropriate to use the effect level of 3 mg/kg from Norberg 2007. An uncertainty factor (UF) of 10 is applied to account for the use of a lowest observed adverse effect level (LOAEL) instead of a no observed adverse effect level (NOAEL) since it has been reported that paralysis has been observed prior to any gastrointestinal effects. An UF of 10 is also applied to account for intraspecies variability. This result in an acute reference dose (RfD) of 0.03 mg/kg-event which is lower than EPA's 2005 chronic RfD of 0.2 mg/kg-day. It is generally not appropriate to set an acute RfD lower than a chronic RfD. Therefore, the *acute RfD will be set at EPA's chronic RfD of 0.2 mg/kg-event*.

References

ATSDR 2007. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Barium and Barium Compounds. August 2007. http://www.atsdr.cdc.gov/toxprofiles/index.asp.

IPCS 1991. International Programme on Chemical Safety. Health and Safety Guide No. 46 – Barium. Geneva, Switzerland: United Nations Environment Programme, International Labour Organization, and the World Health Organization. 1991. http://www.inchem.org/pages/hsg.html.

Lewi 1964. Lewi, Z., Bar-Khayim, Y., Warsaw, D.M., and Jerasalem, M.D. (1964). Food-poisoning from barium carbonate. Lancet, 2:342-343.

Norberg et al. 2007. Norberg, G. F., Fowler, B.A., Norberg, M., Friberg, L. Handbook on the Toxicology of Metals. Third edition. Elsevier. 2007.

A.3 Cadmium

Acute cadmium toxicity begins with gastrointestinal symptoms including: nausea, vomiting, salivation, abdominal pain, cramps and diarrhea. No fatalities were reported in the literature and rapid recovery is experienced due to the low absorption rate of cadmium (ATSDR 2012, Norberg et al. 2007).

There are cases of accidental cadmium poisoning reported in the literature as a result of cadmium plated utensils, metal pitchers, ice cube trays, food molds, solder, pipes, beverage taps and refrigerators (Frant and Kleeman 1941, Lauwerys 1979, Norberg 2007, ATSDR 2012). Norberg 1973 (as reported in ATSDR 2012) reported an effect dose of 0.07 mg/kg based on an accidental poisoning case that occurred due to cadmium contamination of a soft drink machine.

It is appropriate to use the acute effect level from Norberg 1973 (also stated in ATSDR) of 0.07 mg/kg based on cadmium poisoning to humans caused by a soft drink machine. An UF of 3 is used to account for LOAEL to NOAEL with a less severe, transient effect and an UF of 3 is used to account for intraspecies variability. The result is an *acute RfD of 0.007 mg/kg-event*.

References

ATSDR 2012. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Cadmium. September 2012. http://www.atsdr.cdc.gov/toxprofiles/index.asp.

Frant and Kleeman 1941. Frant S, and Kleeman I. 1941. Cadmium 'food poisoning'. J Am Med Assoc. 117:86-89.

Norberg 1973. Nordberg GF, Slorach S, and Stenstrom T. 1973. Kadmiumforgiftning orsakad av kalidrycksoutumat. Lakartidningen 70:601 (as cited in ATSDR, 1999).

Norberg et al. 2007. Norberg, G. F., Fowler, B.A., Norberg, M., Friberg, L. Handbook on the Toxicology of Metals. Third edition. Elsevier. 2007.

Lauwerys, R. 1979. Cadmium in man. In Webb. Webb M, ed. NY, NY: Elsevier/North Holland Biomedical Press. The Chemistry, Biochemistry, and Biology of Cadmium. pp. 433-455.

A.4 Copper

Although copper is an essential element, acute copper toxicity may occur and begins with gastrointestinal symptoms including: nausea, vomiting, abdominal pain and diarrhea. Severe cases may result in liver and kidney damage (Norberg 2007). World Health Organization (WHO 1996) has established a recommended daily allowance (RDA) for copper of 0.09 mg/kg-day.

Several copper drinking water studies have been conducted where doses were established. An adult study conducted by Olivares 2001 reported a NOAEL of 2 mg/L and a LOAEL of 4 mg/L. Olivares 1998 conducted a study on infants that indicated no adverse effects in infants exposed to 2 mg/L copper. Two

additional adult studies conducted by Araya 2001, 2003 reported NOAELs of 2 and 0.8 mg/L, respectively. Spitalny 1984 reported symptoms in a family exposed to 2.8 to 7.8 mg/L. Nichloas 1968 reported symptoms in adult workers exposed to 0.07 mg/kg in drinking water. Knobeloch 1994 reported five copper poisoning cases, some of which were infants symptomatic after exposure to 0.16 to 7.8 mg/L of copper. Although the 1994 Knobeloch study documents infant acute symptoms at exposure concentrations below 2 mg/L, the infants were also exposed to nitrate in drinking water. Mild symptoms subside after exposure is eliminated.

