USER'S GUIDE AND BACKGROUND TECHNICAL DOCUMENT FOR THE NEVADA DIVISION OF ENVIRONMENTAL PROTECTION (NDEP) BASIC COMPARISON LEVELS (BCLs) FOR HUMAN HEALTH FOR THE BMI COMPLEX AND COMMON AREAS

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DISCLAIMER

The Nevada Division of Environmental Protection (NDEP) Basic Comparison Levels (BCLs) address common human health exposure pathways. They consider neither all potential human health exposure pathways nor do they address ecological concerns. The comparison of site characterization data against these risk-based media concentrations provides for an initial screening evaluation to assist users in risk assessment components such as the evaluation of data usability, determination of extent of contamination, identification of chemicals of potential concern, and identification of preliminary remediation goals. The values are derived using equations from U.S. Environmental Protection Agency (USEPA) guidance, USEPA toxicity criteria, and USEPA exposure factors. NDEP officials may decide to follow the guidance provided herein or act at variance with the guidance, based on analysis of site-specific circumstances or availability of new or more relevant data or regulatory policies. NDEP also reserves the right to change this guidance at any time without public notice. Every effort has been made to ensure accuracy in these tables; however, if an error is found, please send an e-mail to Shannon Harbour at sharbour@ndep.nv.gov.

These BCLs are designed for use at the BMI Complex and Common Areas in Henderson, Nevada. The applicability of the BCLs should be verified prior to use at any other site.

The guidance set out in this document is not final NDEP action. It is neither intended to nor can it be relied upon, to create any rights enforceable by a party in litigation with the state of Nevada.

1.0 BACKGROUND ON NDEP BASIC COMPARISON LEVELS (BCLs)

The Internet version of the Nevada Division of Environmental Protection (NDEP) Basic Comparison Levels (BCLs) can be found at the worldwide web address http://ndep.nv.gov/bmi/technical.htm. The printable version is referred to herein as the "BCL Table" and the "BCL Calculations Table" and "Leaching BCLs" spreadsheets are also included in the Excel® file and provide the input parameters and pathway-specific BCLs.

Users are advised to employ these BCLs only after fully understanding this guidance. The BCL Table was not generated to represent action levels or final cleanup levels but rather as a technical screening tool to assist users in risk assessment components such as the evaluation of data usability, determination of extent of contamination, identifying chemicals of potential concern, and identifying preliminary remediation goals. The BCL Table contains current human health toxicity values that are combined with standard exposure factors to estimate contaminant concentrations in environmental media [air, soil (on a dry-weight basis), and water] that are considered by NDEP to be protective of human exposures (including sensitive sub-groups) over a lifetime. Human health BCLs have also been computed for eight radionuclides. Finally, leaching-based BCLs are provided for both chemicals and the eight radionuclides. Exceedance of a BCL does not automatically designate the site as needing a response action. However, exceeding a BCL may suggest that further evaluation of the potential risks posed by site contaminants is appropriate. Further evaluation might include additional sampling, consideration of ambient levels in the environment, and/or a site-specific risk assessment.

For each chemical, BCLs are back-calculated from a target risk level for carcinogens and a target hazard level for non-carcinogens. For the inhalation and direct contact pathways, target risk levels for soil exposures are set at a one-in-a-million (1×10^{-6}) incremental lifetime cancer risk for each chemical for the cancer endpoint and a hazard quotient (HQ) of one (1) for the non-cancer endpoint. Leaching-based BCLs (LBCLs) for the migration-to-groundwater pathway are back-calculated from the following groundwater concentration limits (in order of preference): non-zero maximum contaminant level goals (MCLGs), maximum contaminant levels (MCLs), or health-based limits (based on a cancer risk of 1×10^{-6} or an HQ of 1), with the exception of the compounds discussed in Section 3.8. For residential tap water, USEPA MCLs (USEPA, 2009a) are employed as the BCL. For chemicals lacking an MCL, BCLs are back-calculated using a target cancer risk of 1×10^{-6} for the cancer endpoint and a target hazard index of 1 for the non-cancer endpoint.

BCLs are intended to provide health protection without a full understanding of the specific exposure conditions at the site under study. BCLs are applicable when the exposure factors based on site-specific considerations are likely to be no more conservative than the default exposure assumptions used in the BCL Table. BCLs are media contaminant concentrations below which no further action or study at a site is generally warranted, provided that specified application conditions associated with the BCLs are met. In general, if adequate site data collection shows that the measured maximum or 95% upper confidence level (UCL) (where appropriate[1]) concentration of a particular contaminant is below the relevant BCL (see Section

[1] If a 95% UCL is used, it must be specific to an exposure area.

3.7 for addressing multiple chemicals), then further action at a site may not be warranted. If the maximum or the 95% UCL concentration for relevant media is above the BCL, further study, though not necessarily a cleanup action, is warranted. When considering BCLs as initial cleanup goals, it is recommended that the residential BCL be used, unless agreement has been reached with NDEP officials that a non-residential land use assumption can be justified.

The responsibility for using the BCL Table, and for determining its relevance to site-specific circumstances, lies with the entity recommending the values to be used and the user of the BCL Table. Before using the BCLs at a particular site, the user should determine whether the exposure pathways and exposure scenarios at the site are fully accounted for in the BCL calculations. NDEP BCLs address direct contact exposure pathways for human health (i.e., ingestion, dermal contact, and inhalation) for which generally accepted methods, models, and assumptions have been developed for specific land uses, as well as the protection of groundwater (leaching) pathway. The BCLs do not consider other human exposure pathways or impact to ecological receptors [see Conceptual Site Model (CSM) Section 1.1]. The BCL Table contains guidance on soil chemical impacts to groundwater by identifying chemical-specific dilution-attenuation factors (DAF), that are multiplied by relevant soil concentrations to obtain the LBCL.

The BCLs will be updated over time, as appropriate (once a year at a minimum), to reflect evolving USEPA guidance, changes in toxicological data, and derivation of toxicological surrogates (as applicable) for BMI Complex and Common Areas compounds of interest. There are a number of exotic chemicals associated with the BMI Complex and Common Areas and the need for surrogate derivation will be identified on a case-by-case basis and surrogates will be derived where warranted. BCL updates and special considerations identified by NDEP and users will be posted in Appendix A of the User's Guide, and will be integrated into the BCL Table as needed. Therefore, users are urged to check this appendix for any changes relevant to their site-specific/media-specific chemicals.

1.1 Conceptual Site Model

Developing a CSM is a critical step in properly implementing the soil screening process at a site. The CSM is a comprehensive representation of the site that documents current site conditions. It characterizes the distribution of contaminant concentrations across the site in three dimensions and identifies all potential exposure pathways, migration routes, and potential receptors. The CSM is initially developed from existing site data. Where relevant, these site data should include input from stakeholders about their site knowledge, concerns, and interests, and should be revised continually as new site investigations produce updated or more accurate information. The final CSM represents links among contaminant sources, release mechanisms, exposure pathways, and routes and receptors based on historical information and site data. It summarizes the understanding of the contamination problem.

As an initial check, the CSM should answer the following questions:

- Are there potential ecological concerns?
- Is there potential for land use other than those covered by the BCLs (i.e., residential and commercial/industrial)?

- Are there other likely human exposure pathways that were not considered in development of the BCLs (e.g., impacts on areas used for gardens, farming, fishing, or raising beef, dairy, or other livestock)?
- Are there unusual site conditions (e.g., large areas of contamination, high fugitive dust levels, or wetland or floodplain issues)?
- Is there a probable source of vapor emissions from volatile soil or groundwater contaminants that may affect indoor air?
- Is there potential for a short-term construction scenario to result in higher risks than those associated with the long-term scenarios assumed for the BCLs?

If the answer to any of the questions is yes, then the BCLs may not be fully applicable to a site.

1.2 Application of the Basic Comparison Levels Table

The decision to use the BCLs at a site will be driven by the potential benefits of having generic risk-based concentrations in the absence of site-specific risk assessments. Additional potential uses include:

- Supporting quality assurance programs and data usability evaluations;
- Limiting the number of chemicals of potential concern (COPCs) evaluated in risk assessments;
- Screening sites to determine the need for further evaluation;
- Prioritizing multiple "hot spots" within a facility or exposure realm; and
- Focusing future risk assessment efforts.

In general, BCL concentrations provided in the Table are risk-based. However, for soil there are two important exceptions: (1) when the risk-based BCL for a volatile organic compound (VOC) exceeds its soil saturation limit, the BCL is based on the soil saturation limit ("sat"), and (2) when the risk-based BCL for relatively less toxic non-VOCs exceeds 10^{+5} mg/kg (max), then the max is used as the basis for the BCL. It is important to note that the BCLs for inhalation are for outdoor air and are not applicable to indoor air. The pathways addressed by the BCLs and those not addressed are summarized below.

