

**NEW MEXICO ENVIRONMENT
DEPARTMENT**

**Risk Assessment Guidance for Site Investigations
and Remediation**

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INTRODUCTION

This guidance document is being developed in coordination with the New Mexico Environment Department's (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau's Voluntary Remediation Program.

This guidance document sets forth recommended approaches based on current State and Federal practices and intended for used as guidance for employees of NMED and for facilities within the State of New Mexico.

In the past, the material contained within this document existed in three separate guidance and/or position papers. In order to streamline the risk assessment process and ensure consistency between guidance/position papers, these documents have been combined into one document: *Risk Assessment Guidance for Site Investigations and Remediation*.

The *Risk Assessment Guidance for Site Investigations and Remediation* replaces and supersedes the following documents:

- *Technical Background Document for Development of Soil Screening Levels*, Revision 5.0, 2009,
- *New Mexico Environment Department TPH Screening Guidelines*, October 2006, and
- *Risk-Based Remediation of Polychlorinated Biphenyls at RCRA Corrective Action Sites*, NMED Position Paper, March 2000.

Risk Assessment Guidance for Site Investigations and Remediation is organized into two volumes. Volume I contains information related to conducting screening level human health risk assessments. Previously, the soil screening levels (SSLs) were available in the *Technical Background Document for Development of Soil Screening Levels* while the screening levels for total petroleum hydrocarbons (TPH) were found in the *New Mexico Environment Department TPH Screening Guidelines*. Now both are contained in Volume I. Volume I also summarizes SSLs for select Aroclors and congeners of polychlorinated biphenyls (PCBs). Additional details for derivation of more site-specific SSLs for PCBs are contained within Appendix D.

Volume II provides guidance for conducting a scoping assessment for ecological risk as previously contained within the *Technical Background Document for Development of Soil Screening Levels*.

VOLUME I

TIER 1: SOIL SCREENING GUIDANCE TECHNICAL BACKGROUND DOCUMENT

Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program

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Appendix D: Guidance for Risk-Based Remediation of Polychlorinated Biphenyls

LIST OF ACRONYMS

ASTDR	Agency for Toxic Substances and Disease Registry
CalEPA	California Environmental Protection Agency
CMTP	Composite Model for Leachate Migration with Transformation Products
COPC	Contaminants of Potential Concern
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
DQO	Data Quality Objectives
EPA/ORD	Environmental Protection Agency Office of Research and Development
GWQB	Groundwater Quality Bureau
HEAST	Health Effects Assessment Summary Tables
HWB	Hazardous Waste Bureau
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
MRL	Minimum Risk Level
NAPL	Non-aqueous Phase Liquid
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NRCS	National Resource Conservation Service
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PEF	Particulate Emission Factor
PPRTV	Provisional Peer-reviewed Toxicity Value
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
SCEM	Site Conceptual Exposure Model
SSG	Soil Screening Guidance
SSL	Soil Screening Level
TEF	Toxicity Equivalency Factor
UCL	Upper Confidence Limit
US EPA	United States Environmental Protection Agency
VFs-	Volatilization Factor
VOC	Volatile Organic Compound
WQCC	Water Quality Control Commission

1.0 INTRODUCTION

The New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau (GWQB) have developed this soil screening guidance (SSG) for internal department use within corrective action programs. The SSG discusses the methodology used to derive chemical-specific soil screening levels (SSLs). In addition, guidance is provided to assist in identifying and evaluating appropriate exposure pathways and receptors. Finally, this document provides generic SSLs for chemicals commonly found at contaminated sites based on default exposure parameters under residential and non-residential land-use scenarios.

The SSG provides site managers with a framework for developing and applying the SSLs, and is likely to be most useful for determining whether areas or entire sites are contaminated to an extent that warrants further investigation. It is intended to assist and streamline the site investigation and corrective action process by focusing resources on those sites or areas that pose the greatest risk to human health and the environment. Implementation of the methodologies outlined within this SSG may significantly reduce the time necessary to complete site investigations and cleanup actions at certain sites, as well as improve the consistency of these investigations.

Between various sites there can exist a wide spectrum of contaminant types and concentrations. The level of concern associated with those concentrations depends on several factors, including the likelihood of exposure to levels of potential concern to human health or to ecological receptors. At one end of the spectrum are levels that clearly warrant a response action; at the other end are levels that are below regulatory concern. Appropriate cleanup goals for a site may fall anywhere within this range depending on site-specific conditions. It is important to note that SSLs do not in themselves represent cleanup standards, and the SSLs alone do not trigger the need for a response action or define “unacceptable” levels of contamination in soil. Screening levels such as SSLs identify the lower end of this spectrum – levels below which there is generally no need for further concern—provided the conditions associated with the development of the SSLs are consistent with the site being evaluated.

1.1 Organization of the Document

The NMED SSG is organized into five major sections with supporting appendices. The remainder of Section 1 addresses the purpose of the NMED SSLs and outlines the scope of the document. Section 2 outlines the receptors, exposure pathways, and exposure assumptions used in calculating the NMED SSLs. It also discusses the risk levels on which the SSLs are predicated and presents the SSL model assumptions. Finally, Section 2 discusses site assessment/characterization activities that should be completed prior to comparing site contaminant concentrations with SSLs. These activities include development of data quality objectives, conducting site sampling, preparation of a preliminary conceptual site model (CSM), and identification of contaminants of potential concern (COPCs). Section 3 provides a detailed description of the process used to develop pathway-specific SSLs. Included in this section is a discussion of the human health basis for the SSLs, additive risk, and acute exposures. Additional topics discussed in Section 3 include chemical specific parameters used to develop the SSLs and

calculating volatilization factors, particulate emission factors and soil saturation limits. Section 4 presents methodologies for assessing the potential for migration of contaminants to groundwater from contaminated soil in concert with generic and site-specific leaching models. Finally, Section 5 addresses special use considerations for addressing contaminant concentrations in soil and notes specific problems that can arise when applying the SSLs to specific sites. Generic SSLs for contaminants are presented in Table A-1 of Appendix A. Table A-2 of Appendix A presents the default exposure factor values used in the generation of the NMED SSLs. Physical-chemical values in the calculation of the SSLs are presented in Tables B-1 and B-2 of Appendix B. Toxicity criteria are presented in Table C-1 of Appendix C. Additional discussion of polychlorinated biphenyls (PCBs) is provided in Appendix D.

1.2 Scope of the Soil Screening Guidance

The SSG incorporates readily obtainable site data and utilizes methods from various United States Environmental Protection Agency (US EPA) risk assessment guidance and derives site-specific screening levels for selected contaminants and exposure pathways. Key attributes of the SSG include default values for generic SSLs where site-specific information is unavailable, and the identification of parameters for which site-specific information is needed for the development of site-specific SSLs. The goal of the SSG is to provide a consistent approach for developing site-specific SSLs for evaluating facilities under the auspices of the corrective action process within NMED.

The NMED SSLs are based on a 1E-05 target risk for carcinogens, or a hazard quotient of 1 for noncarcinogens. In instances where an individual contaminant has the capacity to elicit both types of responses, the SSLs preferentially report the screening value representative of the lowest (most stringent) contaminant concentration in environmental media. SSLs for migration to groundwater are based on NMED-specific tap water SSLs. As such, the NMED SSLs serve as a generic benchmark for screening level comparisons of contaminant concentrations in soil. NMED anticipates that the SSLs will be used as a tool to facilitate prompt identification of those contaminants and areas that represent the greatest risks to human health and the environment. While concentrations above the NMED SSLs presented in this document do not automatically designate a site as “contaminated” or trigger the need for a response action, detected concentrations in site soils exceeding screening levels suggest that further evaluation is appropriate. Further evaluation may include additional sampling to further characterize the nature and extent of contamination, consideration of background levels, reevaluation of COPCs or associated risk and hazard using site-specific parameters, and/or a reassessment of the assumptions associated with the generic SSLs (e.g., appropriateness of route-to-route extrapolations, use of chronic toxicity values to evaluate childhood and construction-worker exposures).

Prior to calculating site-specific SSLs, each relevant chemical specific parameter value and toxicological datum should be checked against the most recent version of its source to determine if updated data are available.

In the event that a NMED SSL is not listed for a given chemical, other sources of screening levels should be consulted, such as the US EPA Regional Screening Levels (RSLs) (US EPA, 2011) or a review of toxicological data should be conducted and if available a screening level

calculated for that given chemical. Care should be used when other sources of screening levels are used to ensure that target risk/levels used in development of the levels are consistent with those applied by NMED. For example, the US EPA carcinogenic RSLs are based on a 1E-06 risk level and must be adjusted to a 1E-05 risk level for use.

1.2.1 Exposure Pathways

A complete exposure pathway consists of (1) a source, (2) a mechanism of contaminant release, (3) a receiving or contact medium, (4) a potential receptor population, and (5) an exposure route. All five elements must be present for the exposure pathway to be considered complete.

SSLs have been developed for use in evaluating three discrete exposure scenarios representing a variety of potential land uses: residential, commercial/industrial, and construction. The SSG presents lists of potential pathways for each scenario, though these lists are not intended to be exhaustive. Instead, each list represents a set of typical exposure pathways likely to account for the majority of exposure to contaminants in soil at a given site. These include:

- Direct (or incidental) ingestion of soil,
- Dermal contact with soil,
- Inhalation of volatiles and fugitive dusts from contaminated soil, and
- Migration of chemicals through soil to an underlying potable aquifer or water-bearing unit.

Under some site-specific situations, additional complete exposure pathways may be identified. In these cases, a site-specific evaluation of risk is warranted under which additional exposure pathways can be considered. If other land uses and exposure scenarios are determined to be more appropriate for a site (e.g., vapor intrusion pathway, home gardening/farming, recreational land use, and/or Native American land use), the exposure pathways addressed in this document should be modified or augmented accordingly or a site-specific risk assessment should be conducted. Early identification of the need for additional information is important because it facilitates development of a defensible sampling and analysis strategy.

The exposure pathways evaluated addressed in this guidance are presented by land-use scenario in Table 1-1.

Table 1-1. Exposure Pathways Evaluated in Soil Screening Guidance

Potential Exposure Pathway	Residential	Commercial /Industrial	Construction
Direct ingestion of soil	✓	✓	✓
Dermal contact with soil	✓	✓	✓
Inhalation of dust and volatiles from soil	✓	✓	✓
Inhalation of VOCs from vapor intrusion ^a	--	--	--
^a the inhalation of dust and volatiles from contaminated soil does not account for exposure via vapor intrusion. If volatile organic compounds are present, then the vapor intrusion pathway must be evaluated in addition to the comparison of dust and volatile concentrations against the SSLs.			

1.2.2 Exposure Assumptions

SSLs represent risk-based concentrations in soil derived from equations combining exposure assumptions with toxicity criteria following the US EPA's preferred tiered hierarchy of toxicological data (US EPA 2009a, 2006, 2003, and 1997a). The models and assumptions used were developed to be consistent with the Superfund concept of "reasonable maximum exposure" (US EPA 1989 and 2009a). This is intended to provide an upper-bound estimate of chronic exposure by combining both average and conservative (i.e., 90th to 95th percentile) values in the calculations. The default intake and duration assumptions presented here are intended to be protective of all potentially exposed populations for each land use consideration. Exposure point concentrations in soil should reflect either directly measured or estimated values using fate and transport models. When assessing chronic, long-term exposures, the maximum detected site concentration should be used for an initial screen against the SSLs. A more refined assessment may include use of an estimate of the average [95 percent upper confidence level (UCL) of the mean] concentration if sufficient site data to allow for an accurate estimation of the UCL. Where the potential for acute toxicity may be of concern, estimates based on the maximum exposure may be more appropriate.

The resulting estimate of exposure is then compared with chemical-specific toxicity criteria. To calculate the SSLs, the exposure equations and pathway models are rearranged to back calculate an "acceptable level" of a contaminant in soil corresponding to a specific level of target risk or hazard.

1.2.3 Target Risk and Hazard

Target risk and hazard levels for human health are risk management-based criteria for carcinogenic and non-carcinogenic responses, respectively, to determine: (1) whether site-related contamination poses an unacceptable risk to human health and requires corrective action or (2) whether implemented corrective action(s) sufficiently protects human health. If an estimated risk or hazard falls within the target range, the risk manager must decide whether or not the site poses an unacceptable risk. This decision should take into account the degree of inherent conservatism or level of uncertainty associated with the site-specific estimates of risk and hazard. An estimated risk that exceeds these targets, however, does not necessarily indicate that the current conditions are not safe or that they present an unacceptable risk. Rather, a site risk calculation that exceeds a target value may simply indicate the need for further evaluation or refinement of the exposure model.

For cumulative exposure via the ingestion, inhalation, and dermal pathways, toxicity criteria are used to calculate an acceptable level of contamination in soil. SSLs are based on a carcinogenic risk level of one-in-one-hundred thousand (1E-05) and a non-carcinogenic hazard quotient of 1. A carcinogenic risk level is defined as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. The non-carcinogenic hazard quotient assumes that there is a level of exposure below which it is unlikely for even sensitive populations to experience adverse health effects.

1.2.4 SSL Model Assumptions

The models used to calculate inhalation exposure and protection of groundwater based on potential migration of contaminants in soil are intended to be utilized at an early stage in the site investigation process when information regarding the site may be limited. For this reason, the models incorporate a number of simplifying assumptions. For instance, the models assume an infinite contaminant source, i.e. a constant concentration is maintained for the duration of the exposure period. Although this is a highly conservative assumption, finite source models require accurate data regarding source size and volume. Such data are unlikely to be available from limited sampling efforts. The models also assume that contamination is homogeneous throughout the source and that no biological or chemical degradation occurs. Where sufficient site-specific data are available, more detailed finite-source models may be used in place of the default model assumptions presented in this SSG.

2.0 DEVELOPMENT OF PATHWAY SPECIFIC SOIL SCREENING LEVELS

The following sections present the technical basis and limitations used to calculate SSLs for residential, commercial/industrial, and construction land use scenarios. The equations used to evaluate inhalation and migration to groundwater include a number of easily obtainable site-specific input parameters. Where site-specific data are not available, conservative default values are presented. The equations used are presented in Sections 2.2, 2.3, and 2.4. Generic SSLs calculated for 220 chemicals, using these default values, are presented in Table A-1 of Appendix A.

2.1 Human Health Basis

The toxicity criteria used for calculating the SSLs are presented in Table C-1 of Appendix C. The primary sources for the human health benchmarks follow the US EPA Superfund programs tiered hierarchy of human health toxicity values (US EPA 2011, 2003):

- 1) Integrated Risk Information System (IRIS) (US EPA 2011) (www.epa.gov/iris),
- 2) Provisional peer reviewed toxicity values (PPRTVs) (now available on-line at <http://hhpprtv.ornl.gov/>),
- 3) Agency for Toxic Substances and Disease Registry (ATSDR) (<http://www.atsdr.cdc.gov/>) and minimal risk levels (MRLs) (<http://www.atsdr.cdc.gov/mrls/index.asp>),
- 4) California EPA's Office of Environmental and Health Hazard Assessment values (CalEPA) (<http://www.oehha.ca.gov/air/allrels.html> and <http://www.oehha.ca.gov/risk/pdf/tcdb072109alpha.pdf>), and
- 5) Health Effects Assessment Summary Tables (HEAST) (US EPA 1997a).

Special assumptions were also applied in determining appropriate toxicological data for certain chemicals.

Dioxins/Furans. Toxicity data for the congeners for the dioxin and furan congeners were assessed using the 2005 World Health Organization's (WHO) toxicity equivalency factors (TEF) (Van den berg, et al 2006) and are summarized in Table 2-1. The TEFs were applied to available toxicity data for 2,3,7,8-TCDD.

Table 2-1. Dioxin and Furan Toxicity Equivalency Factors

Dioxin and Furan Congeners	TEF
Chlorinated dibenzo-p-dioxins	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
Chlorinated dibenzofurans	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003

PCBs. Toxicity for the non-ortho [International Union of Pure and Applied Chemistry (IUPAC) numbers 77, 81, 126, and 169] and mono-ortho congeners (IUPAC numbers 105, 114, 118, 123, 156, 157, 167, and 189) for the PCB congeners were assessed using the 2005 WHO TEFs (Van den berg, et al 2006) while TEFs for di-ortho congeners (IUPAC numbers 170 and 180) are taken from Ahlborg, et al, 1993 (see Table 2-2).

Table 2-2. PCB TEFs

IUPAC No.	Structure	TEF
77	3,3',4,4'-TetraCB	0.0001
81	3,4,4',5'-TetraCB	0.0003
105	2,3,3',4,4'-PeCB	0.00003
114	2,3,4,4',5'-PeCB	0.00003
118	2,3',4,4',5'-PeCB	0.00003
123	2',3,4,4',5'-PeCB	0.00003
126	3,3',4,4',5'-PeCB	0.1
156	2,3,3',4,4',5'-HxCB	0.00003
157	2,3,3',4,4',5'-HxCB	0.00003
167	2,3',4,4',5,5'-HxCB	0.00003
169	3,3',4,4',5,5'-HxCB	0.03
189	2,3,3',4,4',5,5'-HpCB	0.00003
170	2,2',3,3',4,4',5'-HpCB	0.0001
180	2,2',3,4,4',5,5'-HpCB	0.00001

Cadmium. IRIS provides an oral reference dose (RfD) for both water and food. For deriving the tap water SSL, the RfD for water was applied and for the soil-based SSL, the RfD for food was applied.

Vanadium. The oral RfD from IRIS was modified to be based on the molecular weight of vanadium versus vanadium sulfate.

Lead. The US EPA recommended levels for lead, based on blood-lead modeling (Integrated Exposure Uptake Biokinetic Model, IEUBK) were applied.

Total Chromium. The IUR for total chromium is based on a ratio of 1:6 (Cr VI:CrIII) as noted in IRIS. If there is reason to believe that this ratio for total chromium is not representative of site conditions, then valence-specific site concentrations and SSLs for chromium III and chromium VI should be applied.

Chromium VI. The IUR for chromium VI was derived by multiplying the total chromium IUR by 7. This is because the total chromium IUR from IRIS is based on a ratio of 1:6 (Cr VI:CrIII).

2.1.1 Additive Risk

It is important to note that no consideration is provided in the calculation of individual NMED SSLs for additive risk when exposures to multiple chemicals occur. The SSG addresses this issue in Section 5. Because the NMED SSLs for carcinogenic effects correspond to a 1E-05 risk level individually, exposure to multiple contaminants may result in a cumulative site risk that is above the anticipated risk management range. While carcinogenic risks of multiple chemicals are simply added together, the issue of additive hazard is more complex for noncarcinogens because of the theory that a threshold exists for noncarcinogenic effects. This threshold is defined as the level below which adverse effects are not expected to occur, and represents the basis for the RfD and reference concentration (RfC). Since adverse effects are not expected to occur at the RfD or RfC and the SSLs are derived by setting the potential exposure dose to the RfD or RfC, the SSLs do not address the risk of exposure to multiple chemicals at levels where the individual chemicals alone would not be expected to cause any adverse effects. In such cases, the SSLs may not provide an accurate indicator for the likelihood of harmful effects. As a first-tier screening approach, noncarcinogenic effects should be considered additive. In the event that the hazard index results in a value above the target level of 1, noncarcinogenic effects may be evaluated for those chemicals with the same toxic endpoint and/or mechanism of action. The sources provided in Section 2.1 should be consulted to determine the endpoint and/or target organ system prior to attempting to evaluate the additive health effects resulting from simultaneous exposure to multiple contaminants.

2.1.2 Acute Exposures

The exposure assumptions used to develop the SSLs are based on a chronic exposure scenario and do not account for situations where high-level exposures may result in acute toxic effects. Such situations may arise when contaminant concentrations are very high, or may result from

specific site-related conditions and/or behavioral patterns (i.e., pica behavior in children). Such exposures may be of concern for those contaminants that primarily exhibit acute health effects. Toxicological information regarding cyanide and phenol indicate that acute effects may be of concern for children exhibiting pica behavior. Pica is typically described as a compulsive craving to ingest non-food items (such as clay or paint). Although it can be exhibited by adults as well, it is typically of greatest concern in children because they often exhibit behavior (e.g., outdoor play activities and greater hand-to-mouth contact) that results in greater exposure to soil than for a typical adult. In addition, children also have a lower overall body weight relative to the predicted intake.

2.1.3 Early-Life Exposures to Carcinogens

US EPA's (2005) Supplemental Guidance states that early life exposures (i.e., neonatal and early life) to carcinogens can result in an increase in cancer risk later in life from exposures to certain carcinogens. US EPA's (2005) suggestion is to apply age-specific factors to the estimated cancer risks. The life stages that were considered were: 1) children under 2 years of age; and 2) children aged 2 to 6 years; 3) children 6 years to 16 years of age; and 4) after 16 years of age. Effects of mutagenicity have been incorporated into the SSLs for those contaminants which are considered carcinogenic by a mutagenic mode of action.

2.1.4 Direct Ingestion

Exposure to contaminants through incidental ingestion of soil can result from the inadvertent consumption of soils adhering to the hands, food items, or objects that are placed into the mouth. It can also result from swallowing dust particles that have been inhaled and deposited in the mouth and subsequently swallowed. Commercial/industrial, construction workers, and residential receptors may inadvertently ingest soil that adheres to their hands while involved in work- or recreation-related activities. Calculation of SSLs for direct ingestion are based on the methodology presented in US EPA's *Risk Assessment Guidance for Superfund (RAGS): Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (US EPA 1991 2001), *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a).

2.1.5 Dermal Absorption

Exposure to soil contaminants may result from dermal contact with contaminated soil and the subsequent absorption of contaminants through the skin. Contact with soil is most likely to occur as a result of digging, gardening, landscaping, or outdoor recreation activities. Excavation activities may also be a potential source of exposure to contaminants, particularly for construction workers. Calculation of the screening levels for ingestion of soil under the residential exposure scenario is based on the methodology presented in US EPA's *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (1991), and *Soil Screening Guidance: Technical Background Document* (US EPA 1996a). The suggested default input values used to develop the NMED SSLs are consistent with US EPA's interim RAGS, *Part E*,

Supplemental Guidance for Dermal Risk Assessment (US EPA 2004).