It is appropriate to use the RDA of 0.09 mg/kg-day with UF of 1. It would be appropriate to use the 1998 Olivares study NOAEL of 2 mg/L which corresponds to a NOAEL of 0.2 mg/kg. However, after using an UF of 3 for intraspecies variability the resulting RfD would be 0.07 mg/kg, less than the RDA. It is appropriate to use the RDA as the *acute RfD, 0.09 mg/kg-event*.

References

Araya 2001. Araya M, McGoldrick MC, Klevay LM, et al. 2001. Determination of an acute no-observed-adverse-effect level (NOAEL) for copper in water. Regul Toxicol Pharmacol. 34(2):137-145.

Araya 2003. Araya M, Chen B, Klevay LM, et al. 2003. Confirmation of an acute no-observed-adverse-effect and low-observed-adverse-effect level for copper in bottled drinking water in a multi-site international study. Regul Toxicol Pharmacol. 38(3):389-399.

Knobeloch 1994. Knobeloch, L., Ziarnik, M., Howard, J., Theis, B., Farmer, D., Anderson, H., and Proctor, M. (1994). Gastrointestinal upsets associated with ingestion of copper-contaminated water. Environ. Health Perspect., 102:958-961.

Norberg et al. 2007. Norberg, G. F., Fowler, B.A., Norberg, M., Friberg, L. Handbook on the Toxicology of Metals. Third edition. Elsevier. 2007.

Nichloas 1968. Nicholas, P.O. (1966). Food Poisoning in the Morning Tea. The Lancet, 7558, 292.

Olivares 1998. Olivares M, Pizarro F, Speisky H, et al. 1998. Copper in infant nutrition: safety of World Health Organization provisional guideline value for copper content of drinking water. J Pediatr Gastroenterol Nutr. 26:251-257.

Olivares 2001. Olivares M, Araya M, Pizarro F, Uauy R. 2001. Nausea threshold in apparently healthy individuals who drink fluids containing graded concentrations of copper. Regul Toxicol Pharmacol. 33(3):271-275.

Spitalny 1984. Spitalny, K.C., Brondum, J., Vogt, R.L., Sargent, H.E., and Kappel, S. (1984). Drinking-water induced copper intoxication in a Vermont family. Pediatrics, 74:1103-1106.

WHO 1996. World Health Organization. Trace Elements in Human Nutrition and Health. 1996. http://www.who.int/nutrition/publications/micronutrients/9241561734/en/index.html.

A.5 Cyanide

Acute cyanide toxicity results in respiratory distress followed by convulsions, loss of consciousness, respiratory failure and death (ATSDR 2006).

Although cyanide poisoning has been widely studied, no lowest effect levels have been reported in the literature. ATSDR 2006 reports an average fatal dose of 1.52 mg/kg and a lowest fatal dose of 0.56 mg/kg from Gettler and Baine 1938.

It is appropriate to use the lowest fatal dose of 0.56 mg/kg from Gettler and Baine 1938 as cited in ATSDR 2006. An UF of 10 is applied to account for a severe lethal effect and an UF of 10 is applied to account for intraspecies variability. This results in an acute *RfD of 0.0056 mg/kg-event*.

References

ATSDR 2006. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Cyanide. July 2006. http://www.atsdr.cdc.gov/toxprofiles/index.asp.

Gettler and Baine 1938. Gettler, A.O. and Baine, J.O. (1938). The toxicology of cyanide. Am. J. Med. Sci., 195:182-198.

A.6 Fluoride

Acute fluoride toxicity begins with gastrointestinal symptoms including: nausea, vomiting, weakness, diarrhea, muscle twitching and excess salivation. Rapid recovery generally takes place once the exposure is eliminated (Hoffman 1980, ATSDR 2003).

Reports of accidental fluoride poisoning due to exposure via drinking water resulting from malfunctioning fluoridators have been reported in the literature. Hoffman 1980 reported a dose of 70 to 140 mg/kg caused gastrointestinal symptoms in children. Vogt 1982 estimated that a dose of 0.7 to 1.3 mg/kg caused nausea in adults and 2 to 3 mg/kg caused vomiting in adults. Two studies investigated reports of fluoride poisoning by poison control centers. Augenstien 1991 estimated an effect dose from 2 to 4 mg/kg and a lethal dose from 6 to 83 mg/kg. Spoerke 1980 estimated an effect dose of 50 to 225 mg/kg. A dose of 5 mg/kg where medical attention is required has been established by the Centers for Disease Control (CDC 1995) as reported in Whitman 1990 and as cited in ATSDR 2003 and Ellenhorn 1997.

It is appropriate to use 5 mg/kg based on CDC's recommended dose for seeking medical attention. There are other lower potential lethal doses reported from poison control centers but these doses cannot be verified. An UF of 10 was applied to account for a use of a LOAEL instead of a NOAEL. It is assumed that intraspecies variability was taken into consideration when the dose to received medical treatment was established. This results in an *acute RfD of 5 mg/kg-event*.

References

ATSDR 2003. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Fluoride, Hydrogen Fluoride and Fluorine. September 2003. http://www.atsdr.cdc.gov/toxprofiles/index.asp.