Environmental Media	Pathways Addressed by BCLs		Pathways Not Addressed by BCLs	
	Residential	Industrial/Commercial	Residential	Industrial/Commercial
Soil	• Ingestion • Inhalation of particulates • Inhalation of VOCs • Dermal contact	• Ingestion • Inhalation of particulates • Inhalation of VOCs • Dermal contact	• Intrusion of VOCs into indoor air • Groundwater contact from soil-leached chemicals • Ingestion of livestock or produce	• Intrusion of VOCs into indoor air • Groundwater contact from soil-leached chemicals • Particulate emission during construction/ excavations activities
Groundwater	• Ingestion from drinking • Inhalation of VOCs	• None	• Dermal absorption while bathing • Intrusion of VOCs into indoor air	• Ingestion from drinking • Inhalation of VOCs • Dermal absorption • Intrusion of VOCs into indoor air

1.3 Potential Issues and Misapplication of BCLs

As discussed previously, the BCLs should be used only when the conditions at the site being screened are similar to those under which the BCLs were derived for use. Special care should be exercised to prevent misuse of the BCLs and to protect human health. Specifically, the following should be avoided:

- Applying BCLs to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios.
- Not considering background concentrations when choosing BCLs.
- Use of BCLs as cleanup levels without considering other relevant criteria.
- Use of BCLs as cleanup levels without verifying applicability with a qualified risk assessor.
- Use of outdated BCLs that have been superseded by more recent publications.
- Not considering the effects of the presence of multiple chemicals.

2.0 NDEP BASIC COMPARISON LEVELS (BCLs)

The BCL Table was generated using equations incorporated into a calculation spreadsheet, except for the column "DAF" [the dilution-attenuation factor for use in calculating LBCLs]. Table 1 provides the Standard Default Exposure Factors used to calculate BCLs. Toxicity values, as well as physical and chemical parameters, are input into the spreadsheet. There are seven primary sections of the BCL Table: 1) toxicity values, 2) physical/chemical input parameters, 3) BCLs for residential land use scenarios, 4) BCLs for industrial/commercial land use scenarios (indoor and outdoor workers), 5) BCLs for ambient air, 6) BCLs for residential tap water, and 7) LBCLs for protection of groundwater. The "printable" version of the BCL Table contains only the toxicity values, volatile organic compound (VOC) designation, skin absorption value, and final comparison levels (http://ndep.nv.gov/bmi/technical.htm) while the "BCLs Calculation

Table" provides the actual spreadsheet used to derive the BCLs. The default values and equations used in developing the Table are discussed below.

2.1 Toxicity Values

Cancer and noncancer toxicity values were obtained from USEPA's Integrated Risk Information System (IRIS) on-line database (USEPA, 2010), EPA's Provisional Peer-Reviewed Toxicity Values Database (PPRTV) (USEPA, 2008), USEPA's National Center for Environmental Assessment (NCEA), USEPA's Health Effects Assessment Summary Table (HEAST) (USEPA, 1997a), and other sources. The OSWER Directive 9285.7-53 (dated December 5, 2003) (USEPA, 2003a) designates the following hierarchy for toxicity criteria: IRIS (indicated by "I" in the table) and "other sources". For the BCLs, these other sources included (in order of preference) (1) PPRTV ("P") and (2) NCEA ("N"), (3) HEAST ("H"), (4) surrogate value (S), and (5) other documents ("o") (e.g., California EPA toxicity criteria). California EPA toxicity criteria were used on a case-by-case basis and are designated with a "CA" in the BCL Table. Finally, it should be noted that the USEPA has withdrawn toxicity values for certain chemicals. These are designated with an "x" in the BCL Table and should be discussed in the uncertainty section if used in a risk assessment.

HEAST has not been updated since the last version was released in 1997 (USEPA, 1997a). HEAST values that have been externally peer reviewed are now in the PPRTV database and are noted by the letter "P" in the key column of the BCL Table next to the toxicity value. The PPRTV values currently represent the second tier of human health toxicity values for the USEPA Superfund and hazardous waste programs.

The USEPA Superfund Program has updated its inhalation risk methodology (Risk Assessment Guidance for Superfund (RAGS), Part F", USEPA, 2009b) to be consistent with USEPA's *Inhalation Dosimetry Methodology*[2], which represents USEPA's current approach for inhalation dosimetry and derivation of inhalation toxicity criteria. RAGS Part F currently recommends that when estimating risk via inhalation, risk assessors should use the concentration of the chemical in air as the exposure metric (e.g., mg/m^3), rather than inhalation intake of a contaminant in air based on IR [intake rate] and BW [body weight] (e.g., mg/kg-day) (as described in USEPA 1989a). The full details of this approach are provided in RAGS, Part F (USEPA, 2009b). Consistent with that guidance, cancer-based BCLs for the inhalation pathway were calculated using the inhalation unit risk (IUR[3]) rather than the inhalation slope factor (SFi[4]) (USEPA, 2009b). Based on the same rationale, USEPA also currently recommends that non-cancer hazard

[2] http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=71993

[3] The IUR is defined by USEPA as the upper-bound excess lifetime cancer risk estimated to results from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air (USEPA, 2009b).

[4] The SF_i is defined by USEPA as the plausible upper-bound estimate of the probability of an increased cancer risk per unit intake of a chemical over a lifetime via inhalation, expressed in units of risk per mg of substance per kg body weight per day: $(mg/kg\text{-}day)^{-1}$ (USEPA, 1989a).

quotients should be calculated using the reference concentration (RfC[5]) rather than the inhalation reference dose (RfD_i[6]) (USEPA, 2009b). Accordingly, the non-cancer-based BCLs for the inhalation pathway were calculated using the chemical-specific RfC.

Several chemicals in the table did not have toxicity criteria from any of the USEPA hierarchy of sources used in this guidance (USEPA, 2003a). Therefore, other sources were used as the basis for the toxicity criteria for these chemicals. Table B-1 provides a listing of these chemicals and the source of the toxicity values used to calculate the BCLs.

In addition, due to the vast number of specialized compounds and analytical issues associated with the BMI Complex and Common Areas, toxicological surrogates have been derived for several compounds. The toxicity criteria for the surrogates are entered into the BCL Table for the applicable chemical lacking criteria. The derivations for the toxicological surrogates are summarized in Appendix B.

2.2 Soil-to-Air Volatilization Factors (VFs)

The physical/chemical data section of the BCL calculation spreadsheet provides the information used to calculate the volatilization factors (VFs) for VOCs. VOCs are defined as those chemicals that have a Henry's Law constant greater than 10^{-5} (atm-m^3/mol) and a molecular weight less than 200 g/mole (USEPA, 1991a). The soil-to-air VF defines the relationship between the concentration of the contaminant in soil and the flux of the volatilized contaminant to air (USEPA, 1996a). The emission terms used in the VFs are chemical specific and were calculated using chemical-specific physical/chemical data obtained from the following sources: the 1996 *Soil Screening Guidance* (USEPA, 1996a,b), the 1996 *Superfund Chemical Data Matrix* (USEPA, 1996c), and the 1988 *Superfund Exposure Assessment Manual* (USEPA, 1988). The VFs used to calculate the soil screening levels are presented in the physical/chemical data section of the spreadsheet, based on equation below, which is from the USEPA's Soil Screening Guidance (USEPA, 1996a).

$$VF_s\left(\frac{m^3}{kg}\right) = \left(\frac{Q}{C}\right) x \frac{(3.14 \times D_A \times T)^{1/2}}{(2\,\rho_b \times D_A)} \times 10^{-4}\left(\frac{m^2}{cm^2}\right)$$

Default values for the soil-to-air VF input parameters, listed below, are taken from USEPA, 1996a.

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[5] The RfC (expressed in units of mg of substance/m^3 air) is an estimate of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (USEPA, 2009b).

[6] The RfD_i (expressed in units of mg of substance per kg body weight per day [mg/kg-day]) is an estimate of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (USEPA, 2009b).

Input Parameter	Definition (units)	Value
VF	Volatilization factor (m^3/kg)	Chemical specific
D_A	Apparent diffusivity (cm^2/s)	Chemical specific
Q/C	Inverse of the mean concentrate at the center of a 0.5-acre square source (g/m^2-s per kg/m^3)	68.81(default)
T	Exposure interval (seconds [s])	9.5×10^8 (30 years)
ρ_b	Dry soil bulk density(g/cm^3)	1.5
Θ_a	Air-filled soil porosity (L_{air}/L_{soil})	0.28 ($n - \Theta_w$)
N	Total soil porosity (L_{pore}/L_{soil})	0.43 or $1 - (\rho_b/\rho_s)$
Θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15
ρ_s	Soil particle density (g/cm^3)	2.65
Di	Diffusivity in air (cm^2/s)	Chemical specific
H	Henry's Law constant	Chemical specific
H'	Dimensionless Henry's Law constant	Calculated from H by multiplying by 41 (USEPA, 1991a)
D_w	Diffusivity in water (cm^2/s)	Chemical specific
K_d	Soil/water partition coefficient (cm^3/g) = $K_{oc}f_{oc}$	Chemical specific
K_{oc}	Soil organic carbon/water partition coefficient (cm^3/g)	Chemical specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.006 (0.6%)

2.3 Volatilization Factor for Residential Water

For residential water, a default upper-bound volatilization constant (VFw) of 0.5 L/m^3 is used that is based on all uses of household water (e.g., showering, laundering, and dish washing) (RAGS Part B; USEPA 1991a).