2.1.6 Inhalation

US EPA toxicity data indicate that risks from exposure to some chemicals via the inhalation pathway far outweigh the risk via ingestion or dermal contact; therefore, the NMED SSLs have been designed to address inhalation of volatiles and fugitive dusts. To address the soil/sediment-to-air pathways, the SSL calculations incorporate a volatilization factor (VF) for volatile contaminants (See Section 3.1) and a particulate emission factor (PEF) (See Section 3.3) for nonvolatile and volatile contaminants. The SSLs follow the procedures for evaluating inhalation soil, volatile organic compounds (VOCs), and fugitive dust particles presented in US EPA's *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), Final* (US EPA 2009a), *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (US EPA 1991), *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (US EPA 1998a), and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a).

VOCs may adhere to soil particles or be present in interstitial air spaces in soil, and may volatilize into ambient air. This pathway may be particularly significant if the VOC emissions are concentrated in indoor spaces of onsite buildings, or buildings that may be built in the future. The NMED SSLs do not account for vapor intrusion and inhalation of volatile organics volatilized into indoor air. If vapor intrusion into indoor air is a concern, additional analysis of this pathway may be necessary and the latest guidance on evaluating the vapor intrusion pathway should be consulted: for example, the US EPA's 2002 *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Soil Vapor Intrusion Guidance)*. For the purpose of calculating the NMED SSLs, VOCs are considered those chemicals having a Henry's Law constant greater than $1\text{E-}05$ atm-m³/mole and a molecular weight less than 200 g/mole.

Inhalation of contaminants via inhalation of fugitive dusts is assessed using a PEF that relates the contaminant concentration in soil/sediment with the concentration of respirable particles in the air due to fugitive dust emissions. It is important to note that the PEF used to address residential and commercial/industrial exposures evaluates only windborne dust emissions and does not consider emissions from traffic or other forms of mechanical disturbance which could lead to a greater level of exposure. The PEF used to address construction worker exposures evaluates windborne dust emissions and emissions from vehicle traffic associated with construction activities. Therefore, the fugitive dust pathway should be considered carefully when developing the CSM at sites where receptors may be exposed to fugitive dusts by other mechanisms. The development of the PEF for both residential and non-residential land uses is discussed further in Section 3.3.

2.2 Residential land uses

Residential exposures are assessed based on child and adult receptors. As discussed below, the child forms the basis for evaluation of noncarcinogenic effects incurred under residential exposures, while carcinogenic responses are modeled based upon age-adjusted values to account for exposures averaged over a lifetime. Under most circumstances, onsite residential receptors are expected to be the most conservative receptor basis for risk assessment purposes due to the assumption that exposure occurs 24 hours a day, 350 days per year, extending over a 30-year exposure duration. Table 2-3 provides a summary of the exposure characteristics and parameters associated with a residential land use receptor.

Table 2-3. Summary of the Residential Land Use Receptors

Exposure Characteristics	<ul style="list-style-type: none"> • Substantial soil exposure (esp. children) • High soil ingestion rate (esp. children) • Significant time spent indoors • Long-term exposure • Surface and subsurface soil exposure (0-10 feet below ground surface, bgs)
Default Exposure Parameters	
Exposure frequency (days/yr)	350
Exposure duration (yr)	6 (child) 24 (adult)
Soil ingestion rate (mg/day)	200 (child) 100 (adult)
Body Weight (kg)	15 (child) 70 (adult)
Skin surface area exposed (cm ²)	2,800 (child) 5,700 (adult)
Skin-soil adherence factor (mg/cm ²)	0.2 (child) 0.07 (adult)

2.2.1 *Residential Receptors*

A residential receptor is assumed to be a long-term receptor occupying a dwelling within the site boundaries and thus is exposed to contaminants 24 hours per day, and is assumed to live at the site for 30 years (representing the 90th percentile of the length of time someone lives in a single location), remaining onsite for 350 days per year. Exposure to soil (to depths of zero to 10 feet below ground surface) is expected to occur during home maintenance activities, yard work and landscaping, and outdoor play activities. The SSLs do not take into consideration ingestion of homegrown produce/meat/dairy or inhalation of volatiles migrating indoors via vapor intrusion.

If these pathways are complete, analysis of risks resulting from these additional exposure pathways must be determined and added to the risks determined using the SSL screen.

Contaminant intake is assumed to occur via three exposure pathways – direct ingestion, dermal absorption, and inhalation of volatiles and fugitive dusts. For the residential scenario, both adult and child receptors were evaluated because children often exhibit behavior (e.g., greater hand-to-mouth contact) that can result in greater exposure to soils than those associated with a typical adult. In addition, children also have a lower overall body weight relative to the predicted intake.

Equations 1 and 2 are used to calculate cumulative SSLs for a residential receptor exposed to non-carcinogenic and carcinogenic contaminants via all three exposure pathways (ingestion of soil, inhalation of soil, and dermal contact with soil). Default exposure parameters are provided for use when site-specific data are not available.

Equation 1
Combined Exposures to Noncarcinogenic Contaminants in Soil,
Residential Scenario

$$C_{oral} = \frac{THQ \times AT_r \times BW_c}{EF_r \times ED_c \times (1/RfD_o) \times IRS_c \times (10^{-6})}$$

$$C_{inh} = \frac{THQ \times AT_r}{EF_r \times ED_c \times ET_{rs} \times (1/RfC) \times [(1/VF_s) + (1/PEF_w)]}$$

$$C_{dermal} = \frac{THQ \times AT_r \times BW_c}{EF_r \times ED_c \times [1/(RfD_o \times GIABS)] \times SA_c \times AF_c \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{res} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}} + \frac{1}{C_{dermal}}}$$

Parameter	Definition (units)	Default
C _{oral}	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
C _{dermal}	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C _{inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL _{res}	Soil screening level, all pathways (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW _c	Body weight, child (kg)	15

AT _r	Averaging time, noncarcinogens (days)	ED _c x 365
EF _r	Exposure frequency, resident (day/yr)	350
ED _c	Exposure duration, child (years)	6
ET _{rs}	Exposure time, resident (hour/day x day/hour)	1
IRS _c	Soil ingestion rate, child (mg/day)	200
RfD _o	Oral reference dose (mg/kg-day)	Chemical-specific
SA _c	Dermal surface area, child (cm ² /day)	2,800
AF _c	Soil adherence factor, child (mg/cm ²)	0.2
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
ABS _d	Skin absorption factor (unitless)	Chemical-specific
RfC	Inhalation reference concentration (mg/m ³)	Chemical-specific
10 ⁻⁶	Unit conversion factor (kg)/mg	10 ⁻⁶
VF _s	Volatilization factor for soil (m ³ /kg)	See Equation 22
PEF _w	Particulate emission factor (m ³ /kg)	See Equation 24

Equation 2
Combined Exposures to Carcinogenic Contaminants in Soil,
Residential Scenario

$$C_{oral} = \frac{TR \times AT_r}{CFS_o \times EF_r \times IFS_{adj} \times 10^{-6}}$$

$$C_{inh} = \frac{TR \times AT_r}{IUR \times 1000 \times EF_r \times \left(\frac{1}{VF_s} + \frac{1}{PEF_w} \right) \times ED_r \times ET_{rs}}$$

$$C_{dermal} = \frac{TR \times AT_r}{EF_r \times SFS_{adj} \times \frac{CFS_o}{GIABS} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{res} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}} + \frac{1}{C_{dermal}}}$$

Parameter	Definition (units)	Default
C _{oral}	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
C _{dermal}	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C _{inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL _{res}	Soil screening level, all pathways (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT _r	Averaging time, carcinogens (days)	25,550
EF _r	Exposure frequency, resident (day/yr)	350

IFS _{adj}	Age-adjusted soil ingestion factor ([mg-yr]/[kg-day]) (See Equation 3)	114
CSF _o	Oral cancer slope factor (mg/kg-day) ⁻¹	Chemical-specific
SFS _{adj}	Age-adjusted dermal factor ([mg-yr]/[kg-day]) (See Equation 4)	361
ABS _d	Skin absorption factor (unitless)	Chemical-specific
1000	Unit conversion factor (µg/mg)	1000
IUR	Inhalation unit risk (µg/m ³) ⁻¹	Chemical-specific
ED _r	Exposure duration, resident (years)	30
ET _{rs}	Exposure time, resident (hour/day x day/hour)	1
10 ⁻⁶	Unit conversion factor (kg/mg)	10 ⁻⁶
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
VF _s	Volatilization factor for soil (m ³ /kg)	See Equation 22
PEF _w	Particulate emission factor (m ³ /kg)	See Equation 24

Noncarcinogenic contaminants are evaluated based solely on childhood exposures using Equation 1. By combining the higher contaminant intake rates with the lower relative body weight, “childhood only” exposures lead to a lower, or more conservative, risk-based concentration compared to an adult-only exposure. In addition, this approach is considered conservative because it combines the higher 6-year exposure for children with chronic toxicity criteria.

Unlike non-carcinogens, the duration of exposure to carcinogens is averaged over the lifetime of the receptor because of the assumption that cancer may develop even after actual exposure has ceased. As a result, the total dose received is averaged over a lifetime of 70 years. In addition, to be protective of exposures in a residential setting, the carcinogenic exposure parameter values are age-adjusted to account for exposures incurred in children (1-6 years of age) and adults (7-31 years of age). Carcinogenic exposures are age-adjusted to account for the physiological differences between children and adults as well as behavioral differences that result in markedly different relative rates of exposure. Equations 3 and 4 are used to calculate age-adjusted ingestion, dermal and inhalation factors which account for the differences in soil ingestion rate, skin surface area, soil adherence factors, inhalation rate, and body weight for children versus adults. The age-adjusted factors calculated using these equations are applied in Equation 2 to develop generic NMED SSLs for carcinogenic effects.

Equation 3		
Calculation of Age-Adjusted Soil Ingestion Factor		
$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{(ED_r - ED_c) \times IRS_a}{BW_a}$		
Parameter	Definition (units)	Default
IFS _{adj}	Age-adjusted soil ingestion factor for carcinogens [(mg-yr)/(kg-day)]	114
ED _c	Exposure duration, child (years)	6
IRS _c	Soil ingestion rate, child (mg/day)	200

BW _c	Body weight, child (kg)	15
ED _r	Exposure duration, resident (years)	30
IRS _a	Soil ingestion rate, adult (mg/day)	100
BW _a	Body weight, adult (kg)	70

Equation 4**Calculation of Age-Adjusted Soil Dermal Factor**

$$\text{SFS}_{\text{adj}} = \frac{\text{ED}_c \times \text{AF}_c \times \text{SA}_c}{\text{BW}_c} + \frac{(\text{ED}_r - \text{ED}_c) \times \text{AF}_a \times \text{SA}_a}{\text{BW}_a}$$

Parameter	Definition (units)	Default
SFS _{adj}	Age-adjusted dermal factor for carcinogens [(mg-yr)/(kg-day)]	361
ED _c	Exposure duration, child (years)	6
AF _c	Soil adherence factor, child (mg/cm ²)	0.2
SA _c	Dermal surface area, child (cm ² /day)	2,800
BW _c	Body weight, child (kg)	15
ED _r	Exposure duration, resident (years)	30
AF _a	Soil adherence factor, adult (mg/cm ²)	0.07
SA _a	Dermal surface area, adult (cm ² /day)	5,700
BW _a	Body weight, adult (kg)	70

Equations 1 and 2 are appropriate for all chemicals with the exception of vinyl chloride and those carcinogens exhibiting mutagenic toxicity. For vinyl chloride, the US EPA IRIS database provides cancer slope factors for both a child and an adult. The child-based cancer slope factor takes into consideration potential risks during the developmental stages of childhood and thus is more protective than the adult cancer slope factor. The equations used to derive the SSLs for vinyl chloride incorporate age adjustments for exposure and are presented in Equation 5. As vinyl chloride does not have an adsorption factor, dermal risks are not assessed.

**Equation 5
Combined SSL for Vinyl Chloride
Residential Scenario**

$$C_{vc-oral} = \frac{TR}{\left(\frac{CFS_o \times EF_r \times IFS_{adj} \times 10^{-6}}{AT} \right) + \left(\frac{CFS_o \times IRS_c \times 10^{-6}}{BW_c} \right)} \quad \text{Equation 5}$$

$$C_{vc-inh} = \frac{TR}{\left(\frac{IUR \times EF_r \times ED \times ET_{rs} \times 1000}{AT \times VF} + \left(\frac{IUR}{VF} \times 1000 \right) \right)} \quad \text{Equation 6}$$

Combined Exposures:

$$SSL_{res-vc} = \frac{1}{\frac{1}{C_{vc-oral}} + \frac{1}{C_{vc-inh}}}$$

Parameter	Definition (units)	Default
$C_{vc-oral}$	Contaminant concentration (mg/kg)	Chemical-specific
C_{vc-inh}	Contaminant concentration (mg/kg)	Chemical-specific
C_{res-vc}	Combined SSL for vinyl chloride (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
BW_c	Body weight, child (kg)	15
AT	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
IFS_{adj}	Age-adjusted soil ingestion factor ([mg-yr]/[kg-day]) (See Equation 3)	114
CSF_o	Oral cancer slope factor (mg/kg-day) ⁻¹	Chemical-specific
IRS_c	Child soil ingestion factor (mg/day)	200
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
IUR	Inhalation unit risk ($\mu\text{g}/\text{m}^3$) ⁻¹	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
ED	Exposure duration (yr)	30
ET_{rs}	Exposure time (hour/day x day/hour)	1
1000	Conversion factor ($\mu\text{g}/\text{mg}$)	1000
VF	Volatilization factor for soil (m^3/kg)	See Equation 22

Equations 6 through 11 show the derivation of the SSLs for carcinogenic chemicals exhibiting mutagenic properties. Mutagenicity is only assessed for the residential scenario.

Equation 6
SSL for Ingestion of Soil- Mutagens

$$C_{mu-oral} = \frac{TR \times AT_r}{CFS_o \times EF_r \times IFSM_{adj} \times 10^{-6}}$$

Parameter	Definition (units)	Default
$C_{mu-oral}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day) ⁻¹	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
$IFSM_{adj}$	Age-adjusted soil ingestion rate (mg-yr/kg-day) (See Equation 7)	489.5
10^{-6}	Conversion factor (kg/mg)	10^{-6}

Equation 7
Calculation of Age-Adjusted Soil Ingestion Factor, Mutagens

$$IFSM_{adj} = \frac{ED_{0-2} \times IRS_c \times 10}{BW_c} + \frac{ED_{2-6} \times IRS_c \times 3}{BW_c} + \frac{ED_{6-16} \times IRS_a \times 3}{BW_a} + \frac{ED_{16-30} \times IRS_a \times 1}{BW_a}$$

Parameter	Definition (units)	Default
$IFSM_{adj}$	Age-adjusted soil ingestion factor for mutagens [(mg-yr)/(kg-day)]	489.5
ED_{0-2}	Exposure duration, child (years)	2
ED_{2-6}	Exposure duration, child (years)	4
ED_{6-16}	Exposure duration, adult (years)	10
ED_{16-30}	Exposure duration, adult (years)	24
IRS_c	Soil ingestion rate, child (mg/day)	200
IRS_a	Soil ingestion rate, adult (mg/day)	100
BW_c	Body weight, child (kg)	15
BW_a	Body weight, adult (kg)	70
BW_a	Body weight, adult (kg)	70

Equation 8
SSL for Inhalation of Soil- Mutagens

$$C_{mu-inh} = \frac{TR \times AT_r}{(EF_r \times ET_{rs} \times 1000) \times [(ED_{0-2} \times IUR \times 10) + (ED_{2-6} \times IUR \times 3) + (ED_{6-16} \times IUR \times 3) + (ED_{16-30} \times IUR \times 1)] \times \left(\frac{1}{VF_s} + \frac{1}{PEF_w} \right)}$$

Parameter	Definition (units)	Default
C_{mu-inh}	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
IUR	Inhalation Unit Risk ($\mu\text{g}/\text{m}^3$) ⁻¹	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
ED	Exposure duration (yr)	
	ED ₀₋₂	2
	ED ₂₋₆	4
	ED ₆₋₁₆	10
	ED ₁₆₋₃₀	14
ET_{rs}	Exposure time (hour/day x day/hour)	1
1000	Conversion factor ($\mu\text{g}/\text{mg}$)	1000
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 22
PEF_w	Particulate emission factor (m^3/kg)	See Equation 24

Equation 9
SSL for Dermal Contact with Soil- Mutagens

$$C_{mu-dermal} = \frac{TR \times AT_r}{\frac{CFS_o}{GIABS} \times EF_r \times DFSM_{adj} \times ABS_d \times 10^{-6}}$$

Parameter	Definition (units)	Default
$C_{mu-dermal}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CFS_o	Oral cancer slope factor ($\text{mg}/\text{kg}\cdot\text{day}$) ⁻¹	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
$DFSM_{adj}$	Age-adjusted soil contact factor ($\text{mg}\cdot\text{yr}/\text{kg}\cdot\text{day}$) (See Equation 10)	1445
ABS_d	Skin absorption factor (unitless)	Chemical-specific
10^{-6}	Conversion factor (kg/mg)	10^{-6}

Equation 10
Calculation of Age-Adjusted Soil Contact Factor, Mutagens

$$DFSM_{adj} = \frac{ED_{0-2} \times AF_c \times SA_c \times 10}{BW_c} + \frac{ED_{2-6} \times AF_c \times SA_c \times 3}{BW_c} + \frac{ED_{6-16} \times AF_a \times SA_a \times 3}{BW_a} + \frac{ED_{16-30} \times AF_a \times SA_a \times 1}{BW_a}$$

Parameter	Definition (units)	Default
DFSM _{adj}	Age-adjusted soil contact factor for mutagens [(mg-yr)/(kg-day)]	1445
ED ₀₋₂	Exposure duration, child (years)	2
ED ₂₋₆	Exposure duration, child (years)	4
ED ₆₋₁₆	Exposure duration, adult (years)	10
ED ₁₆₋₃₀	Exposure duration, adult (years)	14
AF _c	Soil adherence factor, child (mg/cm ²)	0.02
AF _a	Soil adherence factor, adult (mg/cm ²)	0.07
SA _c	Exposed skin area, child, (cm ² /day)	2800
SA _a	Exposed skin area, adult, (cm ² /day)	5700
BW _c	Body weight, child (kg)	15
BW _a	Body weight, adult (kg)	70

The overall SSL for the residential scenario for mutagens is determined following Equation 11.

Equation 11
Determination of the Combined SSL
Mutagens

$$SSL_{res-mu} = \frac{1}{\frac{1}{C_{mu-oral}} + \frac{1}{C_{mu-inh}} + \frac{1}{C_{mu-dermal}}}$$

Parameter	Definition (units)	Default
SSL _{res-mu}	Cumulative SSL for mutagens (mg/kg)	Chemical-specific
C _{mu-oral}	Concentration from soil ingestion (mg/kg) (See Equation 6)	Receptor-specific
C _{mu-inh}	Concentration from inhalation (mg/kg) (See Equation 8)	Receptor-specific
C _{mu-dermal}	Concentration from dermal exposure (mg/kg) (See Equation 9)	Receptor-specific

2.3 Non-residential land uses

Non-residential land uses encompass all commercial and industrial land uses and focus on two very different receptors – a commercial/industrial worker and a construction worker. Unlike those calculated for residential land-uses, NMED SSLs for non-residential land uses are based solely on exposures to adults. Consequently, exposures to carcinogens are not age-adjusted. Due to the wide range of activities and exposure levels a non-residential receptor may be

exposed to during various work-related activities, it is important to ensure that the default exposure parameters are representative of site-specific conditions. Table 2-4 provides a summary of the exposure characteristics and parameters for non-residential land use receptors.

Table 2-4. Summary of Non-Residential Land Use Receptors

Receptor	Commercial/Industrial Worker	Construction Worker
Exposure Characteristics	<ul style="list-style-type: none"> • Substantial soil exposures • High soil ingestion rate • Long-term exposure • Exposure to surface and shallow subsurface soils (0-1 foot bgs) • Adult-only exposure 	<ul style="list-style-type: none"> • Exposed during construction activities only • Short-term exposure • Very high soil ingestion and dust inhalation rates • Exposure to surface and subsurface soils (0-10 feet bgs)
Default Exposure Parameters		
Exposure frequency (days/yr)	225	250
Exposure duration (yr)	25	1
Soil ingestion rate (mg/day)	100	330
Body Weight (kg)	70	70
Skin surface area exposed (cm ²)	3,300	3,300
Skin-soil adherence factor (mg/ cm ²)	0.2	0.3

2.3.1 Commercial/Industrial Worker

The commercial/industrial scenario is considered representative of on-site workers who spend all or most of their workday outdoors. A commercial/industrial worker is assumed to be a long-term receptor exposed during the course of a work day as either (1) a full time employee of a company operating on-site who spends most of the work day conducting maintenance or manual labor activities outdoors or (2) a worker who is assumed to regularly perform grounds-keeping activities as part of his/her daily responsibilities. Exposure to surface and shallow subsurface soils (i.e., at depths of zero to 1 ft below ground surface) is expected to occur during moderate digging associated with routine maintenance and grounds-keeping activities. A commercial/industrial receptor is expected to be the most highly exposed receptor in the outdoor environment under generic or day-to-day commercial/industrial conditions. Thus, the screening levels for this receptor are expected to be protective of other reasonably anticipated indoor and outdoor workers at a commercial/industrial facility. However, screening levels developed for the commercial/industrial worker may not be protective of a construction worker due to the latter's increased soil contact rate during construction activities. In addition, the SSLs for the commercial/industrial worker do not account for inhalation of volatiles indoors via vapor intrusion.

Equations 12 and 13 were used to develop generic SSLs for cumulative exposure to carcinogenic and non-carcinogenic contaminants by all exposure pathways. Default exposure parameters (US EPA 2002a) are provided and were used in calculating the NMED SSLs.