Augenstien 1991. Augenstein, L., Spoerke, D.G., Kulig, K.W., Hall, A.H., Hall, P.K., Riggs, B.S., Saadi, M.E., and Rumack, B.H. (1991). Fluoride ingestion in children: a review of 87 cases. Pediatrics, 88:907-912.

CDC 1995. Center for Disease Control. Morbidity and Mortality Weekly Report (MMWR). Engineering and administrative Recommendations for Water Fluoridation 1995. September 29, 1995. Vol. 44.

Ellenhorn 1997. Ellenhorn, M.J., Schonwald, S., Ordog, G., and Wasserberger, J. (1997). Ellenhorn's Medical. Toxicology: Diagnosis and Treatment of Human Poisoning, 2nd Edition. Baltimore, MD. Williams & Williams.

Hoffman 1980. Hoffman, R., Mann, J., Calderone, J., Trumbell, J., and Burkhart, M. (1980). Acute fluoride poisoning in a New Mexico elementary school. Pediatrics, 65:897-900.

Spoerke 1980. Spoerke, D.G., Bennett, D.L., and Gullekson, D.J.K. (1980). Toxicity related to acute low dose sodium fluoride ingestions. J. Fam. Practice, 10:139-140.

Vogt 1982. Vogt, R.L., Witherell, L., LaRue, D., and Klaucey, D.N. (1982). Acute fluoride poisoning associated with an on-site fluoridation in a Vermont elementary school. Am. J. Public Health, 72:1168-1171.

A.7 Nickel

Acute nickel toxicity results in nausea, vomiting, abdominal cramps, giddiness, lassitude, headache and cough (ATSDR 2005, Sunderman 1988). Although it is an essential trace element for several other species, the nutritional importance of nickel in humans has not been studied. Nickel is present in a wide variety of foods. There is no evidence that consumption of a normal amount of nickel in a human's diet will cause adverse effects. However, two studies report nickel ingestion from food may cause contact dermatitis in sensitive individuals (Cronin 1980, Gawkrodger 1986, ATSDR 2005).

Sunderman 1988 reported nausea, vomiting, abdominal cramps, giddiness, lassitude, headache and cough in adult workers exposed to 7 to 36 mg/kg in drinking water. Ten of these workers required hospitalization.

It is appropriate to use the lowest effect dose of 7 mg/kg from Saunderman 1988. An UF of 3 is applied to account for the use of a LOAEL instead of a NOAEL and an UF of 10 to account for intraspecies variability. Although 10 out of 20 people did require hospitalization, their exposure may have been increased compared to the 10 who did not require hospitalization and the UF of 10 for intraspecies variability appears to adequately cover this uncertainty. This results in an *acute RfD of 0.2 mg/kg-event*.

References

ATSDR 2005. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Nickel. August 2005. http://www.atsdr.cdc.gov/toxprofiles/index.asp.

Cronin 1980. Cronin, E., DiMichiel, A.D., and Brown, S.S. (1980). Oral challenge in nickel-sensitive women with hand eczema. In: Nickel Toxicology. (Brown, S.S., and F.W. Sunderman, Eds.).

Gawkrodger 1986. Gawkrodger, D.J., Cook, S.W., Fell, G.S., and Huner, J.A.A. (1986). Nickel dermatitis: the reaction or oral nickel challenge. Br. J. Dermatol., 115:33-38.

Sunderman 1988. Sunderman FW, Dingle B, Hopfer SM, and Swift T. 1988. Acute nickel toxicity in electroplating workers whom accidentally ingested a solution of nickel sulfate and nickel chloride. Am. J. Ind. Med. 14:257-266.

A.8 Pentachlorophenol

There are few reports regarding acute toxicity in humans following ingestion of pentachlorophenol. All of the cases reported in the literature lack exposure data and information regarding possible exposure to other chemicals. Symptoms associated with these cases include: hyperthermia generated by uncoupling of oxidative phosphorylation, hemolytic anemia, hepatic enlargement, dermal toxicity, chloracne and death (ATSDR 2001).

Animal studies report symptoms of vomiting, hyperpyrexia and elevated blood pressure, heart rate and respiration rate following acute exposures. ATSDR 2001 reports an acute oral minimum risk level (MRL) of 0.005 mg/kg-day based on delayed ossification of skulls in rat pups. Similar results have been observed in other animal studies.

MDH has derived an acute RfD of 0.0040 mg/kg/day (MDH 2013). UF factors applied include 3 for interspecies variability, 10 for intraspecies variability, 3 for a LOAEL to NOAEL and 3 for database uncertainty. Additivity endpoints include developmental and thyroid (endocrine disrupting). It is appropriate to use MDH's *acute RfD of 0.0040 mg/kg-event*.

References

ATSDR 2001. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Pentachlorophenol. September 2001. http://www.atsdr.cdc.gov/toxprofiles/index.asp.

MDH 2013. Minnesota Department of Health. Toxicological Summary for Pentachlorophenol (PCP). August 2013. http://www.health.state.mn.us/divs/eh/risk/guidance/gw/table.html.

A.9 Phenol

Acute phenol toxicity results in mouth sores, burning mouth, dark urine, diarrhea and in some cases death (ATSDR 2008, Baker 1978).