2.4 Soil Saturation Limits

The physical/chemical data section of the BCL calculation spreadsheet provides the information used to calculate the soil saturation limits. The soil saturation concentration limit, "sat", corresponds to the contaminant concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil-pore air have been reached. Above this concentration, the soil contaminant may be present in free phase (i.e., nonaqueous-phase liquids [NAPLs]) for contaminants that are liquid at ambient soil temperatures and in pure solid phases for compounds that are solid at ambient soil temperatures.

The equation below was used to calculate "sat" for each volatile contaminant. As an update to RAGS HHEM, Part B (USEPA 1991a), the equation takes into account the amount of contaminant that is in the vapor phase in soil, in addition to the amount dissolved in the soil's pore water and sorbed to soil particles. The VF is not applicable when free-phase contaminants are present. How these cases are handled depends on whether the contaminant is liquid or solid at ambient temperatures. Liquid contaminants for which screening levels exceed the "sat" concentration are set equal to "sat," whereas for solids (e.g., non-VOCs), BCLs are based on other appropriate pathways of concern at the site (e.g., ingestion and dermal contact).

$$Sat = \frac{S}{\rho_b}\left(K_d\,\rho_b + \Theta_W + H'\Theta_a\right)$$

Default values for the soil "sat" input parameters, listed below, and are taken from USEPA, 1996a.

Parameter	Definition (units)	Value
Sat	Soil saturation concentration (mg/kg)	Calculated
S	Solubility in water (mg/L-water)	Chemical specific
ρ_b	Dry soil bulk density (kg/L)	1.5
K_d	Soil-water partition coefficient (L/kg)	K_{oc} x f_{oc} (chemical specific)
K_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical specific
f_{oc}	Fraction organic carbon content of soil (g/g)	0.006 or site specific
Θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15
Θ_a	Air-filled soil porosity (L_{air}/L_{soil})	0.28 or n – Θ_w
n	Total soil porosity (L_{pore}/L_{soil})	0.43 or 1 – (ρ_b/ ρ_s)
ρ_s	Soil particle density (g/cm^3)	2.65
H	Henry's Law constant (atm-m^3/mol)	Chemical specific
H'	Dimensionless Henry's Law constant (unitless)	Calculated from H by multiplying by 41 (USEPA, 1991a)

2.5 Particulate Emission Factor for Soils

To address the soil-to-air pathway for particulate emission, the BCL calculations incorporate a particulate emission factor (PEF) for nonvolatile contaminants (designated as "0" in the VOC column of the BCL Table). The PEF relates the contaminant concentration in soil to the concentration of respirable particles in the air due to fugitive dust emissions from soil. The generic PEF was derived using default values that correspond to a receptor-point airborne particulate concentration of approximately 0.76 $\mu g/m^3$ (USEPA, 1996a). The relationship is derived by Cowherd (1985) for a rapid assessment procedure applicable to a typical hazardous waste site where the surface contamination provides a relatively continuous and constant potential for emission over an extended period of time (e.g., years). This represents an annual average emission rate based on wind erosion. The PEF evaluates windborne emissions only and does not consider dust emissions from traffic, or other forms of mechanical disturbance that are typical of short-term construction scenarios, which are not addressed in the BCLs.

The USEPA methodology was followed to derive a PEF for Las Vegas (UESPA, 1996a). Specifically, all standard default parameters were used (e.g., PEF calculation parameters "A", "B", and "C" as obtained from USEPA, 1996a[7]) with the exception of air dispersion modeling constants for the climate zone of Las Vegas. The resulting PEF of 1.2×10^9 m^3/kg (USEPA, 1996a) was used to calculate BCLs.

2.6 Dermal Absorption Factors

Chemical-specific dermal absorption factors for contaminants in soil and dust based on USEPA (2004; RAGS Part E, *Supplemental Guidance for Dermal Risk Assessment*) are employed in the BCL derivations for arsenic, cadmium, chlordane, 2,4-D, DDT, lindane, PAHs, pentachlorophenol, polychlorinated biphenyls (PCBs), and polychlorinated dibenzo-p-dioxins and dibenzofurans (collectively referred to as "dioxins"). For other chemicals, a default dermal

[7] See Exhibits D-1, D-2 and D-4 of USEPA, 1996a.

absorption factor of 0.10 was applied for semi-volatile organic chemicals, in accordance with USEPA (2004). USEPA does not recommend absorption factors for volatile organic chemicals (VOCs) based on the rationale that VOCs are volatilized from the soil on skin and exposure is accounted for via inhalation routes. USEPA does not provide absorption factors for inorganics based on the dependence of absorption on the speciation of the compound and the fact that there are inadequate data in this regard.

2.7 Age-Adjustment Factors

Because contact rates may be different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors ("adj"). Use of age-adjusted factors is especially important for soil ingestion exposures, which are higher during childhood and decrease with age. For purposes of combining exposures across pathways, additional age-adjusted factors are used for dermal exposures. These factors approximate the integrated exposure from birth until age 30, combining contact rates, body weights, and exposure durations for two age groups small children and adults. Age-adjusted factors were obtained from USEPA RAGS Part B (USEPA, 1991a) or developed by analogy. Age-adjusted factors are not applicable to inhalation exposures based on USEPA RAGS Part F (USEPA, 2009b. The equations depicted below are for carcinogens.

(1) ingestion for soil ([mg × yr]/[kg × d]:

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{(ED_r - ED_C) \times IRS_a}{BW_a}$$

(2) skin contact ([mg × yr]/[kg × d]:

$$SFS_{adj} = \frac{ED_c \times \mathrm{AF} \times SA_c}{BW_c} + \frac{(ED_r - ED_c) \times AF \times SA_a}{BW_a}$$

(3) ingestion for water ([l × yr]/[kg × d])

$$IFW_{adj} = \frac{ED_c \times IRW_c}{BW_c} + \frac{(ED_r - ED_c) \times IRW_a}{BW_a}$$

The acronyms and their values are provided in Table 1. These values can also be found in the exposure default section of the BCL Calculations Table.

3.0 HUMAN HEALTH-BASED BCLs

A multi-pathway (integrated) soil BCL was calculated for each chemical for the noncancer and, where relevant, cancer endpoint. For contaminants that exhibit both carcinogenic and non-carcinogenic endpoints, the more stringent (i.e., lower) of the two BCLs is presented in the BCL Table. The integrated soil BCLs were generated from the pathway-specific BCLs for each exposure pathway (ingestion, inhalation, and dermal) which are listed separately in the BCL Calculations Table.

In addition to the multi-pathway soil BCL, tap water BCLs and ambient air BCLs were derived. Where available, the USEPA MCL was used as the basis for tap water BCLs. For chemicals not assigned an MCL, a risk-based tap water concentration was derived. Ambient air BCLs were derived in accordance with USEPA, 2009a.

Default exposure factors used to develop the BCL values were obtained primarily from the USEPA Exposure Factors Handbook (USEPA, 1997b) and the USEPA Supplemental Soil Screening Guidance (USEPA, 2002a). Table 1 lists all exposure factors used, their abbreviations used in the equations in this text, and the source. The equations for calculating the risk or hazard by exposure pathway, as well as for the combined soil pathway BCLs, are provided below.

3.1 Equations for Residential Land Use Scenario (Soil)

Ingestion of Carcinogenic Contaminants in Soil

Eq. 1

$$BCL \text{ mg/kg} = \frac{\text{TR} \times \text{AT} \times 365 \text{ days/year}}{SF_o \times 10^{-6} \text{ kg/mg} \times EF \times IFS_{adj}}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years)
SF_o	=	Oral cancer slope factor $(\text{mg/kg-day})^{-1}$
EF	=	Exposure frequency (350 days)
IFS_{adj}	=	Adjusted soil ingestion (mg-year)/(kg-day) = 114

Ingestion of Non-carcinogenic Contaminants

Eq. 2

$$BCL \text{ mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\frac{1}{\text{RfD}_o} \times 10^{-6} \text{ kg/mg} \times EF \times ED \times IRS}$$

where:

THQ	=	Target hazard quotient of 1

BW	=	Body weight of child (15 kg)
AT	=	Averaging time for child (6 years)
RfD_o	=	Oral reference dose (mg/kg-day)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration of child (6 years)
IRS	=	Soil ingestion rate for child (200 mg/day)

Inhalation of Carcinogenic Contaminants

Eq. 3

$$BCL \text{ mg/kg} = \frac{\text{TR} \times \text{AT}}{IUR_i \times \text{EF} \times \text{ED} \times \text{ET} \times \text{CF} \times [(\frac{1}{\text{PEF}}) \text{ or } (\frac{1}{\text{VF}})]}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years x 365 days/year x 24 hours/day)
IUR_i	=	Inhalation unit risk (chemical-specific) $(\mu g/m^3)^{-1}$
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration (30 years)
ET	=	Exposure time (24 hours/day)
CF	=	Conversion factor (1,000 µg/mg)
PEF	=	Particulate emission factor used for dusts (1.2×10^9 m^3/kg)
VF	=	Volatilization factor used for volatile organic chemicals (m^3/kg)