Equation 12
Combined Exposures to Carcinogenic Contaminants in Soil
Commercial/Industrial Scenario

$$C_{CI-oral} = \frac{TR \times AT_{CI} \times BW_{CI}}{CFS_o \times EF_{CI} \times ED_{CI} \times IR_{CI} \times 10^{-6}}$$

$$C_{CI-inh} = \frac{TR \times AT_{CI}}{IUR \times 1000 \times EF_{CI} \times \left(\frac{1}{VF_s} + \frac{1}{PEF_w} \right) \times ED_{CI} \times ET_{CI}}$$

$$C_{CI-dermal} = \frac{TR \times AT_{CI} \times BW_{CI}}{EF_{CI} \times ED_{CI} \times \frac{CFS_o}{GIABS} \times SA_{CI} \times AF_{CI} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{CI} = \frac{1}{\frac{1}{C_{CI-oral}} + \frac{1}{C_{CI-inh}} + \frac{1}{C_{CI-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CI-oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CI-dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C_{CI-inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CI}	Contaminant concentration, all pathways (mg/kg)	Chemical-specific
TR	Target Risk	1E-05
BW_{CI}	Body weight, adult (kg)	70
AT_{CI}	Averaging time, carcinogens (days)	25,550
EF_{CI}	Exposure frequency, commercial/industrial (day/yr)	225
ED_{CI}	Exposure duration, commercial/industrial (years)	25
IR_{CI}	Soil ingestion rate, commercial/industrial (mg/day)	100
CSF_o	Oral cancer slope factor (mg/kg-day) ⁻¹	Chemical-specific
SA_{CI}	Dermal surface area, commercial/industrial (cm ² /day)	3,300
AF_{CI}	Soil adherence factor, commercial/industrial (mg/cm ²)	0.2
ABS_d	Skin absorption factor (unitless)	Chemical-specific

ET _{CI}	Exposure time, commercial/industrial (8 hours/per 24 hours)	0.33
IUR	Inhalation unit risk (µg/m ³) ⁻¹	Chemical-specific
1000	Unit conversion (µg/mg)	1000
VF _s	Volatilization factor for soil (m ³ /kg)	See Equation 22
PEF _w	Particulate emission factor (m ³ /kg)	See Equation 24

Equation 13

**Combined Exposures to Noncarcinogenic Contaminants in Soil
Commercial/Industrial Scenario**

$$C_{CI-oral} = \frac{THQ \times AT_{CI} \times BW_a}{EF_{CI} \times ED_{CI} \times (1/RfD_o) \times IR_{CI} \times (10^{-6})}$$

$$C_{CI-inh} = \frac{THQ \times AT_{CI}}{EF_{CI} \times ED_{CI} \times ET_{CI} \times (1/RfC) \times [(1/VF_s) + (1/PEF_w)]}$$

$$C_{CI-dermal} = \frac{THQ \times AT_{CI} \times BW_a}{EF_{CI} \times ED_{CI} \times [1/(RfD_o \times GIABS)] \times SA_{CI} \times AF_{CI} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{CI} = \frac{1}{\frac{1}{C_{CI-oral}} + \frac{1}{C_{CI-inh}} + \frac{1}{C_{CI-dermal}}}$$

Parameter	Definition (units)	Default
C _{CI-oral}	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
C _{CI-dermal}	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C _{CI-inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL _{CI}	Soil screening level, all pathways (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW _a	Body weight, adult (kg)	70
AT _{CI}	Averaging time, noncarcinogens (days)	ED x 365
EF _{CI}	Exposure frequency, commercial/industrial (day/yr)	225
ED _{CI}	Exposure duration, commercial/industrial (years)	25
IR _{CI}	Soil ingestion rate, commercial/industrial (mg/day)	100
10 ⁻⁶	Unit conversion factor (kg/mg)	10 ⁻⁶

RfD _o	Oral reference dose (mg/kg-day)	Chemical-specific
SA _{CI}	Dermal surface area, commercial/industrial (cm ² /day)	3,300
AF _{CI}	Soil adherence factor, commercial/industrial (mg/cm ²)	0.2
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
ABS _d	Skin absorption factor (unitless)	Chemical-specific
ET _{CI}	Exposure time(8 hours/day per 1 day/24 hour)	0.33
RfC	Reference concentration (mg/m ³)	Chemical-specific
VF _s	Volatilization factor for soil (m ³ /kg)	See Equation 22
PEF _w	Particulate emission factor (m ³ /kg)	See Equation 24

2.3.2 Construction Worker

A construction worker is assumed to be a receptor that is exposed to contaminated soil during the work day for the duration of a single on-site construction project. If multiple construction projects are anticipated, it is assumed that different workers will be employed for each project. The activities for this receptor typically involve substantial exposures to surface and subsurface soils (i.e., at depths of zero to 10 feet below ground surface) during excavation, maintenance and building construction projects (intrusive operations). A construction worker is assumed to be exposed to contaminants via the following pathways: incidental soil ingestion, dermal contact with soil, and inhalation of contaminated outdoor air (volatile and particulate emissions). While a construction worker receptor is assumed to have a higher soil ingestion rate than a commercial/industrial worker due to the type of activities performed during construction projects, the exposure frequency and duration are assumed to be significantly shorter due to the short-term nature of construction projects. However, chronic toxicity information was used when developing screening levels for a construction worker receptor. This approach is significantly more conservative than using sub-chronic toxicity data because it combines the higher soil exposures for construction workers with chronic toxicity criteria. Equations 14 and 15 were used to develop generic SSLs for cumulative exposure to carcinogenic and non-carcinogenic contaminants by all exposure pathways for a construction worker. Default exposure parameters (US EPA 2002a) are provided and were used in calculating the NMED SSLs.

Equation 14
Combined Exposures to Carcinogenic Contaminants in Soil
Construction Worker Scenarios

$$C_{CW-oral} = \frac{TR \times AT_{CW} \times BW_{CW}}{CFS_o \times EF_{CW} \times ED_{CW} \times IR_{CW} \times 10^{-6}}$$

$$C_{CW-inh} = \frac{TR \times AT_{CW}}{IUR \times 1000 \times EF_{CW} \times \left(\frac{1}{VF_{CW}} + \frac{1}{PEF_{CW}} \right) \times ED_{CW} \times ET_{CW}}$$

$$C_{CW-dermal} = \frac{TR \times AT_{CW} \times BW_{CW}}{EF_{CW} \times ED_{CW} \times \frac{CFS_o}{GIABS} \times SA_{CW} \times AF_{CW} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{CW} = \frac{1}{\frac{1}{C_{CW-oral}} + \frac{1}{C_{CW-inh}} + \frac{1}{C_{CW-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CW-oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CW-dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C_{CW-inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CW}	Contaminant concentration, all pathways (mg/kg)	Chemical-specific
TR	Target Risk	1E-05
BW_{CW}	Body weight, adult (kg)	70
AT_{CW}	Averaging time, carcinogens (days)	365
EF_{CW}	Exposure frequency, construction worker (day/yr)	250
ED_{CW}	Exposure duration, construction worker (years)	1
IR_{CW}	Soil ingestion rate, construction worker (mg/day)	330
CSF_o	Oral cancer slope factor (mg/kg-day) ⁻¹	Chemical-specific
SA_{CW}	Dermal surface area, construction worker (cm ² /day)	3,300
AF_{CW}	Soil adherence factor, construction worker (mg/cm ²)	0.3
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CW}	Exposure time, construction worker (8 hours/day per 1 day/24 hours)	0.33
IUR	Inhalation unit risk (µg/m ³) ⁻¹	Chemical-specific
1000	Unit conversion (µg/mg)	1000
VF_{CW}	Volatilization factor for soil (m ³ /kg)	See Equation 22
PEF_{CW}	Particulate emission factor (m ³ /kg)	See Equation 25

Equation 15

**Combined Exposures to Noncarcinogenic Contaminants in Soil
Construction Worker Scenario**

$$C_{CW-oral} = \frac{THQ \times AT_{CW} \times BW_{CW}}{EF_{CW} \times ED_{CW} \times (1/RfD_o) \times IR_{CW} \times (10^{-6})}$$

$$C_{CW-inh} = \frac{THQ \times AT_{CI}}{EF_{CW} \times ED_{CW} \times ET_{CW} \times (1/RfC) \times [(1/VF_{CW}) + (1/PEF_{CW})]}$$

$$C_{CW-dermal} = \frac{THQ \times AT_{CW} \times BW_{CW}}{EF_{CW} \times ED_{CW} \times [1/(RfD_o \times GIABS)] \times SA_{CW} \times AF_{CW} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{CW} = \frac{1}{\frac{1}{C_{CW-oral}} + \frac{1}{C_{CW-inh}} + \frac{1}{C_{CW-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CW-oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CW-dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C_{CW-inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CW}	Soil screening level, all pathways (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_{CW}	Body weight, adult (kg)	70
AT_{CW}	Averaging time, noncarcinogens (days)	ED x 365
EF_{CW}	Exposure frequency, construction worker (day/yr)	250
ED_{CW}	Exposure duration, construction worker (years)	1
IR_{CW}	Soil ingestion rate, construction worker (mg/day)	330
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_{CW}	Dermal surface area, construction worker (cm ² /day)	3,300
AF_{CW}	Soil adherence factor, construction worker (mg/cm ²)	0.3
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CW}	Exposure time(8 hours/day per 1 day/24 hour)	0.33
RfC	Reference concentration (mg/m ³)	Chemical-specific
VF_{CW}	Volatilization factor for soil (m ³ /kg)	See Equation 22
PEF_{CW}	Particulate emission factor (m ³ /kg)	See Equation 25

2.3.3 *Alternative Evaluation for Lead*

Exposure to lead can result in neurotoxic and developmental effects. The primary receptors of concern are children, whose nervous systems are still undergoing development and who also exhibit behavioral tendencies that increase their likelihood of exposure (e.g., pica). These effects may occur at exposures so low that they may be considered to have no threshold, and are evaluated based on a blood lead level (rather than the external dose as reflected the RfD/RfC methodology). Therefore, US EPA views it to be inappropriate to develop noncarcinogenic “safe” exposure levels (i.e., RfDs) for lead. Instead, US EPA’s lead assessment workgroup has recommended the use of the IEUBK model that relates measured lead concentrations in environmental media with an estimated blood-lead level (US EPA 1994 and 1998b). The model is used to calculate a blood lead level in children when evaluating residential land use and in adults (based on a pregnant mother’s capacity to contribute to fetal blood lead levels), or when evaluating occupational scenarios at sites where access by children is reliably restricted. The NMED SSLs presented in Appendix A include values for lead that were calculated by using the IEUBK to back-calculate a soil concentration for each receptor that would not result in an estimated blood-lead concentration of 10 micrograms per deciliter ($\mu\text{g}/\text{dL}$) or greater (residential adult of 400 mg/kg and industrial and construction worker of 800 mg/kg).

2.4 Tap Water Screening Levels

Exposure to contaminants can occur through the ingestion of domestic/household water and inhalation of volatiles in domestic/household water. The calculations of the NMED tap water screening levels for domestic water are based upon the methodology presented in RAGS, part B (US EPA 1991). The screening levels are based upon ingestion and inhalation of contaminants in water. Although exposure to contaminants could occur through dermal contact with domestic/household water, exposure to contaminants in water is primarily due to ingestion and inhalation. Therefore, dermal contact with water was not included in the calculation of the tap water screening levels (SLs). If it is determined that dermal exposure to water at the site being evaluated is a significant exposure pathway, then dermal contact with water should be evaluated further using methods outlined in RAGS, Part E (US EPA, 2004). While ingestion is for all chemicals, inhalation of volatiles from water was considered for those chemicals with a minimum Henry’s Law constant of $1\text{E}-05 \text{ atm}\cdot\text{m}^3/\text{mole}$ and with a maximum molecular weight of 200 g/mole. To address the groundwater-to-air pathways, the tap water screening levels incorporate a volatilization factor (K) of $0.5 \text{ L}/\text{m}^3$ for volatile contaminants (US EPA, 1991); this derived value defines the relationship between the concentration of a contaminant in household water and the average concentration of the volatilized contaminant in air as a result of all uses of household water (i.e., showering, laundering, dish washing).

As ingestion and inhalation rates may be different for children and adults, carcinogenic risks were calculated using age-adjusted factors, which were obtained from RAGS, Part B (US EPA 1991). Equations 16 through 18 show how SLs for carcinogenic and non-carcinogenic contaminants were developed. Similar to soil, separate equations are used for vinyl chloride (Equation 19) and carcinogens exhibiting mutagenic toxicity (Equation 20).

Equation 16
Ingestion and Inhalation Exposures to Carcinogenic Contaminants in Tap Water Residential Scenario

$$C_{oral} = \frac{TR \times AT_r \times 1000}{EF_r \times CSF_o \times IFW_{adj}}$$

$$C_{inh} = \frac{TR \times AT_r}{EF_r \times ED_r \times ET_{rw} \times IUR \times K}$$

Combined Exposures:

$$SSL_{tap} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion ($\mu\text{g/L}$)	Chemical-specific
C_{ihal}	Contaminant concentration, inhalation ($\mu\text{g/L}$)	Chemical-specific
SSL_{tap}	Tap water screening level ($\mu\text{g/L}$)	Chemical-specific
TR	Target risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
1000	Unit conversion ($\mu\text{g/mg}$)	1000
IFW_{adj}	Age-adjusted water ingestion rate, resident (L-yr/kg-day) (See Equation 17)	1.086
CSF_o	Oral cancer slope factor (mg/kg-day^{-1})	Chemical-specific
ED_r	Exposure duration (years)	30
ET_{rw}	Exposure time (24 hours/day per 1 day/24 hours)	1
IUR	Inhalation unit risk ($\mu\text{g/m}^3$) ⁻¹	Chemical-specific
K	Andelman volatilization factor (L/m^3)	0.5

Equation 17

Calculation of Age-Adjusted Tap Water Ingestion Factor

$$IFW_{adj} = \frac{ED_c \times IRW_c}{BW_c} + \frac{ED_{r-c} \times IRW_a}{BW_a}$$

Parameter	Definition (units)	Default
IFW_{adj}	Age-adjusted water ingestion factor for carcinogens [(L-yr)/(kg-day)]	1.086
ED_c	Exposure duration, child (years)	6
IRW_c	Water ingestion rate, child (L/day)	1
BW_c	Body weight, child (kg)	15
ED_{r-c}	Exposure duration, resident minus child (years)	24
IRW_a	Water ingestion rate, adult (L/day)	2
BW_a	Body weight, adult (kg)	70

Equation 18

Ingestion and Inhalation Exposures to Noncarcinogenic Contaminants in Tap Water Residential Scenario

$$C_{oral} = \frac{THQ \times BW_a \times 1000 \times AT_r}{EF_r \times ED_r \times \left(\frac{1}{RfD_o}\right) \times IRW_a}$$

$$C_{inh} = \frac{THQ \times AT_r \times 1000}{EF_r \times ED_r \times ET_{rw} \times \left(\frac{1}{RfC}\right) \times K}$$

Combined Exposures:

$$SSL_{tap} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C_{inl}	Contaminant concentration, inhalation (µg/L)	Chemical-specific
SSL_{tap}	Tap water screening level (µg/L)	Chemical-specific
THQ	Target hazard quotient	1
BW_a	Body weight, adult (kg)	70
AT_r	Averaging time, noncarcinogens (days)	$ED_r \times 365$
1000	Unit conversion (µg/mg)	1000
EF_r	Exposure frequency, resident (day/yr)	350

ED _r	Exposure duration, resident (years)	30
IRW _a	Water ingestion rate, resident (L/day)	2
RfD _o	Oral reference dose(mg/kg-day)	Chemical-specific
ET _{rw}	Exposure time (24 hours/day per 1day/24 hours)	1
RfC	Reference concentration ((mg/m ³)	Chemical-specific
K	Andelman volatilization factor (L/m ³)	0.5

Equation 19
Ingestion and Inhalation Exposures to Vinyl Chloride in Tap Water
Residential Scenario

$$C_{oral} = \frac{TR}{\left(\frac{CSF_o \times EF_r \times IFW_{adj} \times 0.001}{AT} + \frac{CSF_o \times IRW_c \times 0.001}{BW_c} \right)}$$

$$C_{inh} = \frac{TR}{\left(\frac{IUR \times EF_r \times ED_r \times ET_{rw} \times K}{AT} + (IUR \times K) \right)}$$

Combined Exposures:

$$SSL_{tap} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}}}$$

Parameter	Definition (units)	Default
C _{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C _{ihal}	Contaminant concentration, inhalation (µg/L)	Chemical-specific
SSL _{tap}	Tap water screening level (µg/L)	Chemical-specific
TR	Target risk	1E-05
AT	Averaging time, carcinogens (days)	25,550
EF _r	Exposure frequency, resident (day/yr)	350
0.001	Unit conversion (mg/µg)	0.001
IFW _{adj}	Age-adjusted water ingestion rate, resident (L-yr/kg-day) (See Equation 17)	1.086
IRW _c	Child water ingestion rate, resident (L/day)	1
CSF _o	Oral cancer slope factor (mg/kg-day) ⁻¹	Chemical-specific
ED _r	Exposure duration (years)	30
ET _{rw}	Exposure time (24 hours/day per 1day/24 hours)	1
IUR	Inhalation unit risk (µg/m ³) ⁻¹	Chemical-specific
K	Andelman volatilization factor (L/m ³)	0.5

Equation 20
SL for Tap Water, Residential Exposure – Mutagens

$$C_{mu-oral} = \frac{TR \times AT_r \times 1000}{CFS_o \times EF_r \times IFWM_{adj}}$$

$$C_{mu-inh} = \frac{TR \times AT_r}{(EF_r \times ET_{rs} \times K) \times [(ED_{0-2} \times IUR \times 10) + (ED_{2-6} \times IUR \times 3) + (ED_{6-16} \times IUR \times 3) + (ED_{16-30} \times IUR \times 1)]}$$

Combined Exposures:

$$SSL_{tap-mu} = \frac{1}{\frac{1}{C_{mu-oral}} + \frac{1}{C_{mu-inh}}}$$

Parameter	Definition (units)	Default
$C_{mu-oral}$	Contaminant concentration, ingestion ($\mu\text{g}/\text{kg}$)	Chemical-specific
C_{mu-inh}	Contaminant concentration, inhalation ($\mu\text{g}/\text{kg}$)	Chemical-specific
SSL_{tap-mu}	Tap water screening level ($\mu\text{g}/\text{L}$)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor ($\text{mg}/\text{kg}\text{-day}^{-1}$)	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
ET_{rw}	Exposure time (24 hours/day per 1 day/24 hours)	1
K	Andelman volatilization factor (L/m^3)	0.5
$IFWM_{adj}$	Age-adjusted water ingestion rate ($\text{L}\text{-yr}/\text{kg}\text{-day}$) (See Equation 21)	3.39
1000	Conversion factor ($\mu\text{g}/\text{mg}$)	1000
ED_{0-2}	Exposure duration, child (years)	2
ED_{2-6}	Exposure duration, child (years)	4
ED_{6-16}	Exposure duration, adult (years)	10
ED_{16-30}	Exposure duration, adult (years)	14
IUR	Inhalation unit risk ($\mu\text{g}/\text{m}^3$) ⁻¹	Chemical-specific

Equation 21
Calculation of Age-Adjusted Tap Water Ingestion Factor, Mutagens

$$IFWM_{adj} = \frac{ED_{0-2} \times IRW_c \times 10}{BW_c} + \frac{ED_{2-6} \times IRW_c \times 3}{BW_c} + \frac{ED_{6-16} \times IRW_a \times 3}{BW_a} + \frac{ED_{16-30} \times IRW_a \times 1}{BW_a}$$

Parameter	Definition (units)	Default
IFWM _{adj}	Age-adjusted water ingestion factor for mutagens [(L-yr)/(kg-day)]	3.39
ED ₀₋₂	Exposure duration, child (years)	2
ED ₂₋₆	Exposure duration, child (years)	4
ED ₆₋₁₆	Exposure duration, adult (years)	10
ED ₁₆₋₃₀	Exposure duration, adult (years)	14
IRW _c	Water ingestion rate, child (L/day)	1
IRW _a	Water ingestion rate, adult (L/day)	2
BW _c	Body weight, child (kg)	15
BW _a	Body weight, adult (kg)	70

2.5 Site Assessment and Characterization

The Site Assessment/Site Characterization phase is intended to provide additional spatial and contextual information about the site, which may be used to determine if there is any reason to believe that receptors and/or complete exposure pathways may exist at or in the locality of the site where a release of hazardous waste/constituents has occurred. In addition, the site assessment phase serves as the initial information gathering phase to determine whether potential exposures are sufficiently similar to those upon which the NMED SSLs are predicated to support comparison. Finally, this phase can help to identify sites in need of a more detailed assessment of potential risk. A CSM providing a list of the potentially exposed receptors and potentially complete exposure pathways in the scoping report is used to determine whether further assessment (i.e., a screening level assessment) and/or interim measures are required or whether the site poses minimal threat to human and ecological receptors at or near the site.

The ultimate purpose of the site assessment phase is to address the question: Are exposure pathways complete with regard to contaminant contact by receptors? A complete site assessment will consist of several steps:

- Develop data quality objectives and conduct site sampling;
- Identify preliminary COPCs;
- Develop a preliminary site conceptual exposure model (SCEM);
- Determine Exposure Intervals;
- Compare maximum COPC concentrations for consideration of complete exposure pathways with SSLs;
- Assess concentrations of essential nutrients; and
- If the site maximums are above the SSLs, a Tier 2 approach may be deemed appropriate by NMED using the 95% upper confidence limit (UCL) value) for contaminant concentrations (or detection/quantitation limits for non-detect results).

2.5.1 Development of Data Quality Objectives

Before any additional environmental samples are collected, data quality objectives (DQOs) should be developed. The DQOs should address the qualitative and quantitative nature of the sampling data, in terms of relative quality and intent for use, to ensure that any data collected will be appropriate for the intended objective. Development of the DQOs should consider not only precision, accuracy, representativeness, completeness, and comparability of the data, but also the sampling locations, types of laboratory analyses used, sensitivity of detection limits of the analytical techniques, the resulting data quality, and the employment of adequate quality assurance/quality control measures.

2.5.2 Identification of COPCs

COPCs are those substances (including transformation or breakdown compounds and companion products) likely to be present in environmental media affected by a release. Identification of COPCs should begin with existing knowledge of the process, product, or waste from which the release originated. For example, if facility operations deal primarily with pesticide manufacturing then pesticides should be considered COPCs. Contaminants identified during current or previous site investigation activities should also be evaluated as COPCs. A site-specific COPC list for soil may be generated based on maximum detected (or, if deemed appropriate by NMED, the 95% UCL value) concentrations (US EPA 2002b) and a comparison of detection/quantitation limits for non-detect results to the NMED SSLs. This list may be refined through a site-specific risk assessment. Per US EPA guidance (US EPA 1989), if there is site history to indicate a chemical was potentially used/present at a site, and the chemical was detected in at least one sample, this chemical must be included as a COPC and evaluated in the screening assessment.