Bennett 1950 reported a lethal dose of 230 mg/kg. EPA 2002 estimates the lowest lethal doses range between 14 to 930 mg/kg. Baker 1978 reported a lowest effect level of 0.14 to 3.4 mg/kg-day. However, exposure data in this study was uncertain. A study conducted on cases at a poison control center reported a lowest effect dose for a child of 98 mg/kg (Spiller 1993). ATSDR 2008 reports an acute oral MRL of 1 mg/kg-day based on decreased fetal weight in a rat study using divided gavage dosing to reduce the increased toxicity with gavage dosing vs. drinking water exposure.

It is appropriate to use ATSDR's acute MRL of 1 mg/kg-day based on decreased fetal weight in a rat study. A BMD of 152 mg/kg-day was derived using EPA's software. An UF of 10 was used for intraspecies variability and another UF of 10 was used for interspecies variability resulting in an acute MRL of 1 mg/kg. This result in an *acute RfD of 1 mg/kg-event*.

References

ATSDR 2008. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Phenol. September 2008. http://www.atsdr.cdc.gov/toxprofiles/index.asp.

Baker 1978. Baker, E.L., Bertozzi, P.E., Field, P.H., Basteyns, B.J., and Skinner, H.G. (1978). Phenol poisoning due to contaminated drinking water. Arch. Environ. Health, 33:89-94.

Bennett, I.L., James, D.F., and Golden, A. (1950). Severe acidosis due to phenol poisoning.

Report of two cases. Ann. Intern. Med., 32:324-327.

Spiller HA, Quadrani-Kushner DA, and Cleveland P. 1993. A five year evaluation of acute exposures to phenol disinfectant (26%). Clin Toxicol. 31:307-313.

Appendix B: Site specific risk assessment – Minimum requirements

This section includes the minimum requirements for using the SRVs in a *site specific risk assessment* and is not intended to replace program specific guidance. *Site specific risk assessments are conducted to 1) evaluate an exposure pathway that exists on a site that is not included in the SRVs or 2) obtain a more realistic estimate of potential human health risks at a site using site specific information. A site specific risk assessment allows more flexibility when determining exposure concentrations and the use of site specific information to derive site specific SRVs. In comparison, a risk evaluation uses procedures for determining exposure concentrations and deriving SRVs that are applicable to the majority of sites in Minnesota.*

The site specific risk assessment procedure listed below has been modified from the risk evaluation procedure listed in Section 4.0. Much of the process will be identical. Parts of the process that are identical are listed in normal font. Items that differ between the two processes are listed in italics.

This assessment should be conducted using EPA's reasonable maximum exposure (RME) concept to provide a realistic and health protective estimate of risks. It should not be based on a worst case scenario.

SRVs evaluate chronic noncancer and cancer risks and acute risks for a limited number of chemicals (listed in Section 3.3.2). Any other potential subchronic, short-term or acute risks associated with a site should be evaluated.

B.1 Identify LUC and contaminants of potential concern

Site uses should be clearly identified to determine which LUC is appropriate for the site and identify the contaminants of potential concern (COPC). Table 1 and Figures 1 through 6 should be used to determine the appropriate LUC for the site. Any contaminants associated with site uses or that have been detected at the site should be included as COPCs.

B.2 Exposure pathways and receptors

All potential exposure pathways and receptors must be identified. For an exposure pathway to be complete, the following three conditions must exist:

- Source of contamination
- Exposure route
- Potential receptor

Possible routes of human health exposure to contaminants in soil include:

- **Incidental soil ingestion**
- Ingestion via produce
- Ingestion via food chain
- **Dermal contact with soil**
- **Inhalation via fugitive dust**
- **Inhalation via volatilization - outdoor air**
- Inhalation via volatilization - indoor air

Routes of exposure included in the derivation of SRVs are bolded. The inhalation via volatilization - indoor air route of exposure is evaluated during the vapor intrusion investigation. If any of the routes of exposure that are not bolded in the list apply to a site (except for the inhalation of volatilization – indoor air), a site specific risk assessment may be required (Appendix B).

Potential receptors on or off site that may be exposed to site soil contamination should be identified. It is also important to identify the most sensitive receptor that may be exposed.

In general, if there is no completed exposure pathway for a COPC then it can be eliminated.

B.3 Risk assessment conceptual site model

A conceptual site model (CSM) used in a risk evaluation should clearly demonstrate site conditions impacting human health soil exposures and risks. At a minimum, the following items should be clearly illustrated in the CSM:

- Site geological and hydrogeological settings
- Locations, concentrations and volumes of contamination
- Contaminant migration pathways
- Exposure pathways
- Potential receptors on or off site

B.4 Exposure area/point and exposure concentrations

An exposure area or exposure point is where a receptor contacts contaminated soil. Chronic, subchronic and short-term exposures typically occur in an exposure area, whereas acute exposure occurs at an exposure point. Due to the possible transport of contamination off site, exposure areas or points may be located on or off site. Site use should be taken into consideration when determining appropriate exposure areas and exposure points.