Inhalation of Non-carcinogenic Contaminants

Eq. 4

$$BCL \text{ mg/kg} = \frac{\text{THQ} \times \text{AT}}{\text{EF} \times \text{ED} \times \text{ET} \times \frac{1}{RfC_i} \times [(\frac{1}{\text{PEF}}) \text{ or } (\frac{1}{\text{VF}})]}$$

where:

THQ	=	Target hazard quotient of 1
AT	=	Averaging time for child (6 years x 365 days/year x 24 hours/day)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration for child (6 years)
ET	=	Exposure time (24 hours/day)
RfC_i	=	Inhalation reference concentration in (chemical specific) (mg/m^3)
PEF	=	Particulate emission factor used for dusts (1.2×10^9 m^3/kg)
VF	=	Volatilization factor used for volatile organic chemicals (m^3/kg)

Skin Contact of Carcinogenic Contaminants

Eq. 5

$$BCL \text{ mg/kg} = \frac{\text{TR} \times \text{AT} \times 365 \text{ days/year}}{SF_o \times \text{EF} \times SFS_{adj} \times \text{ABS} \times 10^{-6} \text{ kg/mg}}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years)
SF_o	=	Oral cancer slope factor (chemical specific) $(\text{mg/kg-day})^{-1}$
EF	=	Exposure frequency (350 days/year)
SFS_{adj}	=	Skin contact factor for soils (361 mg-year/kg-day)
ABS	=	Skin absorption (chemical specific)

Skin Contact of Non-carcinogenic Contaminants

Eq. 6

$$BCL \text{ mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ day/year}}{\text{EF} \times \text{ED} \times \frac{1}{\text{RfD}_o} \times 10^{-6} \text{ kg/mg} \times \text{SA} \times \text{AF} \times \text{ABS}}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of child (15 kg)
AT	=	Averaging time of child (6 years)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration of child (6 years)
RfD_o	=	Oral reference dose (chemical-specific) (mg/kg-day)
SA	=	Surface area of child (2800 cm^2/day)
AF	=	Adherence factor of child (0.2 mg/cm^2)
ABS	=	Skin absorption (chemical specific)

Soil BCL for Combined Exposure Pathways for Carcinogenic Contaminants for Residential Receptor

Eq. 7

$$BCL \text{ mg/kg} = \frac{1}{\frac{1}{\text{Eq. 1}} + \frac{1}{\text{Eq. 3}} + \frac{1}{\text{Eq. 5}}}$$

Soil BCL for Combined Exposure Pathways for Non-carcinogenic Contaminants for Residential Receptor-

Eq. 8

$$BCL\ \text{mg/kg} = \frac{1}{\frac{1}{\text{Eq. 2}} + \frac{1}{\text{Eq. 4}} + \frac{1}{\text{Eq. 6}}}$$

Equation 4 for uses the PEF approach for solids and the VF approach for volatile compounds.

3.2 Equations for the Indoor Commercial/Industrial Worker Scenario (Soil)

Ingestion of Carcinogenic Contaminants

Eq. 9

$$BCL\ \text{mg/kg} = \frac{\text{TR} \times \text{BW} \times \text{AT} \times 365\ \text{days/year}}{SF_o \times 10^{-6}\ \text{kg/mg} \times \text{EF} \times \text{ED} \times \text{IRS}}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years)
BW	=	Body weight of adult (70 kg)
SF_o	=	Oral cancer slope factor (chemical specific) $(\text{mg/kg-day})^{-1}$
EF	=	Exposure frequency (250 days/year)
ED	=	Exposure duration (25 years)
IRS	=	Soil ingestion rate for adult (50 mg/day)

Ingestion of Non-carcinogenic Contaminants

Eq. 10

$$BCL\ \text{mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365\ \text{days/year}}{\frac{1}{\text{RfD}_o} \times 10^{-6}\ \text{kg/mg} \times \text{EF} \times \text{ED} \times \text{IRS}}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time (25 years)
RfD_o	=	Oral reference dose (chemical specific) (mg/kg-day)
EF	=	Exposure frequency (250 days/year)

ED	=	Exposure duration (25 years)
IRS	=	Ingestion rate for soil (50 mg/day)

Inhalation of Carcinogenic Contaminants

Eq. 11

$$BCL\ \text{mg/kg} = \frac{\text{TR} \times \text{AT}}{IUR_i \times \text{EF} \times \text{ED} \times \text{ET} \times \text{CF} \times [(\frac{1}{\text{PEF}}) \text{ or } (\frac{1}{\text{VF}})]}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years x 365 days/year x 24 hours/day)
IUR_i	=	Inhalation unit risk (chemical-specific) $(\mu g/m^3)^{-1}$
EF	=	Exposure frequency (250 days/year)
ED	=	Exposure duration (25 years)
ET	=	Exposure time (8 hours/day)
CF	=	Conversion Factor (1,000 µg/mg)
PEF	=	Particulate emission factor used for dusts (1.2×10^9 m^3/kg)
VF	=	Volatilization factor used for volatile organic chemicals (m^3/kg)

Inhalation of Non-carcinogenic Contaminants

Eq. 12

$$BCL\ \text{mg/kg} = \frac{\text{THQ x AT}}{\text{EF} \times \text{ED} \times \text{ET} \times (\frac{1}{\text{RfC}_i}) \text{ x } [(\frac{1}{\text{PEF}}) \text{ or } (\frac{1}{\text{VF}})]}$$

where:

THQ	=	Target hazard quotient of 1
AT	=	Averaging time (25 years x 365 days/year x 24 hours/day)
EF	=	Exposure frequency (250 days/year)
ED	=	Exposure duration (25 years)
ET	=	Exposure time (8 hours/day)
RfC_i	=	Inhalation reference concentration in (chemical specific) (mg/m^3)
PEF	=	Particulate emission factor used for dusts (1.2×10^9 m^3/kg)
VF	=	Volatilization factor used for volatile organic chemicals (m^3/kg)

Dermal contact pathway is not quantitatively evaluated as per USEPA (2002a, 2004).

Soil BCL for Combined Exposure Pathways for Carcinogenic Contaminants for Indoor Commercial/Industrial Worker

Eq. 13

$$BCL \text{ mg/kg} = \frac{1}{\frac{1}{\text{Eq. 9}} + \frac{1}{\text{Eq. 11}}}$$

Soil BCL for Combined Exposure Pathways for Non-carcinogenic Contaminants for Indoor Commercial/Industrial Worker

Eq. 14

$$BCL \text{ mg/kg} = \frac{1}{\frac{1}{\text{Eq. 10}} + \frac{1}{\text{Eq. 12}}}$$

3.3 Equations for the Outdoor Commercial/Industrial Worker Scenario (Soil)

Ingestion of Carcinogenic Contaminants

Eq. 15

$$BCL \text{ mg/kg} = \frac{\text{TR} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{SF_o \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IRS}}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years)
BW	=	Body weight of adult (70kg)
SF_o	=	Oral cancer slope factor (chemical-specific) $(\text{mg/kg-day})^{-1}$
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration (25 years)
IRS	=	Soil ingestion rate for adult (100 mg/day)

Ingestion of Non-carcinogenic Contaminants

Eq. 16

$$BCL \text{ mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\frac{1}{\text{RfD}_o} \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IRS}}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time (25 years)
RfD_o	=	Oral reference dose (chemical-specific) (mg/kg-day)
EF	=	Exposure frequency (225 days/year)
ED	=	exposure duration (25 years)
IRS	=	Soil ingestion rate for adult (100 mg/day)

Inhalation of Carcinogenic Contaminants

Eq. 17

$$BCL \text{ mg/kg} = \frac{\text{TR} \times \text{AT}}{IUR_i \times \text{EF} \times \text{ED} \times \text{ET} \times \text{CF} \times [(\frac{1}{\text{PEF}}) \text{ or } (\frac{1}{\text{VF}})]}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years x 365 days/year x 24 hours/day)
IUR_i	=	Inhalation unit risk (chemical specific) $(\mu g/m^3)^{-1}$
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration (25 years)
ET	=	Exposure time (8 hours/day)
CF	=	Conversion Factor (1,000 µg/mg)
PEF	=	Particulate emission factor used for dusts (1.2×10^9 m^3/kg)
VF	=	Volatilization factor used for volatile organic chemicals (m^3/kg)

Inhalation of Non-carcinogenic Contaminants

Eq.18

$$BCL \text{ mg/kg} = \frac{\text{THQ} \times \text{AT}}{\text{EF} \times \text{ED} \times \text{ET} \times (\frac{1}{\text{RfC}_i}) \times [(\frac{1}{\text{PEF}}) \text{ or } (\frac{1}{\text{VF}})]}$$

where:

THQ	=	Target hazard quotient of 1
AT	=	Averaging time (25 years x 365 days/year x 24 hours/day)
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration (25 years)
ET	=	Exposure time (8 hours/day)
RfC_i	=	Inhalation reference concentration in (chemical specific) (mg/m^3)
PEF	=	Particulate emission factor used for dusts ($1.2 \times 10^9 m^3/kg$)
VF	=	Volatilization factor used for volatile organic chemicals (m^3/kg)

Skin Contact with Carcinogenic Contaminants

Eq. 19

$$BCL \text{ mg/kg} = \frac{\text{TR} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{EF} \times \text{ED} \times SF_o \times 10^{-6} \text{ kg/mg} \times \text{SA} \times \text{AF} \times \text{ABS}}$$

where:

TR	=	Target risk of 10^{-6}
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time of worker (25 years)
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration of worker (25 years)
SF_o	=	Oral cancer slope factor (chemical specific) $(mg/kg\text{-}day)^{-1}$
SA	=	Surface area exposed for adult (3300 cm^2/day)
AF	=	Adherence factor (0.2 mg/cm^2)
ABS	=	Skin absorption (chemical specific)

Skin Contact with Non-carcinogenic Contaminants

Eq. 20

$$BCL \text{ mg/kg} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}{\text{EF} \times \text{ED} \times \frac{1}{\text{RfD}_o} \times 10^{-6} \text{ kg/mg} \times \text{SA} \times \text{AF} \times \text{ABS}}$$

where:

THQ	=	Target hazard quotient of 1

BW	=	Body weight of adult (70 kg)
AT	=	Averaging time of outdoor worker (25 years)
EF	=	Exposure frequency (225 days/year)
ED	=	Exposure duration of worker (25 years)
RfD_o	=	Oral reference dose (chemical specific) (mg/kg-day)
SA	=	Surface area exposed for adult (3300 cm^2/day)
AF	=	Adherence factor (0.2 mg/cm^2)
ABS	=	Skin absorption (chemical-specific)

Soil BCL for Combined Exposure Pathways for Carcinogenic Contaminants for Outdoor Commercial/Industrial Worker

Eq. 21

$$BCL \text{ mg/kg} = \frac{1}{\frac{1}{Eq.15} + \frac{1}{Eq.17} + \frac{1}{Eq.19}}$$

Soil BCL for Combined Exposure Pathways for Non-carcinogenic Contaminants for Outdoor Commercial/Industrial Worker

Eq.22

$$BCL \text{ mg/kg} = \frac{1}{\frac{1}{Eq.16} + \frac{1}{Eq.18} + \frac{1}{Eq.20}}$$

3.4 Equations for Ambient Air

Inhalation of Carcinogenic Contaminants

Eq. 23

$$BCL\ (\mu g/m^3) = \frac{TR \times AT}{ET \times EF \times ED \times IUR_i}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (25 years x 365 days/year x 24 hours/day)
ET	=	Exposure time (24 hours/day)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration of adult resident (30 years)
IUR_i	=	Inhalation unit risk (chemical specific) $(\mu g/m^3)^{-1}$

Inhalation of Non-carcinogenic Contaminants

Eq.24

$$BCL\ (\mu g/m^3) = \frac{THQ \times AT \times 1{,}000\ \mu g/mg}{ET \times EF \times ED \times \frac{1}{RfC_i}}$$

where:

THQ	=	Target hazard quotient of 1
AT	=	Averaging time (6 years x 365 days/year x 24 hours/day)
ET	=	Exposure time (24 hours/day)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration (6 years)
RfC_i	=	Inhalation reference concentration (chemical-specific) (mg/m^3).

3.5 Equations for Residential Tap Water

Ingestion and Inhalation of Carcinogenic Contaminants

Eq. 25

$$BCL\ (\mu g/l) = \frac{TR \times AT \times 365\ days/year}{EF \times [(IFW_{adj} \times SF_o \times 0.001\ mg/\mu g) + (ED \times VF \times IUR_i)^*]}$$

where:

TR	=	Target risk of 10^{-6}
AT	=	Averaging time (70 years)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration (30 years)
IFW_{adj}	=	Ingestion factor for water (1.1 L-year/kg-day)
SF_o	=	Oral cancer slope factor (chemical specific) $(mg/kg\text{-}day)^{-1}$
VF	=	Volatilization factor for water (0.5 L/m^3)
IUR_i	=	Inhalation unit risk (chemical specific) $(\mu g/m^3)^{-1}$

* Inhalation component of the equation is calculated only for volatile organic chemicals.

Ingestion and Inhalation of Non-carcinogenic Contaminants

Eq. 26

$$BCL\ \mu g/L = \frac{THQ \times BW \times AT \times 365\ days/year \times 1{,}000\ \mu g/mg}{EF \times ED\ [(\frac{IRW}{RfD_o}) + (VF \times \frac{1}{RfC_i})^*]}$$

where:

THQ	=	Target hazard quotient of 1
BW	=	Body weight of adult (70 kg)
AT	=	Averaging time of resident (30 years)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration (30 years)
IRW	=	Drinking water ingestion (2 L/day)
RfD_o	=	Oral reference dose (chemical specific) (mg/kg-day)
VF	=	Volatilization factor for water (0.5 L/m^3)
RfC_i	=	Inhalation reference concentration (chemical specific) (mg/m^3)

*Inhalation part of equation only calculated for volatile organic chemicals

Table 1 provides the Standard Default Exposure Factors used in the preceding equations.

3.6 Development of Final Human Health Soil BCLs

Several values are compared in order to develop the final soil BCL. These include the comparison of the health-based BCL to a maximum soil concentration of 100,000 mg/kg for the less toxic chemicals, and to the soil saturation limit, the lower of which is used as the final BCL. These equations are listed below.

Residential Soil BCL

If the contaminant is a solid, the following applies:

Eq. 27a BCL (mg/kg) = Minimum value from Eq. 7, Eq. 8*, or 100,000 mg/kg

*Equation 8 uses the Eq. 4 option.

If the contaminant is not a solid, then the following applies:

Eq. 27b BCL (mg/kg) = Minimum value from saturation, Eq. 7, Eq. 8*, or 100,000 mg/kg

*Equation 8 uses the Eq. 4 option.

Commercial/Industrial Soil BCL

If the contaminant is a solid, the following applies:

Eq. 28a BCL (mg/kg) = Minimum value from Eq. 13, Eq. 14, or 100,000 mg/kg

If the contaminant is not a solid, the following applies:

Eq. 28b BCL (mg/kg) = Minimum value from saturation, Eq. 13, Eq. 14, or 100,000 mg/kg

Commercial/Industrial BCL

If the contaminant is a solid, the following applies:

Eq. 29a BCL (mg/kg) = Minimum value from Eq. 21, Eq. 22, or 100,000 mg/kg

If the contaminant is not a solid, the following applies:

Eq. 29b BCL (mg/kg) = Minimum value from saturation, Eq. 21, Eq. 22, or 100,000 mg/kg

Ambient Air BCL

Eq. 30 BCL ($\mu g/m^3$) = Minimum value from Eq. 23 or Eq. 24

Residential Water BCL

Eq. 31 BCL ($\mu g/L$) = MCL. If an MCL is not assigned, then the minimum value from Eq. 25 or Eq. 26 is used.

3.7 Screening with Multiple Contaminants

A suggested stepwise approach for BCL-screening of sites with multiple pollutants (for each environmental medium of interest) is as follows:

- Compile existing site data.
- Use the CSM to identify all known and potential site contaminants in the BCL Table. Record the BCL concentrations for various media and note whether the chemical has been assigned cancer (indicated by "ca") and/or non-cancer (indicated by "nc") toxicological criteria. Segregate cancer BCLs from non-cancer BCLs and exclude (but do not eliminate) non-risk based BCLs ("sat" or "max").

- For cancer risk estimates, divide the site exposure point concentration (maximum or 95% UCL) by the BCL concentration designated for cancer evaluation ("ca"). Multiply this ratio by 10^{-6} to estimate chemical-specific risk for a reasonable maximum exposure (RME). For multiple pollutants, add this risk estimate for each chemical as follows:

$$Risk = \left[\left(\frac{Conc_x}{BCL_x}\right) + \left(\frac{Conc_y}{BCL_y}\right) + \ldots + \left(\frac{Conc_z}{BCL_z}\right)\right] \times 10^{-6}$$

- For non-cancer hazard estimates, divide the site exposure point concentration term by the respective non-cancer BCL (designated as "nc") and sum the ratios for multiple contaminants. The cumulative ratio represents a screening non-cancer hazard index (HI). A screening hazard index of 1 or less is considered "safe". A ratio greater than 1 suggests the need for further evaluation (see USEPA, 1989a, page 8-14 for segregation of hazard indices by effect and mechanism of action). [Note that carcinogens may also have an associated non-cancer BCL that is not listed in the BCL Table. To obtain these values, the user should view or download the BCL Calculations Tables at the BCL website and display the appropriate sections.]

$$Hazard\ Index = \left[\left(\frac{Conc_x}{BCL_x}\right) + \left(\frac{Conc_y}{BCL_y}\right) + \ldots + \left(\frac{Conc_z}{BCL_z}\right)\right]$$

For initial screening of data when multiple chemicals have been released, a simplified conservative approach of employing one-tenth of the BCL can be applied.