For inorganics, a comparison of site concentrations to appropriate background concentrations may be conducted prior to evaluation against SSLs. Those inorganics that are present at levels indicative of natural background may be eliminated as a COPC. Comparison to background must be conducted following current US Guidance and outlined in this guidance. The general process is a tiered approach.

Step 1. Compare the maximum detected site concentration to the site-specific background reference values (upper tolerance limit) determined for that site. If the site maximum is less than the background reference value, it is assumed that the site concentrations are representative of background and the metal/inorganic is not retained as a COPC. If there is no background value for a constituent, then it will be retained as a COPC.

Step 2: If the maximum site concentration is greater than the background reference value, then a two-sample hypothesis test should be used to compare the distributions of the site data to the distributions of background data to determine if site concentrations are elevated compared with background. The most recent version of US EPA's ProUCL statistical software will be used for hypothesis testing. ProUCL will also be used to determine the most appropriate test (parametric or nonparametric) based on

distribution of the data. Appropriate methods in ProUCL will also be used to compute site-to-background comparisons based on censored data sets containing non-detect values.

Note that the above two-sample test can only be used for site data-sets that have sufficient number of samples (i.e., $n \geq 8$) and number of detections (i.e., ≥ 5 detected observations). Site-to-background point-by-point comparisons will be conducted for site data sets containing fewer than eight samples and fewer than five detected observations. As stated in the current version of ProUCL User's Guide (US EPA, 2010), hypothesis testing is only considered to be reliable with sufficient sample size ($n \geq 8$) and frequency of detection (≥ 5 detected observations). If there are not at least eight samples in the site data set and at least five detections, then the site maximum detected concentrations will be compared to the corresponding background value (i.e., 95% upper tolerance limit) as noted in Step 1 or additional data must be collected to conduct a two-tailed test.

Step 3: Additional lines of evidence may be used to justify exclusion of an inorganic as being site related, such as site history, number of non-detects, etc. Comparison of site data to regional data (such as US Geological Survey (USGS) databases not specific to the site) is not an acceptable line of evidence.

2.5.3 Development of a Preliminary Conceptual Site Model

A CSM is a graphical representation of three-dimensional site conditions that conveys what is known or suspected, at a discrete point in time, about the site-specific sources, releases, release mechanisms, contaminant fate and transport, exposure routes, and potential receptors. The CSM is generally documented by written descriptions and supported by maps, geological cross-sections, tables, diagrams and other illustrations to communicate site conditions. When preparing a CSM, the facility should decide the scope, quantity, and relevance of information to be included, balancing the need to present as complete a picture as possible to document current site conditions and justify risk management actions, with the need to keep the information focused and exclude extraneous data.

As a final check, the CSM should answer the following questions:

- Are there potential land uses present (now or in the foreseeable future) other than those covered by the SSLs? (refer to US EPA 1989).
- Are there other likely human exposure pathways that were not considered in development of the SSLs (e.g. vapor intrusion, direct exposure to groundwater, local fish consumption, raising homegrown produce, beef, dairy, or other livestock)? (refer to US EPA 1989)
- Are there potential ecological concerns? (*Guidance for Assessing Ecological Risks Posed by Chemicals: Screening Level Ecological Risk Assessment*; NMED 2000)

If any conditions such as these exist, the SSLs may need to be adjusted to reflect this new information.

2.5.4 Determine Exposure Intervals

Based on current and potential land-use scenarios, receptors for completed exposure pathways can be exposed to varying depths of soil, or soil exposure intervals. Per US EPA (US EPA 1989), depth of samples should be considered and surface soils should be evaluated separately from subsurface soils due to possible differences in exposure levels that would be encountered by different receptors. Exposure intervals for each receptor are based on the types of activities in which each receptor is likely to be involved. Default exposure intervals are summarized in Table 2-5.

It is assumed that commercial/industrial workers would only be exposed to surface soils (0-1 ft below ground surface). As stated in Section 2.3.1, this receptor may be involved in moderate digging associated with routine maintenance and grounds keeping activities. Therefore, COPC concentrations in soil in the surface soil interval (0-1 ft bgs) should be considered when evaluating exposure by a commercial/industrial worker receptor.

As stated in Section 2.3.2, a construction worker is assumed to be exposed to surface and subsurface soils up to depths of 0-10 ft below ground surface. Construction workers are involved in digging, excavation, maintenance and building construction projects and could be exposed to surface as well as subsurface soil. Therefore, a soil exposure interval of 0-10 feet below ground surface should be considered when evaluating exposure to soil by a construction worker.

Residents could be exposed to surface and subsurface soils during home maintenance activities, yard work, landscaping, and outdoor play activities. Therefore, an exposure soil interval of 0-10 ft below ground surface should be assumed when evaluating soil exposure by a residential receptor.

Exposure to COPCs in soil by ecological receptors should be addressed separately in a tiered approach as outlined by NMED (NMED 2000). However, a discussion of soil exposure intervals for ecological receptors is warranted here because ecological receptors are considered in the CSM and depending on the types of ecological receptors, there can be a differential in exposure levels due to soil exposure intervals. Burrowing animals would be exposed to deeper soils, whereas all other animals would only be exposed to surface and shallow subsurface soils. Therefore, maximum concentrations of COPCs in soil 0-10 ft below ground surface should be assessed for burrowing animals. Maximum COPC concentrations in soil 0-5 ft below ground surface should be assessed for all other animals.

Table 2-5. Soil Exposure Intervals

Receptor	Exposure Intervals (Soil)
Resident (adult and child)	0 – 10 ft bgs
Commercial/Industrial Worker	0 – 1 ft bgs
Construction Worker	0 – 10 ft bgs
Vapor Intrusion	Depth of maximum detection
Ecological Receptors (non-burrowing)	0 – 5 ft bgs
Ecological Receptors (burrowing)	0 – 10 ft bgs

2.5.5 Compare COPC Maximum Concentrations with SSLs

The final step in the site assessment phase is to compare maximum detected COPC concentrations in soil with SSLs based on the complete exposure pathways identified by the preliminary CSM and assessing total risk/hazard from all constituents (Refer to Section 5). These concentrations should also be compared against the SSL leaching values to determine which contaminants present in soil have the capacity to leach to underlying groundwater and impact these resources adversely. As stated earlier, those contaminants exhibiting concentrations in excess of the SSLs represent the initial soil COPC list for a given site. Refinement of this list may be necessary based on a host of factors, including elevated detection or quantitation limits.

3.0 CHEMICAL-SPECIFIC AND PHYSICAL-CHEMICAL PARAMETERS

Chemical-specific parameters required for calculating SSLs include the organic carbon normalized soil-water partition coefficient for organic compounds (K_{oc}), the soil-water partition coefficient (K_d), water solubility (S), octanol-water partition coefficient (K_{ow}), Henry’s Law constant (H), diffusivity in air (D_a), and diffusivity in water (D_w). The following sections describe these values and present methodologies for calculating additional values necessary for calculating the NMED SSLs.

3.1 Volatilization Factor for Soil

Volatile chemicals, defined as those chemicals having a Henry’s Law constant greater than $1E-05 \text{ atm}\cdot\text{m}^3/\text{mole}$ and a molecular weight less than 200 g/mole, were screened for inhalation exposures using a volatilization factor (VF_s) for soils. The soil-to-air VF_s is used to define the relationship between the concentration of the contaminant in soil and the flux of the volatilized contaminant to ambient air. The emission terms used in the VF_s are chemical-specific and were calculated from physical-chemical information obtained from several sources including: US EPA’s *Soil Screening Guidance: Technical Background Document* (US EPA, 1996a and 2001a), *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a), US EPA Master Physical and Chemical Parameter table for development US EPA Regional Screening Levels (US EPA 2011), US EPA’s *Basics of Pump and Treat Groundwater Remediation Technology* (US EPA 1990), US EPA’s *Dermal Exposure Assessment* (US EPA 1992a), *Superfund Public Health Evaluation Manual* (US EPA 1986), US EPA’s *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects

Database (ATSDR 2003), the RAIS database (DOE 2005), and the CHEMFACTS database (US EPA 2000c). The VF_s for the residential and commercial/industrial scenarios is calculated using Equation 22 while the VF_{s-cw} for the construction worker is calculated using Equation 23.

Equation 22		
Derivation of the Volatilization Factor for Residential and Commercial/Industrial Scenarios		
$VF_s = \frac{Q / C_{vol} \times (3.14 \times D_A \times T)^{0.5} \times 10^{-4}}{(2 \times \rho_b \times D_A)}$		
Where:		
$D_A = \frac{\left[\frac{(\theta_a^{10/3} D_a H' + \theta_w^{10/3} D_w)}{n^2} \right]}{\rho_b K_d + \theta_w + \theta_a H'}$		
Parameter	Definition (units)	Default
VF_s	Volatilization factor for soil (m^3/kg)	Chemical-specific
D_A	Apparent diffusivity (cm^2/s)	Chemical-specific
Q/C_{vol}	Inverse of the mean concentration at the center of a 0.5- acre-square source ($g/m^2 \cdot s$ per kg/m^3)	68.18
T	Exposure interval (s)	9.5E+08
ρ_b	Dry soil bulk density (g/cm^3)	1.5
n	Total soil porosity $1 - (\rho_b/\rho_s)$	0.43
θ_a	Air-filled soil porosity ($n - \theta_w$)	0.17
θ_w	Water-filled soil porosity	0.26
ρ_s	Soil particle density (g/cm^3)	2.65
D_a	Diffusivity in air (cm^2/s)	Chemical-specific
H'	Dimensionless Henry's Law constant	Chemical-specific
D_w	Diffusivity in water (cm^2/s)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/g) = $K_{oc} \times f_{oc}$ (organics)	Chemical-specific
K_{oc}	Soil organic carbon partition coefficient (cm^3/g)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015

Equation 23

Derivation of the Volatilization Factor for Construction Worker Scenario

$$VF_{s-cw} = \left(\frac{(3.14 \times D_A \times T)^{0.5}}{2 \times \rho_b \times D_A} \right) \times 10^{-4} \times Q / C \times (1 / F_D)$$

Where:

$$D_A = \frac{\left[\frac{(\theta_a^{10/3} D_a H' + \theta_w^{10/3} D_w)}{n^2} \right]}{\rho_b K_d + \theta_w + \theta_a H'}$$

Parameter	Definition (units)	Default
VF _{s-cw}	Volatilization factor for soil (m ³ /kg)	Chemical-specific
D _A	Apparent diffusivity (cm ² /s)	Chemical-specific
Q/C	Inverse of the mean concentration at the center of a 0.5- acre-square source (g/m ² -s per kg/m ³)	14.31
T	Exposure interval (s)	3.15E+07
10 ⁻⁴	Conversion factor (m ² /cm ²)	1E-04
F _D	Dispersion correction factor (unitless)	0.185
ρ _b	Dry soil bulk density (g/cm ³)	1.5
n	Total soil porosity 1 - (ρ _b /ρ _s)	0.43
θ _a	Air-filled soil porosity (n - θ _w)	0.17
θ _w	Water-filled soil porosity	0.26
ρ _s	Soil particle density (g/cm ³)	2.65
D _a	Diffusivity in air (cm ² /s)	Chemical-specific
H'	Dimensionless Henry's Law constant	Chemical-specific
D _w	Diffusivity in water (cm ² /s)	Chemical-specific
K _d	Soil-water partition coefficient (cm ³ /g) = K _{oc} x f _{oc} (organics)	Chemical-specific
K _{oc}	Soil organic carbon partition coefficient (cm ³ /g)	Chemical-specific
f _{oc}	Fraction organic carbon in soil (g/g)	0.0015

While most of the parameters used to calculate apparent diffusivity (D_A) are either chemical-specific or default values, several state-specific values were used which are more representative of soil conditions found in New Mexico. The default values for θ_w, θ_a, and ρ_b in Equations 22 and 23 are 0.26, 0.17 and 1.5 g/cm³, respectively. These values represent the mean value from a National Resources Conservation Service (NRCS) soil survey database for New Mexico that includes over 1200 sample points (U.S. Department of Agriculture 2000). US EPA guidance (US EPA 2001a) provides additional methodologies for estimating site-specific air-filled soil porosities and water-filled soil porosities.

It should be noted that the basic principle of the VF model (Henry's Law) is applicable only if the soil contaminant concentration is at or below soil saturation, C_{sat}. Above the soil saturation

limit, the model cannot predict an accurate VF-based SSL.

3.2 Soil Saturation Limit

C_{sat} describes a chemical-physical soil condition that integrates certain chemical-specific properties with physical attributes of the soil to estimate the contaminant concentration at which the soil pore water, pore air, and surface sorption sites are saturated with contaminants. Above this concentration, the contaminants may be present in free phase within the soil matrix – as non-aqueous phase liquids (NAPLs) for substances that are liquid at ambient soil temperatures, and pure solid phases for compounds that are solids at ambient soil temperatures (US EPA 1996a). Generic C_{sat} concentrations should not be interpreted as confirmation of a saturated soil condition, but as estimates of when this condition may occur. It should be noted that C_{sat} concentrations are not risk-based values. Instead, they correspond to a theoretical threshold above which free phase contaminant may exist. C_{sat} concentrations, therefore, serve to identify an upper limit to the applicability of generic risk-based soil criteria, because certain default assumptions and models used in the generic algorithms are not applicable when free phase contaminant is present in soil. The basic principle of the volatilization model 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 that have volatilization factor- (VF_s) based screening levels that exceed the “sat” concentration are set equal to “sat” whereas for solids (e.g., polycyclic aromatic hydrocarbons, PAHs), soil screening decisions are based on appropriate other pathways of concern at the site (e.g., ingestion and dermal contact). Equation 24, given below is used to calculate C_{sat} for each volatile contaminant considered within the SSLs.

Equation 24		
Derivation of the Soil Saturation Limit		
$C_{\text{sat}} = \frac{S}{\rho_b} (K_d \rho_b + \theta_w + H' \theta_a)$		
Parameter	Definition (units)	Default
C_{sat}	Soil saturation concentration (mg/kg)	Chemical-specific
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; $K_{oc} \times f_{oc}$)	Chemical-specific
K_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015
θ_w	Water-filled soil porosity ($L_{\text{water}}/L_{\text{soil}}$)	0.26
H'	Dimensionless Henry's Law constant	Chemical-specific
θ_a	Air-filled soil porosity ($n - \theta_w$), ($L_{\text{air}}/L_{\text{soil}}$)	0.17
n	Total soil porosity ($1 - (\rho_b/\rho_s)$), ($L_{\text{pore}}/L_{\text{soil}}$)	0.43
ρ_s	Soil particle density (kg/L)	2.65

Chemical-specific parameters used in Equation 24 were obtained from physical-chemical information obtained from several sources including: US EPA's *Soil Screening Guidance*:

Technical Background Document (US EPA 1996a and US EPA 2002a), the US EPA Regional Screening Levels (US EPA 2011), US EPA's *Basics of Pump and Treat Groundwater remediation Technology* (US EPA 1990), US EPA's *Dermal Exposure Assessment* (US EPA 1992a), *Superfund Public Health Evaluation Manual* (US EPA 1986), US EPA's *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects Database (ATSDR 2003), the RAIS, CHEMFACTS, WATER9, and PHYSPROP databases, and EPISUITE.

3.3 Particulate Emission Factor

Inhalation of chemicals adsorbed to suspended respirable particles is assessed using a chemical-specific PEF, which relates the contaminant concentration in soil to the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. This guidance addresses dust generated from open sources, which is termed "fugitive" because it is not discharged into the atmosphere in a confined flow stream. For further details on the methodology associated with the PEF model, the reader is referred to US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a) and *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (US EPA 1998a).

It is important to note that the PEF for use in evaluating exposures of the residential and commercial/industrial receptors addresses only windborne dust emissions and does not consider emissions from traffic or other forms of mechanical disturbance, which could lead to a greater level of exposure. The PEF for use in evaluating the construction worker exposures considers windborne dust emissions and emissions from vehicle traffic associated with construction activities. Therefore, the fugitive dust pathway should be considered carefully when developing the CSM at sites where receptors may be exposed to fugitive dusts by other mechanisms. Equation 25 is used to calculate a New-Mexico region-specific PEF value, used for both the residential and commercial/industrial exposure scenarios. A scenario-specific PEF value was calculated for a construction worker receptor (PEF_{cw}) using Equation 26.

Equation 25

**Derivation of the Particulate Emission Factor
Residential and Commercial/Industrial Scenarios**

$$PEF = Q / C_{wind} \times \frac{3,600 \text{ sec / hr}}{0.036 \times (1 - V) \times \left(\frac{U_m}{U_t} \right)^3 \times F(x)}$$

Parameter	Definition (units)	Default
PEF	Particulate emission factor (m ³ /kg)	6.61E+09
Q/C _{wind}	Inverse of a mean concentration at center of a 0.5-acre-square source (g/m ² -s per kg/m ³)	81.85
V	Fraction of vegetative cover (unitless)	0.5
U _m	Mean annual windspeed (m/s)	4.02
U _t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32
F(x)	Function dependent on U _m /U _t derived using Cowherd et al. (1985) (unitless)	0.0553

Equation 26

**Derivation of the Particulate Emission Factor
Construction Worker Scenario**

$$PEF_{CW} = Q / C_{CW} \times \frac{1}{F_D} \left[\frac{T \times A_R}{556 \times \left(\frac{W}{3} \right)^{0.4} \times \frac{(365 \text{ days / yr} - P)}{365 \text{ days / yr}} \times \sum VKT} \right]$$

Parameter	Definition (units)	Default
PEF _{CW}	Particulate emission factor for a construction worker (m ³ /kg)	2.1E+06
Q/C _{CW}	Inverse of a mean concentration at center of a 0.5-acre-square source (g/m ² -s per kg/m ³)	23.02
F _D	Dispersion correction factor (unitless)	0.185
T	Total time over which construction occurs (s)	7.2E+06
A _R	Surface area of road segment (m ²)	274.2
W	Mean vehicle weight (tons)	8
P	Number of days with at least 0.01 inches of precipitation (days/yr)	60
ΣVKT	sum of fleet vehicle kilometers traveled during the exposure duration (km)	168.75

3.4 Physical-Chemical Parameters

Several chemical-specific parameters are required for calculating SSLs including the organic carbon normalized soil-organic carbon/water partition coefficients for organic compounds (K_{oc}), the soil-water partition coefficient for organic and inorganic constituents (K_d), the solubility of a compound in water (S), Henry's Law constant (H), air diffusivity (D_a), water diffusivity (D_w),

and the octanol-water partition coefficient (K_{ow}). Prior to calculating site-specific SSLs, each relevant chemical specific parameter value presented in Appendix B should be checked against the most recent version of its source to determine if updated data are available. Tables B-1 and B-2 in Appendix B provides the chemical-specific parameters used in calculating the NMED SSLs.

Chemical-specific values were obtained from US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a and US EPA 2002a), the US EPA Regional Screening Levels (US EPA 2011), US EPA's *Basics of Pump and Treat Groundwater remediation Technology* (US EPA 1990), US EPA's *Dermal Exposure Assessment* (US EPA 1992a), *Superfund Public Health Evaluation Manual* (US EPA 1986), US EPA's *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects Database (ATSDR 2003), the RAIS, CHEMFACTS, WATER9, and PHYSPROP databases, and EPISUITE.

3.4.1 Solubility, Henry's Law Constant, and K_{ow}

The solubility of a contaminant refers to the maximum amount that can be dissolved in a fixed volume of solvent, usually pure water, at a specific temperature and pH. A chemical with a high solubility readily dissolves in water, while a low solubility indicates an inability to dissolve. Water solubility is generally predicted based on correlations with the octanol-water partition coefficient (K_{ow}). Solubility is used to calculate soil saturation limits for the NMED SSLs.

The octanol-water partition coefficient (K_{ow}) of a chemical is the ratio of a chemical's solubility in octanol versus its solubility in water at equilibrium. Essentially, this chemical-specific property is used as an indication of a contaminant's propensity to migrate from soil to water. It is an important parameter and is used in the assessment of environmental fate and transport for organic chemicals.

The Henry's Law constant (H) is used when evaluating air exposure pathways. For all chemicals that are capable of exchanging across the air-water interface, there is a point at which the rate of volatilization into the air and dissolution to the water or soil will be equal. The ratio of gas- and liquid-phase concentrations of the chemical at this equilibrium point is represented by H, which is used to determine the rate at which a contaminant will volatilize from soil to air. Values for H may be calculated using the following equation and the compound-specific values for solubility (S), vapor pressure (VP), and molecular weight (MW).

$$H = \frac{VP \times MW}{S} \quad \text{Equation 27}$$

The dimensionless form of Henry's Law constant (H') used in calculating soil saturation limits and volatilization factors for the NMED SSLs was calculated by multiplying H by a factor of 41 to convert the Henry's Law constant to a unitless value.

3.4.2 Soil Organic Carbon/Water Partition Coefficients (K_{oc})

The soil organic carbon-water partition coefficient (K_{oc}) is a measure of a chemical's tendency to

adsorb to organic carbon present in soil. High K_{oc} values indicate a tendency for the chemical to adsorb to soil particles rather than remain dissolved in the soil solution. Strongly adsorbed molecules will not mobilize unless the soil particle to which they are adsorbed moves (as in erosion). K_{oc} values of less than 500 indicate weak adsorption and a potential for leaching. K_{oc} is calculated using the following equation:

$$K_{oc} = \frac{\text{conc. adsorbed}/\text{conc. dissolved}}{\% \text{ organic carbon in soil}} \quad \text{Equation 28}$$

K_{oc} can also be calculated by dividing the K_d value by the fraction of organic carbon (f_{oc}) present in the soil or sediment. It should be noted that a strong linear relationship exists between K_{oc} and K_{ow} and that this relationship can be used to predict K_{oc} .

3.4.3 Soil/Water Partition Coefficients (K_d)

Soil-water partition coefficient (K_d) for organic chemicals is the ratio of a contaminant's distribution between soil and water particles. The soil-water partitioning behavior of nonionizing and ionizing organic compounds differs because the partitioning of ionizing organics can be influenced by soil pH. K_d values were used in calculating soil saturation limits and volatilization factors used in developing the NMED SSLs.

For organic compounds, K_d represents the tendency of a chemical to adsorb to the organic carbon fraction in soils, and is represented by:

$$K_d = K_{oc} \times f_{oc} \quad \text{Equation 29}$$

where

K_{oc} = organic carbon partition coefficient (L/kg or cm^3/g); and
 f_{oc} = fraction of organic carbon in soil (mg/mg).