Samples from an exposure area may be averaged over the entire exposure area to arrive at an exposure area concentration. Exposure areas should be defined to include areas of contaminated soil only and should not contain uncontaminated soil. Including uncontaminated areas in the exposure area results in an underestimate of the actual exposure area concentration.

Exposure points should be defined by discrete samples with one exposure concentration.

Samples used to represent an exposure area or exposure point concentration should be representative of the area and depth to which the potential receptor may be exposed.

Areas containing significantly higher concentrations of contamination than surrounding areas are referred to as hot spots. These areas may have been subject to larger releases or contaminated in different ways than other areas of the site. All hot spots should be defined as distinct exposure areas and evaluated separately.

Area and time weighted exposure point concentrations

For the risk evaluation, the exposure concentration used is a spatial average and is assumed to be equal to the temporal average based on the following assumptions:

- *Soil concentrations remain constant over time. There is no mechanism decreasing contaminant concentrations over time, such as biodegradation.*
- *Samples represent a uniform, random distribution of soil samples over the entire exposure area.*

- *A receptor is equally likely to be exposed to any exposure points within the exposure area.*

Rationale and data should be provided for any adjustments made to an exposure concentration due to biodegradation.

In some cases, the spatial average exposure concentration is not equal to the temporal average exposure concentration. It may be appropriate to use area or time weighted exposure concentrations if detailed site specific exposure pattern information is known and if necessary, potential future site use is known and considered. This does require the approval of a MPCA or MDH risk assessor and the Remediation project team.

Area weighted exposure concentration

For cases where samples (contaminant concentrations) are not evenly spaced over the exposure area but a receptor's exposure is equally likely over the entire exposure area, an area weighted average exposure concentration can be calculated.

Time weighted exposure concentration

For cases where a receptor is not equally likely to be exposed over the entire exposure area but the samples are evenly spaced over the exposure area, a time weighted average exposure concentration can be calculated. In this case, the most conservative applicable exposure assumptions must be used to derive the site specific SRVs.

Soil concentration modeling

Data from actual sampling is the most accurate method of determining an exposure concentration and is always preferred. In some cases modeling may be appropriate if the site situation does not allow sampling.

B.5 Sampling

Data obtained from sampling is used to estimate an exposure concentration used to evaluate potential risks. Appropriately designed sampling accomplishes the following:

- Determines presence or absence of contamination
- Identifies contaminants present
- Delineates both lateral and vertical extent of contamination
- Identifies hot spots
- Provides background concentrations when necessary

Two types of sampling designs commonly used are target (judgmental) and probabilistic sampling. In target sample locations are selected based on site information and professional judgment. In probabilistic sample locations are selected based on a random statistical model. Probabilistic models commonly used are: simple random, systematic/grid and stratified sampling.

Simple random is used when the population being sampled is homogeneous without potential hot spots. Sample locations are selected on a random basis so they are not necessarily uniformly distributed across the site. Systematic/grid is often used when little information is available about a site or to fully characterize a site. Sample locations are evenly distributed throughout the site using a grid. Stratified separates a site into homogeneous groups or strata based on soil characteristics, site knowledge and professional judgment. Each strata is sampled independently using an appropriate method, most commonly systematic/grid. These sampling designs are discussed in greater detail in EPA's 2002 Guidance on Choosing a Sampling Design for Environmental Data Collection.

The type of sampling that will be most effective to adequately characterize a site will depend on sampling objectives, how much information is available regarding contaminant releases and site specific characteristics. For most situations a combination of two sampling methods, target and stratified, are recommended. Sites are typically divided into units that share common soil and COPC release characteristics and then sampled appropriately.

The default soil depth a receptor is likely to be directly exposed to will vary by LUC. Exposure concentrations to evaluate any potential risks from ingestion, dermal or inhalation via fugitive dust should be calculated from samples obtained from the surface to the depth a receptor is likely to have direct exposure to (Table 1 and Figures 1 through 6). If a situation exists on site that does not meet the assumptions used to establish the applicable LUC depth of exposure, the exposure concentration is required to be obtained from the site specific depth the receptor is likely to have direct exposure to.

When VOCs or SVOCs are present, exposure concentrations to evaluate potential outdoor inhalation risk from vapor should be calculated from subsurface samples obtained from 2 cm below the soil surface to an appropriate depth based on the specific contaminant present and site characteristics.

Composite sampling

Composite sampling must be approved by the MPCA project team. If any of the following conditions apply, composite sampling should not be conducted:

- VOCs are being analyzed
- Soil samples that are not homogeneous
- Contaminant pattern is unknown or variable
- Matrix interference among contaminants is likely
- Acute risks are being evaluated (includes cases where the SRV is based on acute risks)

Maximum contaminant concentrations should be used for composite samples.

Laboratory analysis

Analysis should be conducted for all COPCs and calculated on a total, dry weight basis. Appropriate quality assurance and quality control (QA/QC) procedures and methods with detection limits below the SRVs should be used.

For general considerations when designing a sampling plan please refer to Minnesota Pollution Control Agency Quality Assurance Project Plan Guidance and MPCA's Data Quality Objectives. Additional information can be found in EPA's SW-846 On-line.