3.8 BCLs for Chemicals with Special Considerations

Most of the BCLs are derived using the equations provided in Sections 3.1 through 3.5. However, there are some chemicals for which the additional information is required. These special cases are discussed below

Asbestos

Technical Guidance for the Calculation of Asbestos-Related Risk in Soils for the Basic Management Incorporated (BMI) Complex and Common Areas (NDEP, 2009a) (http://ndep.nv.gov/bmi/docs/090424_asbestos_guidance_apr09.pdf) provides a guidance framework for characterizing asbestos-related risks (ARR) in soils. This NDEP guidance document provides methodological direction to evaluate soil disturbing activities in areas with known or suspected presence of asbestos contaminated soils and is based on the 2003 draft protocol for assessing ARR prepared for USEPA's Office of Solid Waste and Emergency Response (OSWER) (Berman and Crump, 2003, Berman 2003a; 2003b; 2005). This guidance document is also accompanied by a spreadsheet that can be used as a template for estimating ARR. At present, the inhalation cancer potency factor for asbestos fibers provided by USEPA in the Integrated Risk Information System (IRIS) electronic database[8] is based on dose-response

[8] A database of non-cancer and cancer health effects information maintained by USEPA's National Center for Environmental Assessment (NCEA), used to support risk assessment activities under Superfund and other USEPA programs.

information summarized in USEPA (1986). The NDEP has chosen to utilize the more recent methodology for assessing ARR proposed in Berman and Crump (2003) and fully described in the guidance document.

Cadmium

Because IRIS provides different oral RfDs for cadmium in water and in foods, the BCL for cadmium in water is based on the oral RfD for water of 0.0005 mg/kg-d, and the BCL for soil ingestion is based on the RfD for food of 0.001 mg/kg-d. It should be noted that the BCL for tap water is based on the MCL for cadmium of 5 µg/l.

4,4-Dichlorobenzil

In the absence of 4,4-dichlorobenzil toxicity criteria from standard hierarchy of sources, NDEP has provided interim guidance on this chemical (NDEP, 2009b). This guidance may be found at http://ndep.nv.gov/bmi/docs/090115_dichlorobenzil.pdf and provides an interim RfD for dichlorobenzil of 3.0×10^{-4} mg/kg-d.

Hexachlorocyclohexane (HCH)

The NDEP has adopted a threshold dose value for alpha-, beta-, and gamma-HCH for use in quantifying potential human health risks at the BMI Complex (Integral 2011a, b, and c). These values are 0.003, 0.00006, and 0.00001 mg/kg-d, respectively. The criteria documents supporting this decision are provided on the NDEP BMI Complex website (http://ndep.nv.gov/bmi/technical.htm). These toxicity values have been incorporated into the BCLs for these compounds.

Essential Nutrients; Specifically Calcium, Potassium, and Sodium

Calcium, potassium, and sodium are essentially nutrients and are on the Generally Recognized As Safe (GRAS) list of the Food and Drug Administration (FDA, 2011).

> "GRAS exemptions are granted for substances that are generally recognized, among experts qualified by scientific training and experience to evaluate their safety, as having been adequately shown through scientific procedures ...to be safe under the conditions of their intended use." FDA, 2011
>
> "There is no evidence in the available information on [substance] that demonstrates, or suggests reasonable grounds to suspect, a hazard to the public when they are used at levels that are now current or might reasonably be expected in the future." FDA, 2011

Therefore, these three elements do not need to be included in a risk assessment for potential human health impacts unless they are present in a compound that is a regulated chemical agent and/or in compounds present at concentrations that may create a health hazard through physical/chemical properties (e.g., extremely low or high pH having caustic potential).

Lead

The residential soil value for lead is based on the Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead in children developed using default parameters (USEPA, 1994). More information on this model and other lead risk assessment guidance can be found at http://www.epa.gov/superfund/health/contaminants/lead/index.htm. The industrial BCL is based on equations developed by the technical review group (adult lead model), as described below.

The Adult Lead Model (ALM) is a tool for assessing risks associated with **non-residential** adult exposures to lead in soil. The ALM focuses on estimating fetal blood lead concentrations in pregnant women exposed to lead-containing soils in a commercial/industrial setting. It is the product of extensive evaluations by the Technical Review Workgroup for Lead (TRW). In December 1996, the TRW released the document *Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil* (*TRWR*; USEPA, 1996d), which describes the equations and default parameters that can be used with the ALM.

Magnesium

Magnesium does not have a toxicity criterion, thus an oral RfD was derived using the National Institute of Health (NIH) Recommended Daily Allowance data. An age-adjusted oral RfD was derived using the age-specific RDAs provided by NIH (http://ods.od.nih.gov/factsheets/magnesium.asp). The soil BCLs were derived as described in Section 3.0 using the derived oral RfD of 5.7 mg/kg-d. The tap water BCL was calculated using the oral RfD and the methods described in Section 3.5 and was subsequently used in the derivation of a LBCL for magnesium.

Methyl Iodide

The USEPA has determined a human equivalent concentration (HEC)-based on a NOAEL for methyl iodide of 0.89 ppm (5.2 mg/m^3). The toxic endpoint is based on an increased incidence of salivary gland squamous cell metaplasia (USEPA, 2006). USEPA applied a total uncertainty factor of 30 to account for interspecies extrapolation (UF = 3) and intraspecies extrapolation (UF = 10), resulting in an RfC of 0.17 mg/m^3.

Perchlorate

The residential drinking water BCL for perchlorate is based upon the provisional Nevada Action Level of 18 ppb.

Polychlorinated Dibenzo-p-dioxins, Dibenzofurans, and Some Polychlorinated Biphenyls

The USEPA OSWER Directive 9200.4-26 (USEPA, 1989b) identified a preliminary soil remediation goal of 1 part per billion (ppb) for total dioxin toxicity equivalents (TEQ) at Superfund sites for assumed residential land use, and 5 to 20 ppb TEQ for industrial or commercial land uses. Since this OSWER Directive was issued in 1998, the USEPA issued two sets of documents (USEPA 2000, 2003b) describing their reassessment of the underlying scientific issues pertaining to the risk assessment of dioxins. These documents support some modification to the 1998 preliminary remediation goals. The reassessment proposed that the toxicity criteria for assessing both carcinogenic and non-carcinogenic effects of dioxins should be adjusted to reflect a more conservative judgment based on recent toxicological studies and concerns that background doses and body burdens in humans do not provide an adequate margin

of safety. To date, however, no new USEPA guidance regarding soil screening levels for dioxins has been issued, despite the extensive analyses presented in the dioxin reassessment documents.

One of the key premises of the dioxin reassessment documents was the recent publication of dioxin cancer potency estimates that were based on epidemiological studies. The current dioxin cancer potency estimate of 1.56×10^5 per $(mg/kg\text{-}day)^{-1}$ based on a rat bioassay (Kociba et al., 1978) was suggested to be considerably lower than potency estimates suggested by the epidemiology studies of Becher et al. [1998; 2.2×10^6 $(mg/kg\text{-}day)^{-1}$], Steenland et al. [2001; 1.5×10^6 per $(mg/kg\text{-}day)^{-1}$] and a meta-analysis by USEPA [2003b; 1.1×10^6 (per $mg/kg\text{-}day)^{-1}$]. USEPA (2000, 2003b) also suggested that alternative dose-response modeling of the rat cancer bioassays could support dioxin potency factors in the same range, e.g., 1.1 to 1.4×10^6 per $(mg/kg\text{-}day)^{-1}$. On the other hand, a recent National Toxicology Program rat study (NTP, 2004) reported much lower tumor rates in the same rat strain tested by Kociba et al. (1978). Crouch et al. (2005) estimated this new study would yield a dioxin cancer potency of approximately 1.6×10^4 per $(mg/kg\text{-}day)^{-1}$. The technical issues surrounding this range of cancer potency estimates have been reviewed by Paustenbach et al. (2006).

In view of the current uncertainties about the most appropriate regulatory risk assessment approach for dioxins, NDEP utilized the 1998 OSWER Directive with a modification to address recently identified uncertainties regarding cancer potency in humans. There is approximately one order of magnitude (10-fold) difference between the current USEPA cancer potency factor (which was used to derive the OSWER Directive soil goal of 5 to 20 ppb for industrial/commercial sites) and the midpoint of the epidemiology-based cancer potency estimates discussed above. Applying a 10-fold uncertainty factor to the 5 to 20 ppb soil screening range results in a range of 0.5 to 2 ppb for consideration for a NDEP soil screening level for industrial/commercial land use. Based on this range, a single value of 1 ppb TEQ was selected as an appropriate BCL for industrial/commercial sites. For residential sites, NDEP has adopted the ATSDR soil "screening level" of 50 ppt (0.00005 mg/kg) for residential sites (ATSDR, 2008).