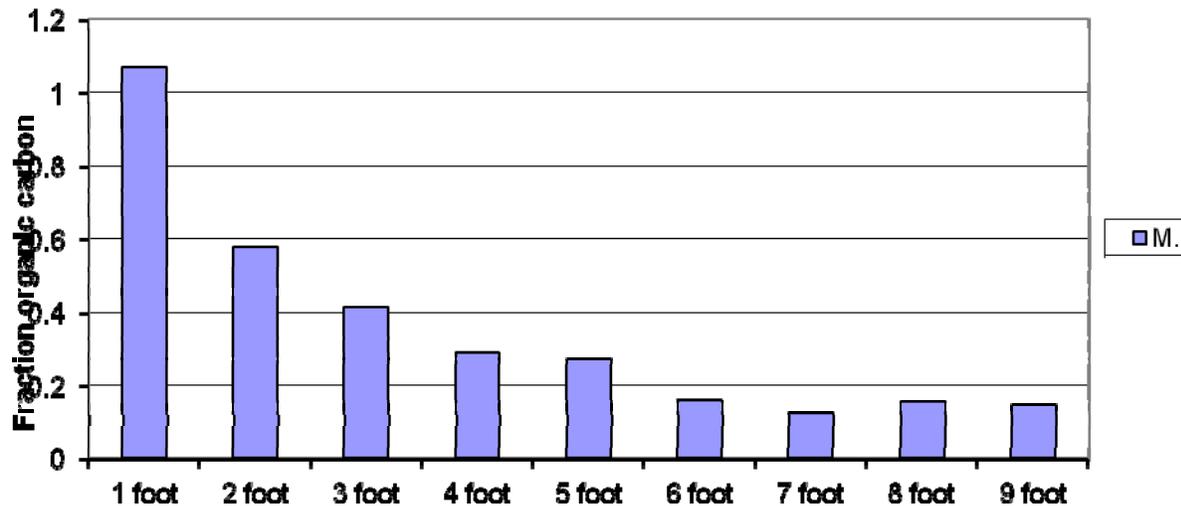
This relationship is generally valid for volatile halogenated hydrocarbons as long as the fraction of organic carbon in soil is above approximately 0.001 (0.1 percent) (Piwoni and Banerjee, 1989; Schwarzenbach and Westall 1981). For low organic carbon soils ($f_{oc} < 0.001$), Piwoni and Banerjee (1989) developed the following empirical correlation for organic chemicals:

$$\log K_d = 1.01 \log K_{ow} - 0.36 \quad \text{Equation 30}$$

The use of a fixed K_{oc} value in the soil-water partition equation for the migration to groundwater pathway is only valid for hydrophobic non-ionizing organic chemicals. For organic chemicals that ionize in the soil environment, existing in both neutral and ionized forms within the normal soil pH range, K_{oc} values must consider the relative proportions and differences in sorptive properties of these forms. For the equations and applications of developing K_{oc} values for ionizing organic acids as a function of pH, the reader is referred to US EPA 1996. The default

value used for f_{oc} in development of NMED SSLs is 0.0015 (0.15%). This value represents the median value of 212 data points included in the NRCS soil survey database for New Mexico (U.S. Department of Agriculture 2000). Only samples collected from a depth of greater than 5 feet were included in the calculation of the mean f_{oc} value. Shallow soil samples tend to have higher f_{oc} values as shown in Figure 2-1. There is a steady decline in f_{oc} value with depth until approximately 5 feet bgs. Below 5 feet, there is little variability in the f_{oc} value. Because a lower f_{oc} value provides a more conservative calculation of SSL, a value representative of deeper soil conditions is used as the default value.

**Figure 2-1 Mean Value - Fraction Organic Carbon (f_{oc})-
All counties in New Mexico**



As with organic chemicals, development of the NMED SSLs for inorganic constituents (i.e., metals) requires a soil-water partition coefficient (K_d) for each contaminant. K_d values for metals are affected by a variety of soil conditions, most notably pH, oxidation-reduction conditions, iron oxide content, soil organic matter content, cation exchange capacity and major ion chemistry. US EPA developed default K_d values for metals using either an equilibrium geochemical speciation model (MINTEQ2) or from empirical pH-dependent adsorption relationships developed by Environmental Protection Agency's Office of Research and Development (EPA/ORD) (US EPA 1996a).

4.0 MIGRATION OF CONTAMINANTS TO GROUNDWATER

Generic SSLs were developed that address the potential for migration of contaminants from soil to groundwater. The methodology used to calculate generic SSLs addresses the potential leaching of contaminants from the vadose zone to groundwater. This method does not take into account any additional attenuation associated with contaminant transport in groundwater. The SSLs developed from this analysis are risk-based values incorporating NMED-specific tap water SSLs. This methodology is modeled after US EPA's *Soil Screening Guidance: Technical*

Background Document (US EPA 1996a) and the Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (US EPA 2002a).

4.1 Overview of the SSL Model Approach

Two approaches to developing soil leachate-based SSLs are presented, the generic model and the site-specific model. Both models use the same set of equations to calculate SSLs and are based on leaching to groundwater scenarios that NMED believes are protective of groundwater. The generic model calculates SSLs using default parameter values generally representative of conditions in New Mexico. These values are presented in Tables B-1 and B-2 of Appendix B. The site-specific model provides the flexibility of using site-specific meteorological, soil and hydrological data to calculate SSLs, while retaining the simplicity and ease of use associated with the generic model.

The development of soil leachate SSLs is based upon a two step process. The first step is the development of a Dilution Attenuation Factor (DAF). The DAF accounts for leachate mixing in the aquifer. A leachate concentration that is protective of ground water is back calculated by multiplying the ground water standard for a given constituent by the DAF. That leachate concentration is then used to back calculate an SSL that is protective of groundwater using a simple linear equilibrium soil/water partition equation. For the generic SSL approach, default parameter values are used for all non-chemical specific parameters. At sites that are not adequately represented by the default values and where more site-specific data are available, it may be more appropriate to use the site-specific SSL model. The site-specific model uses the same spreadsheet equations to calculate SSLs as those in the generic look-up table; however, site-specific data are used in the site-specific model.

The following sections of this document provide a general description of the leaching to groundwater pathway SSL model (generic and site-specific) including the assumptions, equations, and input parameters. Justification for the default parameters used in the generic model is also provided. Additionally, a sensitivity analysis was performed on each of the input parameters to provide guidance on when use of the site-specific model may be warranted. Applicability and limitations of the generic and site-specific models are also presented.

4.2 Model Assumptions

Assumptions regarding the release and distribution of contaminants in the subsurface that are incorporated into the SSL methodology include the following.

- The source is infinite (a constant concentration is maintained for the duration of the exposure period).
- Contamination is uniformly distributed from the surface to the water table.
- Soil/water partitioning is instantaneous and follows a linear equilibrium isotherm.
- There is no attenuation of the contaminant in soil or the aquifer (i.e., irreversible adsorption, chemical transformation or biological degradation).
- The potentially impacted aquifer is unconfined and unconsolidated with

homogenous and isotropic hydrologic properties.

- The receptor well (point of exposure) is at the downgradient edge of the source and is screened within the potentially impacted aquifer.
- NAPLs are not present.

4.3 Soil Water Partition Equation

US EPA’s *Supplemental Soil Screening Guidance: Technical Background Document* (US EPA 1996a) and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a) developed an equation to estimate contaminant release in soil leachate based on the Freundlich adsorption isotherm. The Freundlich equation was modified to relate the sorbed concentration to the total concentration measured in a soil sample (which includes contaminants associated with solid soil, soil-water and soil-air components) (Feenstra 1991). Equation 31, given below, is used to calculate SSLs corresponding to target soil leachate concentrations (C_w).

Equation 31		
Soil Screening Level For Leaching To Groundwater Pathway		
$SSL = C_w \times \left[K_d + \left(\frac{\theta_w + \theta_a H'}{\rho_b} \right) \right]$		
Parameter	Definition (units)	Default
SSL	Soil Screening Level for migration to groundwater pathway (mg/kg)	Chemical-Specific
C_w	Target soil leachate concentration (mg/L)	Chemical-Specific
K_d	Soil /water partition coefficient (L/kg)	Chemical-Specific
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.26
θ_a	Air-filled soil porosity (L_{air}/L_{soil}), $n - \theta_w$	0.17
n	Total soil porosity (L_{pore}/L_{soil}), $1 - (\rho_b/\rho_s)$	0.43
ρ_s	Soil particle density (kg/L)	2.65
ρ_b	Dry soil bulk density (kg/L)	1.5
H'	Dimensionless Henry’s Law constant	Chemical-Specific

Target soil leachate concentrations (C_w) are equivalent to the NMED-specific tap water screening levels multiplied by a DAF.

$$C_w = \text{Tap Water SSL} \times \text{DAF} \qquad \text{Equation 32}$$

The derivation of the DAF is discussed in subsequent sections of this document.

4.4 Dilution Attenuation Factor

Contaminants transported as a leachate through soil to groundwater are affected by physical, chemical, and biological processes that can significantly reduce their concentration. These processes include adsorption, biological degradation, chemical transformation, and dilution from mixing of the leachate with groundwater. The total reduction in concentration between the source of the contaminant (vadose zone soil) and the point of ground water withdrawal is defined as the ratio of contaminant concentration in soil leachate to the concentration in groundwater at the point of withdrawal. This ratio is termed a dilution/attenuation factor (DAF; US EPA 1996a and 1996b). The higher the DAF value, the greater the degree of dilution and attenuation of contaminants along the migration flowpath. A DAF of 1 implies no reduction in contaminant concentration occurs.

Development of New Mexico SSLs considers only the dilution of contaminant concentration through mixing with groundwater in the aquifer directly beneath the source. This is consistent with the conservative assumptions used in the SSL methodology including an infinite source, soil contamination extending from surface to groundwater and the point of exposure occurring at the downgradient edge of the source. The ratio of contaminant concentration in soil leachate to the concentration in groundwater at the point of withdrawal that considers only dilution processes is calculated from a simple water balance equation (Equation 33), described below.

Equation 33
Dilution/Attenuation Factor (DAF)

$$DAF = 1 + \left(\frac{K \times i \times D}{I \times L} \right)$$

Where:

$$D = (0.0112 \times L^2)^{0.5} + D_a \left(1 - \exp \left[\frac{-L \times I}{K \times i \times D_a} \right] \right)$$

Parameter	Definition (units)	Default
DAF	Dilution/attenuation factor (unitless)	Site-Specific
K	Aquifer hydraulic conductivity (m/yr)	Site-Specific
i	Hydraulic gradient (m/m)	Site-Specific
D	Mixing zone depth (m)	Site-Specific
I	Infiltration rate (m/yr)	Site-Specific
L	Source length parallel to groundwater flow (m)	Site-Specific
D _a	Aquifer thickness (m)	Site-Specific

Most of these parameters are available from routine environmental site investigations. The mixing zone depth incorporates one additional parameter, the aquifer thickness (D_a).

For the calculation of SSLs, the DAF is used to back calculate the target soil leachate concentration (C_w in Equation 32) from an appropriate groundwater concentration, such as the tap water SL, a Water Quality Control Commission (WQCC) standard, or a Federal Maximum Contaminant Level (MCL). For example, if the WQCC standard for a constituent is 0.1 mg/L and the DAF is 20, the target soil leachate concentration would be 2 mg/L.

The US EPA conducted an extensive evaluation of the range and distribution of DAFs to select a default value to be used for developing generic SSLs that would be reasonably protective of groundwater quality (US EPA 1996a, 1996b, and 2002a). The evaluation included a probabilistic modeling exercise using US EPA's Composite Model for Leachate Migration with Transformation Products (CMTP). A cumulative frequency distribution of DAF values was developed from the model output. Results of the Monte Carlo modeling analysis indicate that for a 0.5 acre source area a DAF of approximately 170 is protective of groundwater at 90 percent of the sites. Groundwater is protected at 95 percent of the sites with a DAF of 7.

US EPA applied the simple SSL water balance dilution model (Equation 31) to 300 sites included in surveys of hydrogeologic investigations to further evaluate the range and distribution of DAF values. Results of this analysis indicated that a DAF of 10 was protective of groundwater for a 30-acre source and that a DAF of 20 was protective of groundwater for a 0.5 acre-source (US EPA 1996a, 1996b, and 2001).

An assessment was performed of US EPA's methodology to determine whether a default DAF value of 20 for a 0.5 acre source, and a DAF of 10 for a 30 acre source, would be appropriate for use as default values for sites in New Mexico. Typical New Mexico conditions may be notably different than conditions represented by areas included in the US EPA analysis of DAFs. For example, infiltration rates across much of New Mexico are substantially less than the average range of 0.15 to 0.24 m/yr reported for many of the hydrogeologic regions used in the US EPA analysis. In addition, effective porosity was assumed to be 0.35, presumably because this value is representative of the most prevalent aquifer type in the databases used (US EPA 1996a). However, the regions included in the US EPA analysis also contain extensive glacial, regolith, lacustrine, swamp and marsh deposits which have high percentages of fine-grained sediments and thus are not representative of typical New Mexico sandy soils. Sandy soils typically have higher hydraulic conductivities than more fine-grained soils and subsequently higher Darcian velocities, under equal hydraulic gradient. According to the DAF equation (Equation 33), soils with relatively greater hydraulic conductivities will tend to result in a higher calculated DAF.

An assessment was made of input parameters to the DAF equation. In order to support a DAF that is protective of the most vulnerable groundwater environments in New Mexico (i.e. areas close to perennial streams or where ground water is very shallow), environmental parameters typical of those areas in New Mexico were used to assess the DAF. This assessment indicated that the DAF is most sensitive to variations in hydraulic conductivity. This is because this value shows such large variations in the natural environment. If a hydraulic conductivity value representative of a fine-grained sand is used in the DAF equation, along with an infiltration rate representative of New Mexico's arid to semi-arid environments, then the result is a DAF of approximately 20. NMED believes that a DAF of 20 for a 0.5 acre source area is protective of groundwater in New Mexico. If the default DAF is not representative of conditions at a specific site, then it is appropriate to calculate a site-specific DAF based upon available site data.

4.5 Limitations on the Use of the Dilution Attenuation Factor

Because of assumptions used in SSL model approach, use of the DAF model may be inappropriate for certain conditions, including sites where:

- Adsorption or degradation processes are expected to significantly attenuate contaminant concentrations in the soil or aquifer media;
- Saturated thickness is significantly less than 12 meters thick;
- Fractured rock or karst aquifer types exist (violates the unconfined, unconsolidated, homogeneous, isotropic assumptions);
- Facilitated transport is significant (colloidal transport, transport via dissolved organic matter, or transport via solvents other than water; and/or
- NAPLs are present.

For sites that have these types of conditions, consideration should be given to application of a more detailed site-specific analysis than either the generic or site-specific models described herein.

4.6 Generic SSLs for Protection of Groundwater

The migration to groundwater pathway model, incorporating the assumptions, soil-water partition equation, and the DAF, was used to develop NMED SSLs. Default values based on conditions predominant in New Mexico were used for the input parameters in the soil-water partition equation. The NMED SSLs are presented for both default DAF values of 1 and 20.

Target soil leachate concentrations (C_w) are equivalent to the appropriate groundwater standards multiplied by a DAF. To maintain an approach that is protective of groundwater quality in the development of generic SSLs, a DAF of 20 is selected as reasonably protective. However SSLs are provided for two DAFs in Appendix A. The use of the SSL listed for a DAF of 20 is advised unless site-specific data on hydrologic conditions are available, and these indicate that the generic DAF is not representative of site conditions. As will be demonstrated in the sensitivity analysis section of this document, calculation of an SSL using the migration to groundwater pathway model is most sensitive to the DAF. The inclusion of the SSL for a DAF of 1 is provided for convenience to the user. If data on hydrologic conditions are readily available, a site specific DAF can be calculated and multiplied by the generic SSL for a DAF of 1 to provide a site-specific SSL.

The generic approach may be inappropriate for use at sites where conditions are substantially different from the default values used to develop the generic soil leachate SSLs.

4.7 Development of Site Specific SSLs for Protection of Groundwater

New Mexico, as with any other state, offers a variety of geologic and hydrologic conditions that may not be readily represented by a single default parameter value.

Site specific conditions may differ considerably from the typical or average conditions represented by the default values used to calculate generic SSLs. The site-specific model can be used to address the variability inherent in environmental conditions across and within the state.

Application of the site-specific model to develop soil leachate SSLs is the same as the generic approach except that site-specific values are used. Use of the site-specific model approach may incorporate replacement of all default values used for the generic SSLs with site-specific values, or may only include substitution of a single key parameter, such as hydraulic conductivity. The decision to use the site-specific model approach instead of the generic approach should be based on consideration of the sensitivity of the calculated SSL to specific parameters and the availability of those parameters as site-specific data. Sufficient site-specific data may be available such that each of the default values used for developing generic SSLs can be readily substituted with a more representative site-derived value. Conversely, limited site-specific data may restrict the number of default values to be replaced.

The NMED SSLs are generally more sensitive to the dilution factor than to other parameters in the soil-water partition equation. Fortunately, information needed to derive the DAF is usually available for sites that have undergone even the most basic levels of environmental investigation. Apart from the dilution factor, SSLs are most sensitive to the soil-water partition coefficient (K_d) as the values for this parameter can range over several orders of magnitude, particularly for metals. Although the K_d term may be critical in developing protective SSLs, information required to evaluate this parameter is more difficult to obtain and less likely to be available. Porosity and bulk density are not particularly sensitive because of the relatively small range of values encountered in subsurface conditions.

Using benzene as a representative contaminant, a sensitivity analysis was performed to compare a generic soil leachate SSL to site-specific model results simulating a range of model input parameters that might be representative of different conditions in New Mexico. The generic soil leachate SSL calculated using the New Mexico default values and a DAF of 1 is 2.8 $\mu\text{g}/\text{kg}$. These results are summarized in Table 4-1. As shown, the resulting SSLs for benzene range from 1.3 to 6.1 $\mu\text{g}/\text{kg}$ for the various sensitivity simulations compared to the generic SSL of 2.8 $\mu\text{g}/\text{kg}$. These results indicate that the calculation of SSLs using the site-specific approach is not overly sensitive to the reasonable range of porosity (air and water filled), bulk density and fraction of organic carbon expected for New Mexico or even for a range of values for chemical-specific properties. The generic SSL for benzene of 2.8 $\mu\text{g}/\text{kg}$ is representative of values that could be calculated using a spectrum of input parameters, exclusive of the DAF term. Unless there are sufficient data to calculate a site-specific DAF, there is little benefit derived from using the site-specific model approach instead of the generic SSL.

Table 4-1. Input Parameters and Resulting SSLs for the Sensitivity Analysis of the Soil-Water Partition Equation - Migration to Groundwater Pathway Model

Input parameter (NMED default value)	Sensitivity Analysis Values	Resulting SSLs
Bulk density (default value = 1.55 gm/cm)	Lower Limit = 1.20 Upper Limit = 1.90	3.4 2.5
Air filled porosity (default value = 0.18)	Lower Limit = 0.04 ^a Upper Limit = 0.25 ^b	1.3 3.5
Fraction organic carbon (default value = 0.0015)	Lower Limit = 0.0005 Upper Limit = 0.007	2.2 6.1
Volume water content (default value = 0.26)	Lower Limit = 0.05 ^c Upper Limit = 0.40 ^c	1.8 3.5
K _{oc} (default value = 58.9 ml/g)	Lower Limit = 30 Upper Limit = 120	2.4 3.7
Dimensionless Henry's Law constant (default value = 0.228)	Lower Limit = 0.1 Upper Limit = 0.4	2.7 3.0

^a total porosity was reduced from 0.44 to 0.10 for this simulation

^b total porosity was increased from 0.44 to 0.6 for this simulation

^c total porosity remained at 0.44 for this simulation.

As previously stated, calculation of SSLs is most sensitive to the DAF term. The input parameter values and resulting DAFs for the sensitivity analysis are included in Table 4-2. Effects on the DAFs are, from greatest to least, the Darcian velocity (hydraulic conductivity multiplied by the hydraulic gradient), infiltration rates, size of the contaminated area, and the aquifer thickness. Corresponding effects on DAFs for each of these parameters and discussion of the relevance of the use of default values versus site-specific conditions are summarized below:

Table 4-2. Input Parameters and Resulting DAFs for the Sensitivity Analysis of the Dilution Attenuation Factor-Migration to Groundwater Pathway Model

Parameter	Groundwater Velocity (m/yr)	Infiltration Rate (m/yr)	Source Length (m)	Aquifer thickness (m)	Mixing Zone Depth (m)	Dilution Attenuation Factor (DAF)
Groundwater velocity	2.2	0.13	45	12	7.15	3.7
Groundwater velocity	22	0.13	45	12	5.03	19.9
Groundwater velocity	220	0.13	45	12	4.79	181.1
Infiltration Rate	22	0.065	45	12	4.89	37.8
Infiltration Rate	22	0.13	45	12	5.03	19.9
Infiltration Rate	22	0.26	45	12	5.28	10.9
Source Length	22	0.13	22.5	12	2.51	19.9
Source Length	22	0.13	45	12	5.03	19.9
Source Length	22	0.13	348.4	12	38.76*	6.8
Aquifer Thickness	22	0.13	45	3	5.02*	12.3
Aquifer Thickness	22	0.13	45	12	5.03	19.9
Aquifer Thickness	22	0.13	45	48	5.03	19.9

Note: If mixing zone depth calculation is greater than aquifer thickness, then aquifer thickness is used to calculate the DAF.

Higher Darcian velocity results in higher DAFs. Slower mixing of groundwater with soil leachate occurs at lower groundwater velocity. Thus, using a lower velocity will be a more conservative approach. Sandy soils typically have higher hydraulic conductivities than more fine-grained soils and subsequently higher Darcian velocity (under equal hydraulic gradient). Use of a sandy soil type will generally be less conservative (result in higher DAFs) with respect to protection of groundwater quality.

Lower infiltration rates result in higher DAFs. Therefore, using a higher infiltration rate is a more conservative approach (results in a lower DAF).