Data presentation

Sampling data should be presented in a clear and concise manner in tables and include the following statistics:

- *Results of each individual sample*
- *Detection limit and type of detection limit*
- *Number of observations*
- *Frequency of detection*
- *Maximum*
- ***Minimum***
- ***Median***
- ***Arithmetic mean and standard deviation***

- ***95% upper confidence level of the mean (95UCL)***
- ***Identify samples designated with J to reflect an estimated concentration***

For composite samples maximum concentrations should be used. It is not appropriate to report the items ***bolded*** *in the list above for composite samples.*

Non-detects

The Kaplan Meier method available in EPA's ProUCL software is recommended to evaluate non-detect data including calculations of 2,3,7,8-TCDD and Benzo[a]pyrene equivalents (please refer to the Soil Investigation Guidance for additional information.

Background concentrations

For some soil contaminants, existing published background concentrations may lack a sufficient number of samples, be based on outdated quality assurance/quality control (QA/QC) procedures and/or may not accurately represent background concentrations. In these cases, site specific background data are preferred. The following items apply when obtaining background samples:

- Samples should be collected in areas that have not been impacted by environmental contamination from the site and must be representative of natural background concentrations
- Background samples should be of similar soil characteristics, geologic origin, hydrogeologic situation and depth bgs as the samples obtained from the site

Published background concentrations that are based on a sufficient number of samples, up to date QA/QC procedures and are expected to accurately represent background concentrations will be considered when appropriate.

B.6 Risk characterization

Risk characterization determines if there is a possibility that human health risks may exist at a site. The risk evaluation (screening evaluation) is performed by comparing site contaminant concentration to their LUC SRVs using the SRV spreadsheet. Based on the methodology used to derive the SRVs, the following sections recommend specific contaminant concentrations, such as 95% upper confidence level of the mean (95 UCL) or maximum, to use in specific situations. In some cases it may not be possible or appropriate to use these recommendations. For example, if data sets are small it may not be possible to calculate a 95 UCL. If it is not possible to calculate the 95UCL, reference program specific guidance and/or contact the MPCA project team.

Individual contaminant risks

The SRV spreadsheet – Site Specific should be used for this evaluation. For discrete samples or to evaluate chronic noncancer or cancer risks the 95% upper confidence level of the mean (95 UCL) contaminant concentration should be used. If the 95 UCL is greater than the maximum concentration too few samples may have been obtained. In this case, if additional samples are not an option, the maximum concentration should be used. For composite samples or to evaluate acute noncancer risks the maximum contaminant concentration should be used.

Discrete samples or to evaluate **chronic risks:**

- If 95 UCL contaminant concentration is equal to or less than applicable LUC chronic SRV, contaminant does not present an unacceptable human health risk and is not considered a contaminant of concern (COC)

- If 95 UCL contaminant concentration is equal to or less than site background, contaminant does not present an unacceptable human health risk and is not considered a COC
- If 95 UCL contaminant concentration is greater than applicable LUC chronic SRV, contaminant may present an unacceptable human health risk and is considered a COC
    - Exceedance of a chronic SRV indicates the need for further investigation to determine if a chronic risk exists – it does NOT indicate that a risk exists
- If 95 UCL contaminant concentration is greater than site background, contaminant may present an unacceptable human health risk and is considered a COC

Composite samples or to evaluate **acute risks:**

- If maximum contaminant concentration is equal to or less than applicable LUC chronic SRV (composite samples) or acute SRV (acute risks), contaminant does not present a potential human health risk and is not considered a COC
- If maximum contaminant concentration is equal to or less than site background, contaminant does not present a potential human health risk and is not considered a COC
- If maximum contaminant concentration is greater than applicable LUC chronic SRV (composite samples) or acute SRV (acute risks), contaminant may present an unacceptable human health risk and is considered a COC
    - Exceedance of an acute SRV indicates the need for further investigation to determine if an acute risk exists – it does NOT indicate that a risk exists
- If maximum contaminant concentration is greater than site background, contaminant may present an unacceptable human health risk and is considered a COC

In general, if background concentrations exceed the LUC SRVs, it is appropriate to use the site background concentration as the SRV.

To determine the 95 UCL software such as EPA's ProUCL, R or Minitab should be used.

Background threshold values (BTVs)

Ten of the soil reference values (SRVs) derived based on exposure parameters and toxicity values resulted in SRVs that were estimated as being potentially below background soil concentrations. An evaluation was conducted to determine if the health based SRV was below background concentrations and if necessary establish appropriate background values (Background Threshold Values or BTVs) that could be used instead of the health based SRV in MPCA's MERLA and RCRA programs.

MPCA's Remediation and Environmental Analysis and Outcome Divisions (EAO) conducted the evaluation to determine how the SRVs or BTVs for these 10 contaminants could be used at Remediation cleanup sites. Please refer to the "Background Threshold (BTV) Evaluation" document for additional information regarding that evaluation (MPCA 2015a).