Polycyclic Aromatic Hydrocarbons (PAHs)

USEPA has developed a potency factors approach for calculating the potential health risks from PAHs with the characteristic "Bay-K region," a structural distinction that defers carcinogenic properties to benzo-a-pyrene (BaP) and the other carcinogenic PAHs (USEPA, 1993). BaP is the best characterized and most potent of the carcinogenic PAH compounds, and hence, the slope factors for BaP are used in conjunction with the potency factor approach to calculate a BaP equivalent (BaPEq) concentration. Accordingly, each of the carcinogenic PAHs must be multiplied by its associated potency factor to calculate the BaPEq. For each site sample, the summed BaPEq concentration is compared to the BCL for BaP. The TEFs are as follows: benzo(a)pyrene (1.0), benzo(a)anthracene (0.1), benzo(b)fluoranthene (0.1), benzo(k)fluoranthene (0.01), chrysene (0.001), dibenz(a,h)anthracene (1.0), and indeno(1,2,3,-cd)pyrene (0.1) (USEPA, 1993). If one of these seven PAHs is detected at a site, then all seven should be addressed for BaPEqs. One half the detection limit in BaPEqs should be used for all non-detect results.

Thallium

IRIS has many values for the different salts of thallium. However, analytical data packages typically report only total thallium. Therefore, a BCL based on total thallium was derived for practical purposes by adjusting the thallium sulfate RfD by the molecular weight of thallium to derive a thallium-only RfD of 6.6×10^{-5} mg/kg-day.

Total Petroleum Hydrocarbons

Petroleum hydrocarbon mixtures in soils, such as gasoline, kerosene, diesel, or waste oils, are relatively common, and some groups have attempted to develop non-cancer toxicity criteria based on selected petroleum fractions such as gasoline- or diesel-range hydrocarbons. At present, NDEP does not recommend using these petroleum fraction toxicity criteria. Instead, the indicator chemicals for common petroleum hydrocarbon mixtures should be evaluated, including benzene, toluene, ethylbenzene, and total xylenes (BTEX); MTBE (and other oxygenates and/or additives, where relevant); and PAHs. Demonstrating compliance with respect to these indicator compounds will be assumed to also minimize any risks attributable to other petroleum-fraction components in soils.

Vinyl Chloride

IRIS (USEPA, 2009b) presents two cancer slope factors for vinyl chloride—one for adult exposures and a second, more protective, slope factor to account for the unique susceptibility identified in young animals that suggests a greater susceptibility to vinyl chloride carcinogenicity in young children. The more conservative cancer slope factor for children of 1.5 $(mg/kg\text{-}d)^{-1}$ and inhalation unit risk of 8.8×10^{-6} $(\mu g/m^3)^{-1}$ is applied for the BCL corresponding to residential vinyl chloride exposure scenarios, and includes an assumption of lifetime (70 years) exposure for residential receptors as an added conservative measure based on USEPA Region 9 recommendations. The adult exposure cancer slope factor of 0.72 $(mg/kg\text{-}day)^{-1}$ and inhalation unit risk of 4.4×10^{-6} $(\mu g/m^3)^{-1}$ is used as the basis for the commercial/industrial BCL.

Chemicals for Which the BCL is Based on a Toxicological Surrogate

Soil BCLs for the following chemicals that are based on a toxicological surrogate approach include:

- Acenaphthalene
- Benzo[g,h,i]perylene
- Phenanthrene
- Diethyl phosphorodithioate(DEPT)
- Dimethyl phosphorodithioate (DMPT)
- m-Phthalic acid
- o-Phthalic acid
- p-Chlorobenzene sulfonic acid (pCBSA)
- Benzene sulfonic acid (BSA)

Documentation of the basis of the surrogate selection for each of these chemicals is provided in Appendix B.

In addition to the surrogate toxicity values discussed above, several VOCs in the BCL tables had oral toxicity values but were lacking inhalation (RfC) values. In the absence of toxicity values

from the usual hierarchy of sources, surrogate values were derived based upon structure activity relationships and similar target organs (when possible). These chemicals along with their surrogate RfCs and the source chemical for the surrogate values are provided in Table B-2.

4.0 LEACHING-BASED BCLS (LBCLS)

Leaching-based soil screening levels (LBCLs) (on a dry-weight basis) are provided to evaluate the migration to groundwater pathway. Migration of contaminants from soil to groundwater is evaluated as a two-stage process: (1) release of contaminant in soil leachate into groundwater, and (2) dilution of the contaminant upon mixing in groundwater. The LBCL methodology considers both of these transport mechanisms. The USEPA has previously derived soil to groundwater screening levels for several constituents in their *Soil Screening Guidance* (USEPA, 1996a). These values are presented in the BCL Table and the reader is advised to refer to the original USEPA guidance document for their derivation.

Additional LBCLs were derived in accordance with USEPA methodology (1996a) for 15inorganic constituents that have not been derived by the USEPA (1996a) but are included as Site-Related Chemicals (SRCs) at the BMI Complex and Common Areas site, which are:

- Aluminum
- Boron
- Cobalt
- Copper
- Iron
- Lithium
- Magnesium
- Manganese
- Mercury
- Molybdenum
- Nitrate
- Perchlorate
- Titanium
- Tungsten
- Uranium

Also, LBCLs were derived in accordance with USEPA methodology (1996a) for α - hexachlorocyclohexane and β - hexachlorocyclohexane for which the noncancer RfD were updated. Other than the RfD used to estimate the risk-based groundwater concentration for these two chemicals, the same parameters used in USEPA (1996a) were used to develop their LBCLs.

LBCLs were calculated for the 15 inorganic constituents based upon the assumption that the constituent is in equilibrium with the concentration in the adsorbed (soil matrix) phase, the soils are near neutral pH (~6.8), and application of a simple water-balance equation that calculates a dilution factor to account for dilution of soil leachate in an aquifer (USEPA, 1996a). The dilution factor is expressed as the ratio of leachate concentration to the concentration in

groundwater at the receptor point. Accordingly, USEPA refers to this factor as a dilution attenuation factor (DAF). It should be noted that if the soils of interest are not near the specified pH used to develop the LBCLs of 6.8, then the LBCLs may not be used for screening purposes.

The chemical-specific LBCL is back-calculated from a risk-based groundwater concentration (RBCG) (e.g., non-zero MCLGs, MCLs, or other risk-based screening level). As a first step, the RBCG is derived based on the assumptions of a 70-kilogram body weight and ingestion of two liters of water per day. For carcinogens, a target risk of 10^{-6} was employed; for non-carcinogens, a hazard quotient of 1 was employed. As a second step, the RBGC is multiplied by a dilution factor to obtain a target leachate concentration.

Dilution-attenuation processes are physical, chemical, and biological processes that tend to reduce the eventual contaminant concentration at the receptor point and are expressed by a DAF (USEPA, 1996a). When calculating a LBCL value, a DAF is used to back-calculate the target soil leachate concentration from a risk-based groundwater concentration (*e.g.*, maximum contaminant level [MCL] or tap water BCL as presented in the BCL Table). For example, if the RBGC is 0.05 milligrams per liter (mg/L) and the DAF is 10, the target leachate concentration would be 0.5 mg/L. Expressed mathematically:

Eq. A

$$C_L = DAF \times RBGC$$

Where

C_L	=	target leachate concentration (mg/L_W)
DAF	=	dilution-attenuation factor (unitless)
RBGC	=	risk-based groundwater concentration (*e.g.*, maximum contaminant level [MCL] or tap water BCL) (mg/L_w)

The target leachate concentration C_L is related to the concentration sorbed on the soil matrix C_S by the soil-water partition coefficient K_d. Assuming equilibrium between the aqueous phase[9] and adsorbed (soil matrix) phase in the unsaturated zone and that adsorption is linear with respect to concentration:

Eq. B

$$K_d = \frac{C_S}{C_L}$$

where:

K_d	=	soil-water partition coefficient (mg/kg_S per mg/L_W or L_W/kg)
C_S	=	concentration sorbed on soil matrix (mg/kg)
C_L	=	target leachate concentration (mg/L_W).

To develop the LBCLs the sorbed concentration C_S needs to be related to the total concentration measured in a soil sample. Equation 22 of USEPA 1996a relates C_S, using the above

[9] The calculation of LBCLs assumes that non-aqueous phase liquids (NAPLs) are not present.

relationship between C_S and C_L, to the total concentration measured in soil (C_T) on a dry weight basis as follows:

Eq. C

$$C_T = C_L \left(K_d + \frac{\theta_W}{\rho_b} + \frac{\theta_A H'}{\rho_b} \right)$$

where:

C_T	=	total concentration (on a dry weight basis) based on mass of analyte in soil air, soil moisture, and soil matrix (mg/kg_T)
C_L	=	target leachate concentration (mg/L_W).
K_d	=	soil-water partition coefficient (mg/kg_S per mg/L_W or L_W/kg_S)
θ_W	=	moisture content ($cm^3{}_W/cm^3{}_T$)
ρ_b	=	dry bulk density ($g_S/cm^3{}_T$)
θ_A	=	air-filled porosity ($cm^3{}_A/cm^3{}_T$)
H'	=	dimensionless Henry's law constant (unitless)

Substituting Eqn. A into Eqn. C gives:

Eq. D

$$C_T = (DAF \times RBGC) \times \left(K_d + \frac{\theta_W}{\rho_b} + \frac{\theta_A H'}{\rho_b} \right)$$

when expressed in this manner, C_T is equal to LBCL:

Eq. E

$$LBCL = (DAF \times RBGC) \times \left(K_d + \frac{\theta_W}{\rho_b} + \frac{\theta_A H'}{\rho_b} \right)$$

Consistent with USEPA 1996a (page 37) mercury is the only volatile inorganic constituent for which an LBCL was derived; the remaining inorganic constituents are assumed to be non-volatile (*i.e.*, H' is assumed to be zero).