Larger source sizes result in lower DAFs. The default DAF used to develop SSLs for a 0.5 acre source may not be protective of groundwater at sites larger than 0.5 acre. However, the selection of a second source size is arbitrary. If generic SSLs are developed for a 30 acre source, then those values are considered overly conservative for a 12 acre source. Conversely, SSLs developed for a 30 acre source will be less protective of a 40 acre source. Rather than develop a

separate set of generic SSLs for a second (or third or fourth) source size, the following two approaches are proposed.

- As the size of the source area increases, the assumptions underlying the generic model are less applicable. One of the conservative assumptions in the generic SSL approach is the uniform distribution of contaminants throughout the vadose zone. There are few sites that have relatively uniform soil contamination (both laterally and vertically) of a single constituent in an area of greater than 0.5 acres (22,000 ft²). Soil contamination at large facilities (such as federal facilities) are usually concentrated in discrete portions of the site. Contamination at large sites is commonly the result of multiple sources. It is advisable to attempt to subdivide the facility by source and contaminant type and then apply generic SSLs to those smaller source areas.
- If this approach is not practical, calculation of site specific DAFs is recommended. Most of the parameters required for these calculations are available from routine environmental site investigations or can be reasonably estimated from general geologic and hydrologic studies.

Thin aquifers will result in lower DAFs. The nominal aquifer thickness used in the sensitivity analysis was 12 meters (m). Reducing the aquifer thickness to 3 m results in a 40 percent reduction in the DAF. Increasing the aquifer thickness beyond the nominal value has very little impact.

The significant effects of the DAF on the calculation of SSLs, coupled with the common availability of site-specific data used to calculate the DAF, suggest that use of the site specific modeling approach should at least incorporate recalculation of the DAF term. If data are available that indicate soil properties significantly different than the default values (such as high or low f_{oc} for organic contaminants, or highly acidic or basic conditions for metal contaminants) the K_d term should also be evaluated and recalculated.

4.8 Detailed Model Analysis for SSL Development

Sites that have complex or heterogeneous subsurface conditions may require more detailed evaluation for development of SSLs that are reasonably, but not overly, protective of groundwater and surface water resources. These types of sites may require more complex models that can address a wide range of variability in environmental site conditions including soil properties, contaminant mass concentration and distribution, contaminant degradation and transformation, recharge rates and recharge concentration, and depth to the water table. Model codes suitable for these types of more detailed analysis range from simple one-dimensional analytical models to complex three-dimensional numerical models. Resource requirements (data, time and cost) increase for the more complex codes. The selection of an appropriate code needs to balance the required accuracy of the output with the level of effort necessary to develop the model.

4.9 Summary of the Migration to Groundwater Pathway SSLs

SSLs for New Mexico have been developed for the migration to groundwater pathway, and are provided in Table A-1 of Appendix A. The NMED SSLs were developed using default parameter values representative of environmental conditions in New Mexico and utilize a DAF of 20. This approach maintains the conservative approach of the SSL methodology and is protective of groundwater quality under a wide range of site conditions. Soil contaminant concentrations can be compared directly to the generic SSLs to determine if additional investigation is necessary to evaluate potential leaching and migration of contaminants from the vadose zone to groundwater in excess of NMED-specific tap water SSLs.

Site-specific SSLs can be developed by substituting site-related data for the default values in the leaching to groundwater pathway model. SSLs developed from this model are most sensitive to the DAF. SSLs are also provided in the lookup table for a DAF of 1. If data on hydrologic conditions are readily available, a site specific DAF can be calculated.

5.0 USE OF THE SSLs

For screening sites with multiple contaminants, the following procedure should be followed: take the site-specific concentration (first step screening assessments should use the maximum reported concentration) and divide by the SSL concentration for each analyte. For multiple contaminants, simply add the ratio for each chemical.

$$\text{Site Risk} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \dots + \frac{\text{conc}_i}{\text{SSL}_i} \right) \times 10^{-5} \quad \text{Equation 34}$$

$$\text{Site Hazard Index (HI)} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \dots + \frac{\text{conc}_i}{\text{SSL}_i} \right) \times 1 \quad \text{Equation 35}$$

If the total cancer risk is greater than the target risk level of 1E-05 or if the hazard index is greater than one, concentrations at the site warrant further, site-specific evaluation. Site risk and hazard indices less than the target levels indicate that the concentrations at the site are unlikely to result in adverse health impacts.

As with any risk-based tool, the potential exists for misapplication. In most cases the root cause will be a lack of understanding of the intended use of NMED SSLs. In order to prevent misuse of SSLs, the following should be avoided:

- Applying SSLs to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios,
- Use of SSLs as cleanup levels without verifying numbers with a toxicologist or risk assessor, and

- Not considering the effects of additivity when screening multiple chemicals.

It is important to note that the generic NMED SSLs were developed assuming distinct soil horizons for each receptor. The soils of interest differ according to the exposure pathway being addressed. For direct ingestion, dermal, and fugitive dust exposure pathways, the primary soil horizon of concern are surface soils. For inhalation of volatiles and migration to groundwater, subsurface soils are of primary concern. Both a residential receptor and a commercial/industrial worker are typically exposed only to surface soil, which may be defined as extending to a depth of approximately two feet below ground surface, depending on site-specific conditions and the amount of intrusive activity that may occur. Construction workers will typically have much greater exposures to subsurface soils. Therefore, when generic SSLs are used for screening level evaluations at a facility, site-specific conditions must be evaluated for each receptor to determine if the assumptions associated with the generic SSLs are appropriate for comparison with the available site data.

6.0 TOTAL PETROLEUM HYDROCARBONS (TPH)

In some instances, it may be practical to assess areas of soil contamination that are the result of releases of petroleum products such as jet fuel and diesel, using total petroleum hydrocarbon (TPH) analyses. TPH results may be used to delineate the extent of petroleum-related contamination at these sites and ascertain if the residual level of petroleum products in soil represents an unacceptable risk to future users of the site. Petroleum hydrocarbons represent complex mixtures of compounds, some of which are regulated constituents and some compounds that are not regulated. In addition, the amount and types of the constituent compounds in a petroleum hydrocarbon release differ widely depending on what type of product was spilled and how the spill has weathered. This variability makes it difficult to determine the toxicity of weathered petroleum products in soil solely from TPH results; however, these results can be used to approximate risk in some cases, depending upon the nature of the petroleum product, the release scenario, how well the site has been characterized, and anticipated potential future land uses. In some cases, site cleanup cannot be based solely on the results of TPH sampling. NMED will make these determinations on a case by case basis. If NMED determines that additional data are necessary, these TPH guidelines must be used in conjunction with the SSLs for individual petroleum-related contaminants in Table A-1 and other contaminants, as applicable.

The screening levels for each petroleum carbon range from the Massachusetts Department of Environmental Protection (MADEP) Volatile Petroleum Hydrocarbons/Extractable Petroleum Hydrocarbons (VPH/EPH) approach and the percent composition table below were used to generate screening levels corresponding to total TPH. Except for waste oil, the information in the compositional assumptions table was obtained from the Massachusetts Department of Environmental Protection guidance document *Implementation of the MADEP VPH/EPH Approach* (October 31, 2002). TPH toxicity (MADEP, 2009) was based only on the weighted sum of the toxicity of the hydrocarbon fractions listed in Table 6-1.

Table 6-1. TPH Compositional Assumptions in Soil

Petroleum Product	C11-C22 Aromatics	C9-C18 Aliphatics	C19-C36 Aliphatics
Diesel #2/ new crankcase oil	60%	40%	0%
#3 and #6 Fuel Oil	70%	30%	0%
Kerosene and jet fuel	30%	70%	0%
Mineral oil dielectric fluid	20%	40%	40%
Unknown oil ^a	100%	0%	0%
Waste Oil ^b	0%	0%	100%

^a Sites with oil from unknown sources must be tested for VOCs, SVOCs, metals, and PCBs to determine if other potentially toxic constituents are present. The TPH guidelines in Tables 6-2 and 6-3 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED SSLs summarized in Table A-1.

^b Compositional assumption for waste oil developed by NMED is based on review of chromatographs of several types of waste oil. Sites with waste oil must be tested for VOCs, SVOCs, metals, and PCBs to determine if other potentially toxic constituents are present. The TPH guidelines in Tables 6-2 and 6-3 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED SSLs summarized in Table A-1.

A TPH screening guideline was calculated for each of the types of petroleum product based on the assumed composition from Table 6-1 for petroleum products and the direct soil standards incorporating ceiling concentrations given in the MADEP VPH/EPH (December 2009) Excel spreadsheet for each of the carbon fractions (MADEP, 2009). Groundwater concentrations are based on the weighted sum of the noncarcinogenic toxicity of the petroleum fractions.

Method 1 from the MADEP VPH/EPH document and spreadsheet (MADEP, 2009) was applied, which represents generic cleanup standards for soil and groundwater. Method 1 applies if contamination exists in only soil and groundwater. The MADEP VPH/EPH further divides groundwater into standards. Standard GW-1 applies when groundwater may be used for drinking water purposes. GW-1 standards are based upon ingestion and use of groundwater as a potable water supply. The TPH screening guidelines for sites with potable groundwater are presented in Table 6-2. It is noted that the below guidelines are not necessarily risk-based values but may reflect a ceiling level.

Table 6-2. TPH Screening Guidelines for Potable Groundwater (GW-1)

Petroleum Product	TPH		Concentration in Groundwater (mg/L)
	Residential Direct Exposure (mg/kg)	Industrial Direct Exposure (mg/kg)	
Diesel #2/crankcase oil	1000	1800	0.4
#3 and #6 Fuel Oil	1000	1600	0.35
Kerosene and jet fuel	1000	2400	0.55
Mineral oil dielectric	1800	3400	5.92

fluid			
Unknown oil ^a	1000	1000	0.2
Waste Oil ^b	3000	5000	See individual contaminants in Appendix A
Gasoline	Not applicable	Not applicable	See individual contaminants in Appendix A
<p>^a Sites with oil from unknown sources must be tested for VOCs, SVOCs, metals, and PCBs to determine if other potentially toxic constituents are present. The TPH guidelines in Table 6-2 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED soil screening guidelines.</p> <p>^b Compositional assumption for waste oil developed by NMED is based on review of chromatographs of several types of waste oil. Sites with waste oil must be tested for VOCs, SVOCs, metals, and PCBs to determine if other potentially toxic constituents are present. The TPH guidelines in Table 6-2 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED soil screening guidelines.</p>			

The second standard is GW-2 (MADEP, 2009), which is applicable for sites where the depth to groundwater is less than 15 feet from the ground surface and within 30 feet of an occupied structure. The structure may be either residential or industrial. GW-2 standards are based upon “inhalation exposures that could occur to occupants of the building impacted by volatile compounds, which partition from the groundwater” (MADEP, 2001). The GW-2 screening guidelines ONLY apply for the evaluation of inhalation exposures. If potential ingestion or contact with contaminated soil and/or groundwater could occur, then the screening guidelines provided in Table 6-2 should be applied. Table 6-3 lists the TPH screening guidelines for the inhalation scenario (MADEP, 2009). It is noted that the below guidelines are not necessarily risk-based values but may reflect a ceiling level.

Table 6-3. TPH Screening Guidelines – Vapor Migration and Inhalation of Groundwater (GW-2)

Petroleum Product	TPH		Concentration in Groundwater (mg/L)
	Residential Direct Exposure (mg/kg)	Industrial Direct Exposure (mg/kg)	
Diesel #2/crankcase oil	1000	3000	32
#3 and #6 Fuel Oil	1000	3000	36.5
Kerosene and jet fuel	1000	3000	18.5
Mineral oil dielectric fluid	1800	3800	12
Unknown oil ^a	1000	3000	50
Waste Oil ^b	3000	5000	See individual contaminants in Appendix A
Gasoline	Not applicable	Not applicable	See individual contaminants in Appendix A
<p>^a Sites with oil from unknown sources must be tested for VOCs, SVOCs, metals, and PCBs to determine if other potentially toxic constituents are present. The TPH guidelines in Table 6-3 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED SSLs summarized in Table A-1.</p> <p>^b Compositional assumption for waste oil developed by NMED is based on review of chromatographs of several types of waste</p>			

oil. Sites with waste oil must be tested for VOCs, SVOCs, metals, and PCBs to determine if other potentially toxic constituents are present. The TPH guidelines in Table 6-3 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED SSLs summarized in Table A-1.

Mineral oil based hydraulic fluids can be evaluated for petroleum fraction toxicity using the screening guidelines from Tables 6-2 and 6-3 specified for waste oil, because this type of hydraulic fluid is composed of approximately the same range of carbon fractions as waste oil. However, these hydraulic fluids often contain proprietary additives that may be significantly more toxic than the oil itself; these additives must be considered on a site- and product-specific basis (see ATSDR hydraulic fluids profile reference). **Use of alternate screening guideline values requires prior written approval from the NMED.** The TPH screening guidelines in Tables 6-2 and 6-3 must be used in conjunction with the screening levels for petroleum-related contaminants given in Table A-1 because the TPH screening levels are NOT designed to be protective of exposure to these individual petroleum-related contaminants.

The list of petroleum-related contaminants does not include PAHs with individual screening levels that would exceed the total TPH screening levels (e.g., acenaphthene, anthracene, fluoranthene, fluorine, and pyrene). In addition, these TPH screening guidelines are based solely on human health, not ecological risk considerations, protection of surface water, or potential indoor air impacts from soil vapors. Potential soil vapor impacts to structures or utilities are not addressed by these guidelines. Site-specific investigations for potential soil vapor impacts to structures or utilities must be done to assure that screenings are consistently protective of human health, welfare or use of the property. NMED believes that use of these screening guidelines will allow more efficient screenings of petroleum release sites at sites while protecting human health and the environment. Copies of the references cited below are available on the MADEP website at <http://www.mass.gov/dep/cleanup/laws/standard.htm>.

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APPENDIX A

NMED SOIL SCREENING LEVELS (SSLs)

Appendix A

State of New Mexico Soil Screening Levels

Table A-1 provides State of New Mexico Soil Screening Levels (SSLs), as developed by the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau Voluntary Remediation Program for 220 chemicals most commonly associated with environmental releases within the state. These NMED SSLs are derived using default exposure parameter values (refer to Equations in Volume I) and chemical- and State of New Mexico-specific physical parameters (as presented in Tables B-1 and B-2 of Appendix B). These default values are assumed to be appropriately conservative in the face of uncertainty and are likely to be protective for the majority of site conditions relevant to soil exposures within New Mexico.

However, the NMED SSLs are not necessarily protective of all known human exposure pathways, reasonable land uses or ecological threats. Thus, before applying NMED SSLs at a site, it is extremely important to compare the conceptual site model (CSM) with the assumptions upon which the NMED SSLs are predicated to ensure that the site conditions and exposure pathways match those used to develop the NMED SSLs. If this comparison indicates that the site at issue is more complex than the corresponding SSL scenarios, or that there are significant exposure pathways not accounted for by the NMED SSLs, then the NMED SSLs are insufficient for use in a defensible assessment of the site. A more detailed site-specific approach will be necessary to evaluate the additional pathways or site conditions.

TABLE A-1

Column 1:	The first column in Table A-1 presents the names of the chemicals for which NMED has developed SSLs.
Column 2:	The second column presents NMED SSLs predicated on residential soil exposures.
Column 3, 5, 7, and 9:	These columns present indicator categories for the NMED SSL residential, industrial, construction, and tap water basis, whether predicated on carcinogenic (c) and noncarcinogenic (n) effects. In some cases, the risk-based SSL is greater than the soil saturation limit, and in these cases, the SSL is denoted as either “cs” or “ns” depending on carcinogenicity or noncarcinogenicity, respectively. In the case where a noncarcinogenic SSL is greater than the ceiling limit (1E+05), the SSL is denoted as “nl” and in a few cases, “nls” is used to indicate the SSL is both above the saturation level and the ceiling limit. NMED SSLs predicated on a carcinogenic endpoint reflect age-adjusted child-to-adult exposures. NMED SSLs predicated on a noncarcinogenic endpoint reflect child-only exposures. Detected concentrations above a saturation value (“cs”, “ns”, or “nsl”) may indicate the presence of nonaqueous phase liquid (NAPL).
Columns 4 and 6:	The fourth and sixth columns present NMED SSLs analogous to Column 1, with the exception that these values correspond to Industrial/Occupational

and Construction worker (adult-only) exposures, respectively.

Column 8: Presents the tap water SL for the residential scenario.

Columns 10 and 11: The tenth column presents NMED SSLs for the migration to groundwater pathway developed using a default dilution attenuation factor (DAF) of 1, which assume no effective dilution or attenuation. These values can be considered at sites where little or no dilution or attenuation of soil leachate concentrations is expected (e.g., shallow water tables, karst topography). Column 11 presents NMED SSLs for the migration to groundwater pathway developed using a DAF of 20 to account for natural processes that reduce contaminant concentrations in the subsurface. The SSLs based on a DAF of 20 are default SSLs that should be applicable at most sites.

As noted above, separate NMED SSLs are presented for use in evaluating three discrete potential receptor populations: Residential, Industrial/Occupational, and Construction. Each NMED SSL considers incidental ingestion of soil, inhalation of volatiles from soil (limited to those chemicals noted as volatile organic compounds [VOCs] within Table B-2) and/or particulate emissions from impacted soil, and dermal contact with soil.

Generally, if a contaminant is detected at a level in soil exceeding the most relevant NMED SSL, and the site-specific CSM is in general agreement with the underlying assumptions upon which the NMED SSLs are predicated, this result indicates the potential for adverse human health effects to occur. Conversely, if no contaminants are detected above the most relevant NMED SSL, this tends to indicate to the user that environmental conditions may not necessitate remedial action of the surface soil or the vadose zone.

A detection above a NMED SSL does not indicate that unacceptable exposures are, in fact, occurring. The NMED SSLs are predicated on relatively conservative exposure assumptions and an exceedance only tends to indicate the potential for adverse effects. The NMED SSLs do not account for additive exposures, whether for carcinogenic or noncarcinogenic endpoints. Section 5 of Volume I addresses a methodology by which an environmental manager may determine whether further site-evaluation is warranted, however, this methodology does not replace the need for defensible risk assessment where indicated. The SSLs also do not account for ingestion of homegrown produce/animals or the vapor intrusion pathway. If these or other exposure pathways are complete, additional analyses may be warranted.

The NMED SSLs address a basic subset of exposures fundamental to the widest array of environmentally-impacted sites within the State of New Mexico. The NMED SSLs cannot address all relevant exposure pathways associated with all sites. The utility of the NMED SSLs depends heavily upon the understanding of site conditions as accurately reflected in the CSM and nature and extent of contamination determinations. Consideration of the NMED SSLs does not preclude the need for site-specific risk assessment in all instances.

Table A-1: NMED Soil Screening Levels

Chemical	Residential Soil (mg/kg)	End-point	Industrial/Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Acenaphthene	3.44E+03	n	3.67E+04	n	1.86E+04	n	2.19E+03	n	1.69E+01	3.38E+02
Acetaldehyde	2.45E+02	n	1.16E+03	n	2.14E+02	n	1.88E+01	n	3.29E-03	6.58E-02
Acetone	6.66E+04	n	8.68E+05	nls	2.21E+05	nls	2.18E+04	n	3.86E+00	7.71E+01
Acrylonitrile	4.55E+00	c	2.43E+01	c	3.76E+01	n	4.54E-01	c	8.48E-05	1.70E-03
Acetophenone	7.82E+03	ns	1.14E+05	nls	3.10E+04	ns	3.65E+03	n	9.17E-01	1.83E+01
Acrolein	4.04E-01	n	1.92E+00	n	3.56E-01	n	4.16E-02	n	7.30E-06	1.46E-04
Aldrin	2.84E-01	c	1.12E+00	c	7.15E+00	n	3.92E-02	c	4.83E-03	9.66E-02
Aluminum	7.80E+04	n	1.13E+06	nl	4.07E+04	n	3.65E+04	n	5.48E+04	1.10E+06
Anthracene	1.72E+04	n	1.83E+05	nl	6.68E+04	n	1.10E+04	n	2.71E+02	5.41E+03
Antimony	3.13E+01	n	4.54E+02	n	1.24E+02	n	1.46E+01	n	6.61E-01	1.32E+01
Arsenic	3.90E+00	c	1.77E+01	c	5.30E+01	n	4.48E-01	c	1.31E-02	2.62E-01
Barium	1.56E+04	n	2.23E+05	nl	4.35E+03	n	7.30E+03	n	3.01E+02	6.03E+03
Benzene	1.54E+01	c	8.47E+01	c	1.38E+02	n	4.13E+00	c	1.73E-03	3.45E-02
Benzidine	5.01E-03	c	8.33E-02	c	7.20E-01	c	9.36E-04	c	1.83E-06	3.67E-05
Benzo(a)anthracene	1.48E+00	c	2.34E+01	c	2.13E+02	c	2.95E-01	c	7.83E-02	1.57E+00
Benzo(a)pyrene	1.48E-01	c	2.34E+00	c	2.13E+01	c	2.95E-02	c	2.60E-02	5.20E-01
Benzo(b)fluoranthene	1.48E+00	c	2.34E+01	c	2.13E+02	c	2.95E-01	c	2.65E-01	5.31E+00
Benzo(k)fluoranthene	1.48E+01	c	2.34E+02	c	2.06E+03	c	2.95E+00	c	2.60E+00	5.20E+01
Beryllium	1.56E+02	n	2.26E+03	n	1.44E+02	n	7.30E+01	n	5.77E+01	1.15E+03
a-BHC (a-Hexachlorocyclohexane, a-HCH)	7.72E-01	c	3.04E+00	c	2.63E+01	c	1.07E-01	c	4.68E-04	9.35E-03
b-BHC (b-Hexachlorocyclohexane, b-HCH)	2.70E+00	c	1.06E+01	c	9.19E+01	c	3.73E-01	c	1.64E-03	3.27E-02
g-BHC (Lindane)	5.17E+00	c	2.29E+01	c	8.30E+01	n	6.11E-01	c	2.68E-03	5.36E-02
1,1-Biphenyl	5.71E+01	ns	2.72E+02	ns	1.55E+04	ns	8.34E-01	n	6.56E-03	1.31E-01
Bis(2-chloroethyl) ether	2.68E+00	c	1.42E+01	c	7.78E+01	c	1.19E-01	c	2.63E-05	5.27E-04
Bis(2-chloroisopropyl) ether	9.15E+01	c	4.54E+02	cs	3.10E+03	cs	9.60E+00	c	2.33E-03	4.66E-02
Bis(2-ethylhexyl) phthalate	3.47E+02	cs	1.37E+03	cs	4.76E+03	n	4.80E+01	c	8.62E+00	1.72E+02