If a BTV was established for a specific chemical, it will be listed in the SRV spreadsheet in place of the health based SRV. It is not appropriate to include BTVs in calculations of additivity risk.

Site specific SRVs

The SRV spreadsheet - Site Specific may be used to derive site specific SRVs that may be used to establish cleanup values by 1) deriving SRVs that are appropriate to be site specific cleanup values or 2) by presenting a range of risks that may be used to set site specific cleanup values based on the range of risks and other site specific information. All modifications to exposure parameters require approval of the MPCA project team and a MPCA or MDH risk assessor. Table B.1 describes the modifications that are allowed and the appropriate use of the modification.

Table B-1. Site specific SRV parameter modifications

Parameter	Res/Rec-Single Family Home Modification Allowed	Res/Rec-MFH - Multi Family Housing [1] Modification Allowed	Res/Rec-MFH Other [2] Modification Allowed	Res/Rec-Recreational Modification Allowed	Com/Ind Modification Allowed	Approval Required [3]	Modification Can Be Made in Site Specific SRV Spreadsheet	Modification Requires Modified SRV Spreadsheet from MPCA Risk Assessor	Appropriate Purpose of Modification
Acute noncancer SRV									
Toxicity Value	X	X	X	X	NA	X		X	Value is more appropriate to use with different species of chemical present
Ingestion Rate	X	X	X	X	NA	X	X		Present a range of potential risks based on appropriate central and upper percentile estimates
Cancer and chronic noncancer SRVs									
Excess Lifetime Cancer Risk (ELCR)	X	X	X	X	X	X	X		Present a range of potential risks based on ELCR's from 1E-06 to 1E-04
Hazard Quotient (HQ)	X	X	X	X	X	X	X		Present a range of potential risks based on HQ's from 0.2 to 1
Toxicity Values	X	X	X	X	X	X		X	Value is more appropriate to use with different species of chemical present
Exposure Frequency			X	X	X	X	X		Sufficient rational exists to support difference, ex. nursing home, state forest
Exposure Duration			X	X	X	X	X		Sufficient rational exists to support difference, ex. hospital, nursing home

Parameter	Res/Rec-Single Family Home Modification Allowed	Res/Rec-MFH - Multi Family Housing [1] Modification Allowed	Res/Rec-MFH Other [2] Modification Allowed	Res/Rec-Recreational Modification Allowed	Com/Ind Modification Allowed	Approval Required [3]	Modification Can Be Made in Site Specific SRV Spreadsheet	Modification Requires Modified SRV Spreadsheet from MPCA Risk Assessor	Appropriate Purpose of Modification
Ingestion Rate	X	X	X	X	X	X	X		Present a range of potential risks based on appropriate central and upper percentile estimates
Adherence Factor	X	X	X	X	X	X	X		Evaluation of upland sediments
Dermal Absorption	X	X	X	X	X	X		X	Value is more appropriate to use with different species of chemical present
Gastrointestinal Absorption	X	X	X	X	X	X		X	Value is more appropriate to use with different species of chemical present
Relative Bioavailability	X	X	X	X	X	X		X	Value appropriate to use with species of chemical present and site soil characteristics
Age Dependent Adjustment Factors									Not appropriate to modify
Cancer Averaging Time									Not appropriate to modify
Noncancer Averaging Time			X	X	X	X	X		Modification is automated in spreadsheet when exposure duration is modified
Body Weight									Not appropriate to modify
Surface Area									Not appropriate to modify
Standard Volatilization Factor									

Parameter	Res/Rec-Single Family Home Modification Allowed	Res/Rec-MFH - Multi Family Housing [1] Modification Allowed	Res/Rec-MFH Other [2] Modification Allowed	Res/Rec-Recreational Modification Allowed	Com/Ind Modification Allowed	Approval Required [3]	Modification Can Be Made in Site Specific SRV Spreadsheet	Modification Requires Modified SRV Spreadsheet from MPCA Risk Assessor	Appropriate Purpose of Modification
Inverse of Mean Concentration	X	X	X	X	X	X	X		Site specific modeling or different source area than default of 0.5 acre square
Dry Soil Bulk Density	X	X	X	X	X	X	X		Site specific data
Mass Limit Volatilization Factor									
Inverse of Mean Concentration	X	X	X	X	X	X	X		Site specific modeling or different source area than default of 0.5 acre square
Dry Soil Bulk Density	X	X	X	X	X	X	X		Site specific data
Average Depth of Source (thickness)	X	X	X	X	X	X	X		Site specific data
Apparent Diffusivity									
Air Filled Soil Porosity	X	X	X	X	X	X	X		Site specific data
Water Filled Soil Porosity	X	X	X	X	X	X	X		Site specific data
Total Soil Porosity	X	X	X	X	X	X	X		Automatically calculated when soil particle density and dry soil bulk density are modified
Soil Particle Density	X	X	X	X	X	X	X		Site specific data
Dry Soil Bulk Density	X	X	X	X	X	X	X		Site specific data
Fraction of Organic Carbon in Soil	X	X	X	X	X	X	X		Site specific data