Also consistent with USEPA 1996a, LBCL values are presented in this guidance for DAF values of 1 and 20. The LBCLs were developed using a DAF of 20 to account for natural processes that reduce chemical concentrations in the subsurface soil and groundwater. Also included are LBCLs that assume no dilution or attenuation between the source and the receptor (i.e., a DAF of 1). These values can be used at sites where little or no dilution or attenuation of soil leachate concentrations is expected at a site (e.g., sites with shallow water tables, fractured media, karst topography, or source size greater than 30 acres).

The LBCL values (for DAF = 1 and 20) calculated using Equation E, along with the sources of the various parameter values, are listed in Appendix D Table D-1.

Further NDEP guidance on leaching from soil to groundwater is provided in the following documents:

http://ndep.nv.gov/bmi/docs/cover_let-%20leach_guidance.pdf
http://ndep.nv.gov/bmi/docs/100116%20leaching_guidance.pdf

5.0 BCLS FOR RADIONUCLIDES

Radionuclide health effects are based on the deposition of energy in body tissues resulting from radioactive decay. Soil BCLs were calculated for direct exposure pathways related to an individual exposed to site soils, and also for protection of groundwater from leaching of soil radionuclides over time. For each radionuclide, soil BCLs related to direct exposure (ingestion, inhalation, and external irradiation) are back-calculated from a target risk level of one-in-a-million (1×10^{-6}) incremental lifetime cancer risk. BCLs for the migration-to-groundwater pathway are back-calculated from the following groundwater activity limits (in order of preference): non-zero maximum contaminant level goals (MCLGs), maximum contaminant levels (MCLs), or risk-based limits based on a cancer risk of 1×10^{-6}.

Radionuclide BCLs are calculated for a limited number of radionuclides for which soil samples are routinely analyzed at the BMI Complex and Common Areas. These radionuclides include isotopic uranium (uranium-234, uranium-235, uranium-238), isotopic radium (radium-226 and radium-228), and isotopic thorium (thorium-228, thorium-230, and thorium-232). The BCLs for these eight radionuclides and the basis of their derivation are presented in Appendix E.

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Appendix A

Annotation of Updates to the BCL Table

February 2009

1. Corrections to Equations 1 and 4 under Section 2.7.
2. Addition of an Indoor Commercial/Industrial Worker screening values to the BCL Table.
3. Addition of BCLs for lithium, titanium, tungsten, and uranium.
4. Correlation of the "a" footnote in the BCL table to lead.
5. Update to the PEF to reflect the Las Vegas meteorological zone per USEPA (1996a) guidance.
6. Update to the iron oral reference dose from 0.003 to 0.7 mg/kg-day.
7. Removal of the cancer classification for 1,2-dibromoethane from the BCL table.
8. Oral SF for dicofol added to BCL table.
9. Inhalation RfD updated for ethylene glycol.
10. Inhalation RfD for tetrachloroethylene removed from BCL table.
11. Appendix C and Table C-1 added to present source of "other" toxicity criteria.

June 2009

1. Citations corrected in Table 1.
2. Text edits and reformatting of Guidance Document.
3. BCL for magnesium added to table.
4. Radionuclide BCLs added as Appendix D.
5. Leaching based BCLs (LBCLs) added for Aluminum, Boron, Cobalt, Copper, Iron, Magnesium, Manganese, Mercury, Molybdenum, Titanium, Tungsten, and Uranium.
6. Asbestos BCL added.
7. Inhalation pathways revised consistent with USEPA RAGS Part F guidance.
8. Toxicity criteria updated with latest values from IRIS.
9. MCLs used as residential tap water BCLs when available.
10. Dioxin/Furan TEQ BCLs updated.

November 2009

1. Technical HCH removed from table.
2. Soil pH for LBCLs stated.
3. Links in the calculation spreadsheet were corrected for the IURs and their associated citations. It is believed that this error occurred during the June 2009 update. This error is not believed to have materially impacted the resulting BCLs and is noted here for completeness.
4. Uranium LBCL removed from Appendix E; the main BCL table provides an LBCL for this constituent.

August, 2010

1. Email contact for questions or errors updated.
2. Typographical errors corrected.
3. BCL Spreadsheet updated to reflect correct BCLs for dioxin TEQs.
4. Removed route-to-route extrapolations for inhalation toxicity criteria including Table B-1.
5. Clarification that air BCLs are for outdoor air only. Indoor air is not addressed by BCLs.
6. PAH BaPEqs methodology clarified to direct user to include all seven carcinogenic PAHs if one or more are detected in site media.
7. 2-Hexanone added to BCL spreadsheets.
8. Updated BCLs with additions of surrogate-based inhalation toxicity values as provided in Table B-2.
9. Corrected the tapwater BCLs to reflect MCLs when available.
10. Updated Industrial/Commercial worker BCLs for 8 of 24 hours (as appropriate).

January, 2011

1. Minor typographical errors corrected for various entries.
2. Toxicity criteria values updated.
3. For 2,3,7,8-TCDD (1746-01-6), there were two entries in the BCL table and BCL calculation sheet for this chemical, one labeled "Dioxin (2,3,7,8-TCDD)" and another labeled "2,3,7,8-TCDD (Dioxin)." The entry labeled "Dioxin (2,3,7,8-TCDD)" was deleted from the BCL table and the BCL calculations.
4. For octahydro-1357-tetranitro-1357-tetrazocine (HMX) (2691-41-0), there were two entries in the BCL table and BCL calculation sheet for this chemical, one labeled "HMX" and another labeled "octahydro-1357-tetranitro-1357-tetrazocine (HMX)." The entry labeled "HMX" was deleted from the BCL table and the BCL calculations.
5. Four chemicals were added to the BCL tables and BCL calculation tables: 1,2-dichlorotetrafluorethane (1717-00-6), ethanol (64-17-5), n-heptane (142-82-5), and n-octane (111-65-9). All four are VOCs and surrogate RfC values were used.

January, 2012

1. NDEP approved HCH reference doses included in the BCL tables.
2. Equations C, D, and E were edited for minor corrections in Section 4.0.
3. Toxicity criteria values updated.
4. Tap water BCLs for VOCs were corrected for a calculation error.

May, 2012

1. Leaching LBCL added for lithium, nitrate, and perchlorates.

November, 2012

1. 2,3,7,8-TCDD (dioxin) residential and worker BCLs were set to 50 ppt and 1 ppb, respectively. Pathway-specific numbers were deleted.
2. For cadmium, the overall RfD of 0.001 mg/kg-d for food was used to calculate the BCL for ingestion. The BCL for residential water is the MCL of 5 µg/L.
3. For vinyl chloride, the oral slope factor and inhalation unit risk value for the residential BCL was adjusted to account for the 2-fold difference between these values for adults and children. This was accomplished by multiplying by the age-adjusted value of 36/30 = [(1*24/30) + (2*6/30)].

January, 2013

1. The toxicity criteria for 11 chemicals were updated: cyanide, di-n-octyl phthalate, methacrylonitrile, methyl acrylate, p-toluidine, thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, thallium sulfate, and thiocyanate.
2. The solubilities for crotonaldehyde and vinyl bromide were updated.
3. The Henry's Law constant for methyl styrene (mixed isomers) was updated.
4. The MCLs for aldicarb (3.0 µg/L) and aldicarb sulfone (2.0 µg/L) were updated.
5. Twenty-one chemicals were added to the BCL and BCL calculation tables: acetone cyanohydrin, 2-acetylaminofluorene, aldicarb sulfoxide, ammonium sulfate, boron trichloride, 2-chloroethanol, 4-chloro-2-methylaniline HCl, cyclohexene, Decabromodiphenyl ether, 2,2',3,3',4,4',5,5',6,6'- (BDE-209), diethanolamine, ethylene cyanohydrin, hexamethylphosphoramide, lead acetate, lead subacetate, mercuric chloride, 2-methylaniline hydrochloride, N,N`-diphenyl-1,4-benzenediamine, safrole, triacetin, tris(1-chloro-2-propyl)phosphate, and zirconium. Two of these chemicals were VOCs: acetone cyanohydrins and cyclohexene.

Appendix B

Documentation for Toxicological Surrogates

Appendix C

Documentation of "Other" Toxicity Value

Appendix D

Documentation for the Derivation of Leaching BCL

Appendix E

Radionuclide BCL Guidance