Chemical	Residential Soil (mg/kg)	End-point	Industrial/Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Bis(chloromethyl) ether	6.48E-03	c	3.53E-02	c	1.78E-01	c	6.24E-04	c	1.18E-07	2.36E-06
Boron	1.56E+04	n	2.27E+05	nl	4.65E+04	n	7.30E+03	n	2.40E+01	4.80E+02
Bromodichloromethane	5.41E+00	c	3.01E+01	c	1.43E+02	c	1.17E+00	c	2.71E-04	5.41E-03
Bromomethane	1.65E+01	n	8.65E+01	n	1.64E+01	n	8.66E+00	n	1.92E-03	3.85E-02
1,3-Butadiene	8.08E-01	c	4.29E+00	c	3.19E+00	n	1.76E-01	c	1.01E-04	2.02E-03
2-Butanone (Methyl ethyl ketone, MEK)	3.71E+04	n	3.75E+05	nls	8.43E+04	nls	7.06E+03	n	1.27E+00	2.55E+01
tert-Butyl methyl ether (MTBE)	9.01E+02	c	4.89E+03	c	2.49E+04	cs	1.25E+02	c	2.41E-02	4.82E-01
Cadmium	7.03E+01	n	8.97E+02	n	2.77E+02	n	1.83E+01	n	1.37E+00	2.75E+01
Carbon disulfide	1.53E+03	ns	8.33E+03	ns	1.58E+03	ns	1.04E+03	n	2.83E-01	5.65E+00
Carbon tetrachloride	1.08E+01	c	5.98E+01	c	2.26E+02	ns	4.40E+00	c	1.60E-03	3.21E-02
Chlordane	1.62E+01	c	7.19E+01	c	1.35E+02	n	1.35E+00	n	6.87E-02	1.37E+00
2-Chloroacetophenone	1.72E+05	nl	8.12E+05	nl	2.81E+02	n				
2-Chloro-1,3-butadiene	1.69E-01	c	2.03E+02	n	4.39E+00	c	1.62E-01	c	8.51E-05	1.70E-03
1-Chloro-1,1-difluoroethane	1.07E+05	nls	5.05E+05	nls	9.38E+04	nls	1.04E+05	n	5.35E+01	1.07E+03
Chlorobenzene	3.76E+02	ns	2.12E+03	ns	4.06E+02	ns	9.13E+01	n	4.92E-02	9.84E-01
1-Chlorobutane	3.13E+03	ns	4.54E+04	ns	1.24E+04	ns	1.46E+03	n	5.26E-01	1.05E+01
Chlorodifluoromethane	1.03E+05	nls	4.86E+05	nls	9.04E+04	nls	1.04E+05	n	4.27E+01	8.55E+02
Chloroform	5.86E+00	c	3.27E+01	c	1.54E+02	c	1.93E+00	c	4.59E-04	9.18E-03
Chloromethane	2.75E+02	n	1.29E+03	cs	2.41E+02	n	1.88E+02	n	4.40E-02	8.79E-01
b-Chloronaphthalene	6.26E+03	ns	9.08E+04	ns	2.48E+04	ns	2.92E+03	n	1.14E+01	2.27E+02
o-Chloronitrobenzene	1.62E+01	c	1.06E+02	n	8.51E+01	n	2.24E+00	c	1.63E-03	3.27E-02
p-Chloronitrobenzene	6.11E+01	n	1.49E+02	n	2.94E+02	n	1.21E+00	n	8.69E-04	1.74E-02
2-Chlorophenol	3.91E+02	n	5.68E+03	n	1.55E+03	n	1.83E+02	n	1.16E-01	2.31E+00
2-Chloropropane	6.63E+03	ns	3.13E+04	ns	5.78E+03	ns	2.09E+02	n	4.61E-02	9.22E-01
o-Chlorotoluene	1.56E+03	ns	2.27E+04	ns	6.19E+03	ns	7.30E+02	n	5.58E-01	1.12E+01
Chromium III	1.17E+05	nl	1.70E+06	nl	4.65E+05	nl	5.48E+04	n	9.86E+07	1.97E+09
Chromium VI	2.97E+00	c	6.31E+01	n	6.56E+01	c	4.31E-01	c	8.31E-03	1.66E-01
Chrysene	1.48E+02	c	2.34E+03	c	2.06E+04	c	2.95E+01	c	7.99E+00	1.60E+02
Copper	3.13E+03	n	4.54E+04	n	1.24E+04	n	1.46E+03	n	5.15E+01	1.03E+03

Chemical	Residential Soil (mg/kg)	End-point	Industrial/Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Crotonaldehyde	3.37E+00	c	1.14E+03	c	1.14E+02	c	3.54E-01	c	6.23E-05	1.25E-03
Cumene (isopropylbenzene)	2.43E+03	ns	1.45E+04	ns	2.81E+03	ns	6.79E+02	n	8.65E-01	1.73E+01
Cyanide	4.69E+01	n	6.81E+02	n	1.86E+02	n	2.19E+01	n	2.21E-01	4.41E+00
Cyanogen	3.13E+03	ns	4.54E+04	n	1.24E+04	n	1.46E+03	n	2.90E-01	5.79E+00
Cyanogen bromide	7.04E+03	n	1.02E+05	nl	2.79E+04	n	3.29E+03	n	9.42E-01	1.88E+01
Cyanogen chloride	3.91E+03	n	5.68E+04	n	1.55E+04	n	1.83E+03	n	3.33E-01	6.66E+00
DDD	2.03E+01	c	7.98E+01	c	6.90E+02	c	2.80E+00	c	4.94E-01	9.88E+00
DDE	1.43E+01	c	5.63E+01	c	4.87E+02	c	1.98E+00	c	3.49E-01	6.97E+00
DDT	1.72E+01	c	7.81E+01	c	1.42E+02	n	1.98E+00	c	5.00E-01	1.00E+01
Dibenz(a,h)anthracene	1.48E-01	c	2.34E+00	c	2.13E+01	c	2.95E-02	c	8.46E-02	1.69E+00
1,2-Dibromo-3-chloropropane	1.86E+00	c	1.08E+00	c	5.07E+00	c	3.16E-03	c	1.10E-06	2.20E-05
Dibromochloromethane	1.21E+01	c	6.24E+01	c	3.32E+02	cs	1.47E+00	c	3.31E-04	6.61E-03
1,2-Dibromoethane	5.88E-01	c	3.22E+00	c	1.60E+01	c	6.53E-02	c	1.54E-05	3.08E-04
1,4-Dichloro-2-butene	9.73E-02	c	5.45E-01	c	2.53E+00	c	1.16E-02	c	4.33E-06	8.66E-05
1,2-Dichlorobenzene	2.31E+03	ns	1.40E+04	ns	2.71E+03	ns	3.70E+02	n	2.80E-01	5.60E+00
1,4-Dichlorobenzene	3.17E+01	c	1.77E+02	c	8.31E+02	cs	4.27E+00	c	3.19E-03	6.39E-02
3,3-Dichlorobenzidine	1.08E+01	c	4.26E+01	c	3.64E+02	c	1.49E+00	c	7.40E-03	1.48E-01
Dichlorodifluoromethane	1.68E+02	n	7.98E+02	ns	1.49E+02	ns	2.03E+02	n	3.72E-01	7.43E+00
1,1-Dichloroethane	6.45E+01	c	3.59E+02	c	1.70E+03	cs	2.42E+01	c	5.98E-03	1.20E-01
1,2-Dichloroethane	7.89E+00	c	4.35E+01	c	5.87E+01	n	1.49E+00	c	3.56E-04	7.11E-03
cis-1,2-Dichloroethene	1.56E+02	n	2.27E+03	ns	6.19E+02	c	7.30E+01	n	1.84E-02	3.67E-01
trans-1,2-Dichloroethene	2.70E+02	n	1.44E+03	ns	2.73E+02	ns	1.07E+02	n	2.69E-02	5.38E-01
1,1-Dichloroethene	4.49E+02	n	2.29E+03	ns	4.32E+02	ns	3.40E+02	n	1.16E-01	2.32E+00
2,4-Dichlorophenol	1.83E+02	n	2.05E+03	n	7.15E+02	n	1.10E+02	n	9.98E-02	2.00E+00
1,2-Dichloropropane	1.52E+01	c	8.44E+01	c	2.50E+01	n	3.86E+00	c	1.07E-03	2.14E-02
1,3-Dichloropropene	3.37E+01	c	1.77E+02	c	2.09E+02	ns	4.33E+00	c	1.24E-03	2.48E-02
Dicyclopentadiene	3.33E+01	n	1.63E+02	ns	3.04E+01	n	1.39E+01	n	3.80E-02	7.60E-01
Dieldrin	3.04E-01	c	1.20E+00	c	1.03E+01	c	4.20E-02	c	1.27E-03	2.55E-02
Diethyl phthalate	4.89E+04	n	5.47E+05	nl	1.91E+05	nl	2.92E+04	n	9.66E+00	1.93E+02

Chemical	Residential Soil (mg/kg)	End-point	Industrial/Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Dimethyl phthalate	6.11E+05	nl	6.84E+06	nl	2.38E+06	nl	3.65E+05	n	8.06E+01	1.61E+03
Di-n-butyl phthalate (Dibutyl phthalate)	6.11E+03	n	6.84E+04	n	2.38E+04	n	3.65E+03	n	6.97E+00	1.39E+02
2,4-Dimethylphenol	1.22E+03	n	1.37E+04	n	4.76E+03	n	7.30E+02	n	6.65E-01	1.33E+01
4,6-Dinitro-o-cresol	4.89E+00	n	5.47E+01	n	1.91E+01	n	2.92E+00	n	3.81E-03	7.62E-02
2,4-Dinitrophenol	1.22E+02	n	1.37E+03	n	4.76E+02	n	7.30E+01	n	6.31E-02	1.26E+00
2,4-Dinitrotoluene	1.57E+01	c	6.18E+01	c	4.76E+02	n	2.17E+00	c	2.25E-03	4.49E-02
2,6-Dinitrotoluene	6.11E+01	n	6.84E+02	n	2.38E+02	n	3.65E+01	n	3.85E-02	7.70E-01
2,4/2,6-Dinitrotoluene Mixture	7.15E+00	c	2.82E+01	c	2.45E+02	c	9.88E-01	c	1.04E-03	2.08E-02
1,4-Dioxane	4.86E+01	c	1.92E+02	c	1.66E+03	c	6.72E+00	c	1.19E-03	2.38E-02
1,2-Diphenylhydrazine	6.08E+00	c	2.39E+01	c	2.07E+02	c	8.40E-01	c	2.04E-03	4.08E-02
Endosulfan	3.67E+02	n	4.10E+03	n	1.43E+03	n	2.19E+02	n	2.26E+00	4.52E+01
Endrin	1.83E+01	n	2.05E+02	n	7.15E+01	n	1.10E+01	n	3.32E-01	6.64E+00
Epichlorohydrin	4.10E+01	n	2.06E+02	n	3.84E+01	n	2.07E+00	n	3.89E-04	7.78E-03
Ethyl acetate	7.04E+04	ns	1.02E+06	nls	2.79E+05	nls	3.29E+04	n	5.99E+00	1.20E+02
Ethyl acrylate	1.33E+02	c	6.62E+02	c	4.52E+03	cs	1.40E+01	c	2.67E-03	5.34E-02
Ethyl chloride	2.98E+04	ns	1.41E+05	nls	2.61E+04	nls	2.09E+04	n	5.37E+00	1.07E+02
Ethyl ether	1.56E+04	ns	2.27E+05	nls	6.19E+04	ns	7.30E+03	n	1.41E+00	2.83E+01
Ethyl methacrylate	4.55E+03	ns	3.80E+04	ns	2.79E+04	ns	5.26E+02	n	1.04E-01	2.09E+00
Ethylbenzene	6.84E+01	c	3.78E+02	cs	1.83E+03	cs	1.48E+01	c	1.30E-02	2.60E-01
Ethylene oxide	4.06E+00	c	2.22E+01	c	1.11E+02	c	4.41E-01	c	7.88E-05	1.58E-03
Fluoranthene	2.29E+03	n	2.44E+04	n	8.91E+03	n	1.46E+03	n	1.22E+02	2.43E+03
Fluorene	2.29E+03	n	2.44E+04	ns	8.91E+03	ns	1.46E+03	n	2.03E+01	4.06E+02
Fluoride	3.13E+03	n	4.54E+04	n	1.24E+04	n	1.46E+03	n	4.19E-01	8.37E+00
Furan	7.82E+01	n	1.14E+03	n	3.10E+02	n	3.65E+01	n	1.16E-02	2.32E-01
Heptachlor	1.08E+00	c	4.26E+00	c	3.68E+01	c	1.49E-01	c	9.27E-03	1.85E-01
Hexachlorobenzene	3.04E+00	c	1.20E+01	c	1.03E+02	c	4.20E-01	c	3.98E-03	7.96E-02
Hexachloro-1,3-butadiene	6.11E+01	n	2.46E+02	c	2.38E+02	n	8.62E+00	c	1.28E-02	2.57E-01
Hexachlorocyclopentadiene	3.67E+02	n	4.10E+03	n	8.11E+02	n	2.19E+02	n	5.27E-01	1.05E+01
Hexachloroethane	4.28E+01	n	4.79E+02	n	1.67E+02	n	1.68E+01	c	8.18E-03	1.64E-01

Chemical	Residential Soil (mg/kg)	End-point	Industrial/Occupational Soil (mg/kg)	Endpoint	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
n-Hexane	9.38E+02	ns	5.11E+03	ns	9.73E+02	ns	8.76E+02	n	7.65E+00	1.53E+02
HMX	3.91E+03	n	5.68E+04	n	1.55E+04	n	1.83E+03	n	1.77E+00	3.54E+01
Hydrazine anhydride	2.13E+00	c	1.06E+01	c	6.85E+01	c	2.24E-01	c	5.08E-04	1.02E-02
Hydrogen cyanide	1.07E+01	n	5.98E+01	n	1.14E+01	n	1.55E+00	n	2.70E-04	5.39E-03
Indeno(1,2,3-c,d)pyrene	1.48E+00	c	2.34E+01	c	2.13E+02	c	2.95E-01	c	8.63E-01	1.73E+01
Iron	5.48E+04	n	7.95E+05	nl	2.17E+05	nl	2.56E+04	n	6.46E+02	1.29E+04
Isobutanol (Isobutyl alcohol)	2.35E+04	ns	3.41E+05	nls	9.29E+04	ns	1.10E+04	n	1.95E+00	3.89E+01
Isophorone	5.12E+03	c	1.37E+05	cs	4.75E+04	n	7.07E+02	c	1.92E-01	3.84E+00
Lead	4.00E+02	IEU BK	8.00E+02	IEUB K	8.00E+02	IEU BK				
Lead (tetraethyl-)	6.11E-03	n	6.84E-02	n	2.38E-02	n	3.65E-03	n	1.38E-05	2.76E-04
Maleic hydrazide	3.06E+04	n	3.42E+05	nl	1.19E+05	nl	1.83E+04	n	3.25E+00	6.51E+01
Manganese	1.86E+03	n	2.67E+04	nl	4.40E+02	n	8.76E+02	n	5.72E+01	1.14E+03
Mercury (elemental)	1.56E+01	ns	7.36E+01	ns	1.36E+01	ns	6.26E-01	n	3.27E-02	6.54E-01
Mercury (methyl)	7.82E+00	n	1.14E+02	n	3.10E+01	n	3.65E+00	n	1.05E-03	2.09E-02
Mercury (salts)	2.35E+01	n	3.41E+02	ns	9.29E+01	n	1.10E+01	n	5.73E-01	1.15E+01
Methacrylonitrile	4.84E+00	n	3.92E+01	n	8.18E+00	n	1.04E+00	n	2.02E-04	4.05E-03
Methomyl	1.53E+03	n	1.71E+04	n	5.96E+03	n	9.13E+02	n	1.72E-01	3.44E+00
Methyl acetate	7.82E+04	ns	1.14E+06	nls	3.10E+05	nls	3.65E+04	n	6.51E+00	1.30E+02
Methyl acrylate	2.35E+03	n	3.41E+04	ns	9.29E+03	ns	1.10E+03	n	2.00E-01	4.01E+00
Methyl isobutyl ketone	5.82E+03	ns	7.38E+04	ns	1.85E+04	ns	1.99E+03	n	3.84E-01	7.68E+00
Methyl methacrylate	1.12E+04	ns	5.69E+04	ns	1.07E+04	ns	1.42E+03	n	2.68E-01	5.35E+00
Methyl styrene (alpha)	5.48E+03	ns	7.95E+04	ns	2.17E+04	ns	2.56E+03	n	3.14E+00	6.29E+01
Methyl styrene (mixture)	2.72E+02	ns	2.11E+03	ns	4.34E+02	ns	6.04E+01	n	7.61E-02	1.52E+00
Methylcyclohexane	5.63E+03	ns	2.65E+04	ns	4.93E+03	ns	6.26E+03	n	1.61E+01	3.21E+02
Methylene bromide (Dibromomethane)	5.16E+01	n	2.54E+02	n	3.10E+03	ns	8.16E+00	n	1.71E-03	3.42E-02
Methylene chloride	4.09E+02	n	4.70E+03	c	1.12E+03	ns	1.86E+02	n	4.12E-02	8.24E-01
Molybdenum	3.91E+02	n	5.68E+03	n	1.55E+03	n	1.83E+02	n	3.70E+00	7.40E+01
Naphthalene	4.30E+01	c	2.41E+02	c	1.58E+02	n	1.43E+00	c	3.57E-03	7.13E-02
Nickel	1.56E+03	n	2.25E+04	n	6.19E+03	n	7.30E+02	n	4.77E+01	9.53E+02

Chemical	Residential Soil (mg/kg)	End-point	Industrial/Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Nitrate	1.25E+05	nl	1.82E+06	nl	4.96E+05	nl	5.84E+04	n	1.67E+01	3.35E+02
Nitrite	7.82E+03	n	1.14E+05	nl	3.10E+04	n	3.65E+03	n	1.05E+00	2.09E+01
Nitrobenzene	5.35E+01	c	3.00E+02	c	3.32E+02	n	1.22E+00	c	6.24E-04	1.25E-02
Nitroglycerin	6.11E+00	n	6.84E+01	n	2.38E+01	n	3.65E+00	n	1.27E-03	2.53E-02
N-Nitrosodiethylamine	7.68E-03	c	1.28E-01	c	1.10E+00	c	1.44E-03	c	4.27E-07	8.55E-06
N-Nitrosodimethylamine	2.26E-02	c	3.76E-01	c	1.91E+00	n	4.22E-03	c	8.76E-07	1.75E-05
N-Nitrosodi-n-butylamine	6.89E-01	c	2.92E+00	c	2.19E+01	c	2.44E-02	c	3.78E-05	7.55E-04
N-Nitrosodiphenylamine	9.93E+02	c	3.91E+03	c	3.36E+04	c	1.37E+02	c	5.65E-01	1.13E+01
N-Nitrosopyrrolidine	2.32E+00	c	9.12E+00	c	7.88E+01	c	3.20E-01	c	9.96E-05	1.99E-03
m-Nitrotoluene	7.82E+00	n	1.14E+02	n	3.10E+01	n	3.65E+00	n	2.62E-03	5.24E-02
o-Nitrotoluene	2.91E+01	c	1.02E+03	cs	2.79E+02	n	3.05E+00	c	2.23E-03	4.46E-02
p-Nitrotoluene	2.44E+02	n	2.74E+03	c	9.53E+02	n	4.20E+01	c	3.02E-02	6.03E-01
Pentachlorobenzene	4.89E+01	n	5.47E+02	n	1.91E+02	n	2.92E+01	n	1.68E-01	3.35E+00
Pentachlorophenol	8.94E+00	c	3.00E+01	c	3.10E+02	c	1.68E+00	c	1.28E-02	2.56E-01
Perchlorate	5.48E+01	n	7.95E+02	ns	2.17E+02	n	2.56E+01	n	7.32E-03	1.46E-01
Phenanthrene	1.83E+03	ns	2.05E+04	n	7.15E+03	n	1.10E+03	n	2.86E+01	5.71E+02
Phenol	1.83E+04	n	2.05E+05	nl	6.88E+04	n	1.10E+04	n	4.97E+00	9.95E+01
Polychlorinatedbiphenyls (PCBs)										
Aroclor 1016	3.93E+00	n	4.13E+01	n	1.53E+01	n	2.56E+00	n	1.83E-01	3.67E+00
Aroclor 1221	1.49E+00	c	6.24E+00	c	4.63E+01	cs	6.81E-02	c	8.69E-04	1.74E-02
Aroclor 1232	1.49E+00	c	6.24E+00	c	4.63E+01	cs	6.81E-02	c	8.69E-04	1.74E-02
Aroclor 1242	2.22E+00	c	8.26E+00	c	7.58E+01	c	3.36E-01	c	3.94E-02	7.88E-01
Aroclor 1248	2.22E+00	c	8.26E+00	c	7.58E+01	c	3.36E-01	c	3.86E-02	7.73E-01
Aroclor 1254	1.12E+00	n	8.26E+00	c	4.36E+00	n	3.36E-01	c	6.58E-02	1.32E+00
Aroclor 1260	2.22E+00	c	8.26E+00	c	7.58E+01	c	3.36E-01	c	1.76E-01	3.53E+00
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	3.41E-01	c	1.27E+00	c	1.17E+01	c	5.17E-02	c	2.77E-02	5.53E-01
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	3.41E+00	c	1.27E+01	c	1.17E+02	c	5.17E-01	c	2.71E-01	5.42E+00
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 180)	1.14E+00	c	4.24E+00	c	3.89E+01	c	1.72E-01	c	9.04E-02	1.81E+00