Parameter	Res/Rec-Single Family Home Modification Allowed	Res/Rec-MFH - Multi Family Housing [1] Modification Allowed	Res/Rec-MFH Other [2] Modification Allowed	Res/Rec-Recreational Modification Allowed	Com/Ind Modification Allowed	Approval Required [3]	Modification Can Be Made in Site Specific SRV Spreadsheet	Modification Requires Modified SRV Spreadsheet from MPCA Risk Assessor	Appropriate Purpose of Modification
Particulate Emission Factor									
Inverse of Mean Concentration	X	X	X	X	X	X	X		Site specific modeling or different source area than default of 0.5 acre square
Fraction of Vegetative Cover		X	X	X	X	X	X		Sufficient rational exists to support difference, ex. no significant amount of exposed soil
Mean Annual Windspeed (MAW) [4]	X	X	X	X	X	X	X		All three parameters: MAW, ETV and dependent function are required to be modified at the same time based on modeling
Equivalent Threshold Value (ETV) [4]	X	X	X	X	X	X	X		
MAW & EVT Dependent Function [4]	X	X	X	X	X	X	X		
Soil Saturation Limit									
Dry Soil Bulk Density	X	X	X	X	X	X	X		Site specific data
Fraction of Organic Carbon in Soil	X	X	X	X	X	X	X		Site specific data
Water Filled Soil Porosity	X	X	X	X	X	X	X		Site specific data
Air Filled Soil Porosity	X	X	X	X	X	X	X		Site specific data
Total Soil Porosity	X	X	X	X	X	X	X		Automatically calculated when soil particle density and dry soil bulk density are modified
Soil Particle Density	X	X	X	X	X	X	X		Site specific data

Parameter	Res/Rec-Single Family Home Modification Allowed	Res/Rec-MFH - Multi Family Housing [1] Modification Allowed	Res/Rec-MFH Other [2] Modification Allowed	Res/Rec-Recreational Modification Allowed	Com/Ind Modification Allowed	Approval Required [3]	Modification Can Be Made in Site Specific SRV Spreadsheet	Modification Requires Modified SRV Spreadsheet from MPCA Risk Assessor	Appropriate Purpose of Modification

Res/Rec - Residential/Recreational

Com/Ind - Commercial/Industrial

[1] - Includes "multi-family housing" portion of the Res/Rec-Multi-Family Housing and Other Areas Land Use Category

[2] - Includes "other" portion of the Res/Rec-Multi-Family Housing and Other Areas Land Use Category

[3] - Modifications must be approved by MPCA project team and MPCA risk assessor

[4] - MAW, ETV and dependent function are all required to be modified at the same time based on modeling

Additive risks

Additive risks are generally required to be evaluated quantitatively using the SRV spreadsheet – Site Specific since site specific SRVs will be derived using modified site specific exposure parameters. All site noncancer risks are summed according to similar target endpoints and compared to a hazard quotient (HQ) of 1.0. All cancer risks are summed and compared to an excess lifetime cancer risk (ELCR) of 1E-05.

- *If the summed noncancer risks for a specific target endpoint are equal to or less than 1.0, there is not an unacceptable additive noncancer human health risk on site*
- *If the summed noncancer risks for a specific target endpoint are greater than 1.0, there is a potential unacceptable additive noncancer human health risk on site*
- *If the summed cancer risks are equal to or less than 1E-05, there is not an unacceptable additive cancer human health risk on site*
- *If the summed cancer risks are greater than 1E-05, there is a potential unacceptable additive cancer human health risk on site*

In some cases, it may not be possible to evaluate additive risks quantitatively and it may be necessary and appropriate to evaluate additive risks qualitatively.

B.7 Uncertainty

A thorough explanation of the uncertainties involved in the risk evaluation should be provided.
Uncertainties that could have a significant effect on the outcome of the risk evaluation (either an under or over estimate of risks) may exist for two reasons:

- Lack of knowledge of the site which can be reduced by additional research or knowledge
  - Site specific data or information
  - Scientific information
- Natural variability which cannot be reduced by additional research or knowledge

There are many uncertainties involved in the risk evaluation. Some examples are exposure assumptions, sampling, laboratory analysis, toxicity information, contaminant speciation and professional judgment.

B.8 Conclusion

A concise summary should be provided indicating whether an unacceptable human health risk exists on site. This summary should include:

- Quantitative results from the SRV spreadsheet
  - Whether contaminant concentrations exceed their respective SRVs
  - Whether the additive risk evaluations exceed the target noncancer and cancer risk levels
- Qualitative discussion of potential risks associated with contaminants lacking toxicity data
- Quantitative and/or qualitative discussion of uncertainty and how it may impact the quantitative results

If all contaminant concentrations are below the appropriate LUC SRVs and both noncancer and cancer additive risks are below target risks, it can be concluded that unacceptable human health risk do not exist at the site. If there are contaminant concentrations in exceedance of the appropriate LUC SRVs and/or noncancer or cancer additive risks are above target risks, this does not indicate there is an actual human health risk at the site. It indicates a need for further investigation by the specific program to determine if there may be an actual human health risk at the site.