Chemical	Residential Soil (mg/kg)	End-point	Industrial/Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
189)										
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	1.14E+00	c	4.24E+00	c	3.89E+01	c	1.72E-01	c	5.41E-02	1.08E+00
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	1.14E+00	c	4.24E+00	c	3.89E+01	c	1.72E-01	c	5.52E-02	1.10E+00
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	1.14E+00	c	4.24E+00	c	3.89E+01	c	1.72E-01	c	5.52E-02	1.10E+00
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	1.14E-03	c	4.24E-03	c	3.89E-02	c	1.72E-04	c	5.41E-05	1.08E-03
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	1.14E+00	c	4.24E+00	c	3.89E+01	c	1.72E-01	c	3.38E-02	6.75E-01
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	1.14E+00	c	4.24E+00	c	3.89E+01	c	1.72E-01	c	3.31E-02	6.62E-01
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	1.14E+00	c	4.24E+00	c	3.89E+01	c	1.72E-01	c	3.38E-02	6.75E-01
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	1.14E+00	c	4.24E+00	c	3.89E+01	c	1.72E-01	c	3.38E-02	6.75E-01
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	3.41E-04	c	1.27E-03	c	1.17E-02	c	5.17E-05	c	9.93E-06	1.99E-04
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	3.41E-01	c	1.27E+00	c	1.17E+01	c	5.17E-02	c	6.06E-03	1.21E-01
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	1.14E-01	c	4.24E-01	c	3.89E+00	c	1.72E-02	c	2.02E-03	4.04E-02
Propylene oxide	2.31E+01	c	1.16E+02	c	7.06E+02	n	2.31E+00	c	4.19E-04	8.38E-03
Pyrene	1.72E+03	n	1.83E+04	n	6.68E+03	n	1.10E+03	n	8.94E+01	1.79E+03
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)	5.82E+01	c	3.41E+03	c	9.29E+02	n	6.11E+00	c	1.88E-03	3.75E-02
Selenium	3.91E+02	n	5.68E+03	n	1.55E+03	n	1.83E+02	n	9.65E-01	1.93E+01
Silver	3.91E+02	n	5.68E+03	n	1.55E+03	n	1.83E+02	n	1.57E+00	3.13E+01
Strontium	4.69E+04	n	6.81E+05	nl	1.86E+05	nl	2.19E+04	n	7.73E+02	1.55E+04
Styrene	7.28E+03	ns	5.00E+04	ns	9.99E+03	ns	1.62E+03	n	1.39E+00	2.77E+01
2,3,7,8-TCDD	4.50E-05	c	2.04E-04	c	2.84E-04	n	5.17E-06	c	1.93E-06	3.86E-05
2,3,7,8-TCDF	4.50E-04	c	2.04E-03	c	1.52E-02	c	5.17E-05	c	1.08E-05	2.17E-04
1,2,4,5-Tetrachlorobenzene	1.83E+01	n	2.05E+02	n	7.15E+01	n	1.10E+01	n	3.84E-02	7.68E-01
1,1,1,2-Tetrachloroethane	2.91E+01	c	1.61E+02	c	7.79E+02	cs	5.24E+00	c	1.65E-03	3.29E-02
1,1,2,2-Tetrachloroethane	8.02E+00	c	4.35E+01	c	2.21E+02	c	6.71E-01	c	2.13E-04	4.26E-03
Tetrachloroethene	7.02E+00	c	3.66E+01	c	2.12E+02	cs	1.08E+00	c	4.30E-04	8.61E-03
Tetryl (Trinitrophenylmethylnitramine)	2.44E+02	n	2.74E+03	n	9.53E+02	n	1.46E+02	n	1.03E+00	2.07E+01

Chemical	Residential Soil (mg/kg)	End-point	Industrial/Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Thallium	7.82E-01	n	1.14E+01	n	3.10E+00	n	3.65E-01	n	2.60E-02	5.20E-01
Toluene	5.27E+03	ns	5.77E+04	ns	1.34E+04	ns	2.28E+03	n	1.27E+00	2.53E+01
Toxaphene	4.42E+00	c	1.74E+01	c	1.50E+02	c	6.11E-01	c	7.08E-02	1.42E+00
Tribromomethane (Bromoform)	6.16E+02	c	2.42E+03	c	4.76E+03	n	8.51E+01	c	6.04E-01	1.21E+01
1,1,2-Trichloro-1,2,2-trifluoroethane	7.21E+04	nls	3.47E+05	nls	6.47E+04	nls	5.92E+04	n	1.72E+02	3.45E+03
1,2,4-Trichlorobenzene	7.30E+01	n	3.67E+02	ns	6.87E+01	ns	4.12E+00	n	9.13E-03	1.83E-01
1,1,1-Trichloroethane	1.56E+04	ns	7.89E+04	ns	1.48E+04	ns	9.13E+03	n	2.91E+00	5.82E+01
1,1,2-Trichloroethane	2.81E+00	n	1.33E+01	c	4.72E+02	ns	4.16E-01	n	1.12E-04	2.23E-03
Trichloroethylene	8.77E+00	n	4.13E+01	c	7.68E+00	cs	3.40E+00	n	1.05E-03	2.11E-02
Trichlorofluoromethane	1.41E+03	ns	6.94E+03	ns	1.30E+03	ns	1.29E+03	n	8.89E-01	1.78E+01
2,4,5-Trichlorophenol	6.11E+03	n	6.84E+04	n	2.38E+04	n	3.65E+03	n	1.04E+01	2.07E+02
2,4,6-Trichlorophenol	6.11E+01	n	6.84E+02	n	2.38E+02	n	3.65E+01	n	1.04E-01	2.07E+00
1,1,2-Trichloropropane	3.91E+02	n	5.68E+03	ns	1.55E+03	ns	1.83E+02	n	5.79E-02	1.16E+00
1,2,3-Trichloropropane	4.97E-02	c	3.76E+01	c	7.23E+00	c	7.18E-03	c	2.50E-06	5.00E-05
Triethylamine	2.21E+02	n	1.04E+03	n	1.93E+02	n	1.46E+01	n	3.65E-03	7.31E-02
2,4,6-Trinitrotoluene	3.91E+01	n	5.68E+02	n	1.55E+02	n	1.83E+01	n	8.01E-02	1.60E+00
Uranium (soluble salts)	2.35E+02	n	3.41E+03	n	9.29E+02	ns	1.10E+02	n	4.93E+01	9.86E+02
Vanadium	3.91E+02	n	5.68E+03	n	1.55E+03	n	1.83E+02	n	1.83E+02	3.65E+03
Vinyl acetate	2.56E+03	n	1.23E+04	ns	2.30E+03	ns	4.12E+02	n	7.59E-02	1.52E+00
Vinyl bromide	2.36E+00	c	1.32E+01	n	8.51E+00	n	1.52E+00	c	4.00E-04	8.00E-03
Vinyl chloride	7.28E-01	c	2.61E+01	c	1.49E+02	c	1.62E-01	c	5.42E-05	1.08E-03
m-Xylene	7.74E+02	ns	3.78E+03	ns	7.05E+02	ns	2.03E+02	n	1.56E-01	3.12E+00
o-Xylene	8.98E+02	ns	4.41E+03	ns	8.23E+02	ns	2.03E+02	n	1.56E-01	3.13E+00
Xylenes	8.14E+02	ns	3.98E+03	ns	7.43E+02	ns	2.03E+02	n	1.56E-01	3.13E+00
Zinc	2.35E+04	n	3.41E+05	nl	9.29E+04	n	1.10E+04	n	6.82E+02	1.36E+04

c – carcinogen
 cs - carcinogenic, SSL may exceed saturation
 n – noncarcinogenic
 nl - noncarcinogen, SSL may exceed ceiling limit

ns - noncarcinogen, SSL may exceed saturation

nls - noncarcinogen, SSL may exceed both saturation and ceiling limit

APPENDIX B

CHEMICAL AND PHYSICAL PROPERTIES

Table B-1: Chemical CAS and Molecular Weight

Chemical	Chemical Abstract Service (CAS) Number	Molecular Weight (g/mole)
Acenaphthene	83-32-9	154.21
Acetaldehyde	75-07-0	44.05
Acetone	67-64-1	58.08
Acrylonitrile	107-13-1	41.05
Acetophenone	98-86-2	120.15
Acrolein	107-02-8	56.06
Aldrin	309-00-2	364.92
Aluminum	7429-90-5	26.98
Anthracene	120-12-7	178.24
Antimony	7440-36-0	121.75
Arsenic	7440-38-2	74.92
Barium	7440-39-3	137.33
Benzene	71-43-2	78.1
Benzidine	92-87-5	184.23
Benzo(a)anthracene	56-55-3	228
Benzo(a)pyrene	50-32-8	250
Benzo(b)fluoranthene	205-99-2	252.3
Benzo(k)fluoranthene	207-08-9	252.3
Beryllium	7440-41-7	9.01
a-BHC (HCH)	319-84-6	290.85
b-BHC (HCH)	319-85-7	290.85
g-BHC	58-89-9	290.85
1,1-Biphenyl	92-52-4	150
Bis(2-chloroethyl) ether	111-44-4	140
Bis(2-chloroisopropyl) ether	39638-32-9	170
Bis(2-ethylhexyl) phthalate	117-81-7	390.54
Bis(chloromethyl) ether	542-88-1	120
Boron	7440-42-8	10.81
Bromodichloromethane	75-27-4	164
Bromomethane	74-83-9	94.95
1,3-Butadiene	106-99-0	54
2-Butanone (Methyl ethyl ketone, MEK)	78-93-3	72
tert-Butyl methyl ether (MTBE)	1634-04-4	88.2
Cadmium	7440-43-9	112.41
Carbon disulfide	75-15-0	76
Carbon tetrachloride	56-23-5	154
Chlordane	12789-03-6	409.8
2-Chloroacetophenone	532-27-4	154.59
2-Chloro-1,3-butadiene	126-99-8	88
1-Chloro-1,1-difluoroethane	75-68-3	100.5
Chlorobenzene	108-90-7	113
1-Chlorobutane	109-69-3	92.57
Chlorodifluoromethane	75-45-6	86.47

Chemical	Chemical Abstract Service (CAS) Number	Molecular Weight (g/mole)
Chloroform	67-66-3	120
Chloromethane	74-87-3	51
b-Chloronaphthalene	91-58-7	160
<i>o</i> -Chloronitrobenzene	88-73-3	153.33
<i>p</i> -Chloronitrobenzene	100-00-5	153.33
2-Chlorophenol	95-57-8	130
2-Chloropropane	75-29-6	78.54
<i>o</i> -Chlorotoluene	95-49-8	172.57
Chromium III	16065-83-1	52
Chromium VI	18540-29-9	52
Chrysene	218-01-9	228.28
Copper	7440-50-8	63.55
Crotonaldehyde	123-73-9	70.09
Cumene (isopropylbenzene)	98-82-8	120
Cyanide	57-12-5	27.03
Cyanogen	460-19-5	52
Cyanogen bromide	506-68-3	52
Cyanogen chloride	506-77-4	52
DDD	72-54-8	320
DDE	72-55-9	318
DDT	50-29-3	354.5
Dibenz(a,h)anthracene	53-70-3	278.3
1,2-Dibromo-3-chloropropane	96-12-8	240
Dibromochloromethane	124-48-1	210
1,2-Dibromoethane	106-93-4	188
1,4-Dichloro-2-butene	764-41-0	130
1,2-Dichlorobenzene	95-50-1	147
1,4-Dichlorobenzene	106-46-7	147
3,3-Dichlorobenzidine	91-94-1	253.13
Dichlorodifluoromethane	75-71-8	120
1,1-Dichloroethane	75-34-3	99
1,2-Dichloroethane	107-06-2	99
<i>cis</i> -1,2-Dichloroethene	156-59-2	97
<i>trans</i> -1,2-Dichloroethene	156-60-5	97
1,1-Dichloroethene	75-35-4	97
2,4-Dichlorophenol	120-83-2	163
1,2-Dichloropropane	78-87-5	110
1,3-Dichloropropene	542-75-6	111
Dicyclopentadiene	77-73-6	130
Dieldrin	60-57-1	381
Diethyl phthalate	84-66-2	222.2
Dimethyl phthalate	131-11-3	194.19
Di-n-butyl phthalate (Dibutyl phthalate)	84-74-2	278.34
2,4-Dimethylphenol	105-67-9	122.16
4,6-Dinitro- <i>o</i> -cresol	534-52-1	198.14

Chemical	Chemical Abstract Service (CAS) Number	Molecular Weight (g/mole)
2,4-Dinitrophenol	51-28-5	184.11
2,4-Dinitrotoluene	121-14-2	182.14
2,6-Dinitrotoluene	606-20-2	182.14
2,4/2,6-Dinitrotoluene Mixture	25321-14-6	182.14
1,4-Dioxane	123-91-1	88.11
1,2-Diphenylhydrazine	122-66-7	184.24
Endosulfan	115-29-7	406.95
Endrin	72-20-8	381
Epichlorohydrin	106-89-8	93
Ethyl acetate	141-78-6	88
Ethyl acrylate	140-88-5	100.1
Ethyl chloride	75-00-3	65
Ethyl ether	60-29-7	74.12
Ethyl methacrylate	97-63-2	114.12
Ethylbenzene	100-41-4	106.2
Ethylene oxide	75-21-8	44
Fluoranthene	206-44-0	202.3
Fluorene	86-73-7	166.21
Fluoride	7782-41-4	38
Furan	110-00-9	68
Heptachlor	76-44-8	373.5
Hexachlorobenzene	118-74-1	284.8
Hexachloro-1,3-butadiene	87-68-3	260.76
Hexachlorocyclopentadiene	77-47-4	272.75
Hexachloroethane	67-72-1	236.74
n-Hexane	110-54-3	86
HMX	2691-41-0	296.2
Hydrazine anhydride	302-01-2	32.05
Hydrogen cyanide	74-90-8	27
Indeno(1,2,3-c,d)pyrene	193-39-5	276.3
Iron	7439-89-6	55.84
Isobutanol (Isobutyl alcohol)	78-83-1	74
Isophorone	78-59-1	138.21
Lead	7439-92-1	207.2
Lead (tetraethyl-)	78-00-2	64.52
Maleic hydrazide	123-33-1	110
Manganese	7439-96-5	54.94
Mercury (elemental)	7439-97-6	200
Mercury (methyl)	22967-92-6	215.62
Mercury Chloride (Mercury Salts)	7487-94-7	271.5
Methacrylonitrile	126-98-7	67.09
Methomyl	16752-77-5	160
Methyl acetate	79-20-9	74.08
Methyl acrylate	96-33-3	86.09
Methyl isobutyl ketone	108-10-1	100

Chemical	Chemical Abstract Service (CAS) Number	Molecular Weight (g/mole)
Methyl methacrylate	80-62-6	100
Methyl styrene (alpha)	98-83-9	118.18
Methyl styrene (mixture)	25013-15-4	118.18
Methylcyclohexane	108-87-2	98
Methylene bromide (Dibromomethane)	74-95-3	170
Methylene chloride	75-09-2	85
Molybdenum	7439-98-7	95.94
Naphthalene	91-20-3	128.16
Nickel	7440-02-0	58.71
Nitrate	14797-55-8	101.1
Nitrite	14797-65-0	46
Nitrobenzene	98-95-3	120
Nitroglycerin	55-63-0	227.08
<i>N</i> -Nitrosodiethylamine	55-18-5	102.14
<i>N</i> -Nitrosodimethylamine	62-75-9	74.08
<i>N</i> -Nitrosodi- <i>n</i> -butylamine	924-16-3	158.2
<i>N</i> -Nitrosodiphenylamine	86-30-6	198.23
<i>N</i> -Nitrosopyrrolidine	930-55-2	100.2
<i>m</i> -Nitrotoluene	99-08-1	137.1
<i>o</i> -Nitrotoluene	88-72-2	137.13
<i>p</i> -Nitrotoluene	99-99-0	137.1
Pentachlorobenzene	608-93-5	250.32
Pentachlorophenol	87-86-5	266.34
Perchlorate	14797-73-0	117.49
Phenanthrene	85-01-8	178.2
Phenol	108-95-2	94
Polychlorinatedbiphenyls		
Aroclor 1016	12674-11-2	257.55
Aroclor 1221	11104-28-2	262
Aroclor 1232	11141-16-5	262
Aroclor 1242	53469-21-9	291.99
Aroclor 1248	12672-29-6	291.99
Aroclor 1254	11097-69-1	326.44
Aroclor 1260	11096-82-5	395.33
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	35065-30-6	395.33
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	35065-29-3	395.33
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	39635-31-9	395.33
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	52663-72-6	360.88
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	69782-90-7	360.88
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	38380-08-4	360.88
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	32774-16-6	360.88
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	65510-44-3	326.44
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	31508-00-6	326.44
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	32598-14-4	326.44
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	74472-37-0	326.44

Chemical	Chemical Abstract Service (CAS) Number	Molecular Weight (g/mole)
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	57465-28-8	326.44
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	32598-13-3	291.99
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	70362-50-4	291.99
Propylene oxide	75-56-9	58
Pyrene	129-00-0	200
RDX	121-82-4	222.12
Selenium	7782-49-2	78.96
Silver	7440-22-4	107.87
Strontium	7440-24-6	87.62
Styrene	100-42-5	100
2,3,7,8-TCDD	1746-01-6	321.98
2,3,7,8-TCDF	51207-31-9	305.98
1,2,4,5-Tetrachlorobenzene	95-94-3	215.89
1,1,1,2-Tetrachloroethane	630-20-6	167.85
1,1,2,2-Tetrachloroethane	79-34-5	169.86
Tetrachloroethene	127-18-4	170
Tetryl (Trinitrophenylmethylnitramine)	479-45-8	287.15
Thallium	7440-28-0	204.37
Toluene	108-88-3	92
Toxaphene	8001-35-2	414
Tribromomethane (Bromoform)	75-25-2	252.73
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	187.38
1,2,4-Trichlorobenzene	120-82-1	181
1,1,1-Trichloroethane	71-55-6	130
1,1,2-Trichloroethane	79-00-5	133
Trichloroethylene	79-01-6	131
Trichlorofluoromethane	75-69-4	140
2,4,5-Trichlorophenol	95-95-4	197.46
2,4,6-Trichlorophenol	88-06-2	197.46
1,1,2-Trichloropropane	598-77-6	147.43
1,2,3-Trichloropropane	96-18-4	147.43
Triethylamine	121-44-8	101.19
2,4,6-Trinitrotoluene	118-96-7	227.13
Uranium (soluble salts)	--	
Vanadium	7440-62-2	50.94
Vinyl acetate	108-05-4	86
Vinyl bromide	593-60-2	106.95
Vinyl chloride	75-01-4	63
<i>m</i> -Xylene	108-38-3	106
<i>o</i> -Xylene	95-47-6	106
Xylenes	1330-20-7	106
Zinc	7440-66-6	65.38

Table B-2: Physical and Chemical Properties

Chemical	H (atm- m ³ /mole)	H' (dimensio n-less)	D _a (cm ² /s)	D _w (cm ² /s)	K _{oc} (cm ³ /g)	K _d (cm ³ /g)	S (mg/L- water)	D _A (cm ² /s)	Res./Indus VF (m ³ /kg)	Comm VF (mg ³ /kg)	SAT (mg/kg)	VOC?
Acenaphthene	1.8E-04	7.54E-03	5.06E-02	8.30E-06	5.03E+03	7.54E+00	3.90E+00	5.22E-07	1.72E+05	3.55E+04		✓
Acetaldehyde	6.7E-05	2.73E-03	1.28E-01	1.40E-05	1.00E+00	1.50E-03	1.00E+06	2.25E-05	2.61E+04	5.40E+03	1.75E+05	✓
Acetone	3.5E-05	1.44E-03	1.06E-01	1.10E-05	2.36E+00	3.55E-03	1.00E+06	1.08E-05	3.78E+04	7.80E+03	1.77E+05	✓
Acrylonitrile	1.4E-04	5.66E-03	1.14E-01	1.23E-05	8.51E+00	1.28E-02	7.54E+04	3.61E-05	2.07E+04	4.27E+03	1.41E+04	✓
Acetophenone	1.0E-05	4.26E-04	6.50E-02	8.70E-06	5.19E+01	7.78E-02	6.13E+03	2.45E-06	7.94E+04	1.64E+04	1.54E+03	✓
Acrolein	1.2E-04	5.00E-03	1.34E-01	1.41E-05	1.00E+00	1.50E-03	1.00E+06	4.02E-05	1.96E+04	4.04E+03	1.75E+05	✓
Aldrin	4.4E-05	1.80E-03	3.72E-02	4.35E-06	8.20E+04	1.23E+02	1.70E-02	6.68E-09				
Aluminum						1.50E+03						
Anthracene	5.6E-05	2.30E-03	3.90E-02	7.90E-06	1.64E+04	2.45E+01	4.34E-02	4.78E-08	5.68E+05	1.17E+05		✓
Antimony						4.50E+01						
Arsenic						2.90E+01						
Barium						4.10E+01						
Benzene	5.6E-03	2.30E-01	8.95E-02	1.03E-05	1.46E+02	2.19E-01	1.79E+03	4.77E-04	5.68E+03	1.17E+03	7.51E+02	✓
Benzidine	7.0E-11	2.87E-09	5.87E-02	6.86E-06	1.19E+03	1.79E+00	3.22E+02	1.39E-07				
Benzo(a)anthracene	1.2E-05	4.92E-04	5.09E-02	5.94E-06	1.77E+05	2.65E+02	9.40E-03	1.80E-09				
Benzo(a)pyrene	4.6E-07	1.89E-05	4.76E-02	5.56E-06	5.87E+05	8.81E+02	1.62E-03	2.61E-10				
Benzo(b)fluoranthene	6.6E-07	2.71E-05	4.76E-02	5.56E-06	5.99E+05	8.99E+02	1.50E-03	2.60E-10				
Benzo(k)fluoranthene	5.9E-07	2.42E-05	4.76E-02	5.56E-06	5.87E+05	8.81E+02	8.00E-04	2.63E-10				
Beryllium						7.90E+02						
α-BHC (HCH)	1.2E-05	4.92E-04	4.33E-02	5.06E-06	2.81E+03	4.21E+00	8.00E+00	9.29E-08				
β-BHC (HCH)	4.4E-07	1.80E-05	2.77E-02	7.40E-06	2.81E+03	4.21E+00	8.00E+00	6.81E-08				
γ-BHC	5.1E-06	2.09E-04	4.33E-02	5.06E-06	2.81E+03	4.21E+00	8.00E+00	6.58E-08				
1,1-Biphenyl	3.2E-04	1.31E-02	4.70E-02	7.60E-06	5.13E+03	7.69E+00	6.94E+00	7.98E-07	1.39E+05	2.87E+04	5.46E+01	✓
Bis(2-chloroethyl) ether	1.8E-05	7.38E-04	5.70E-02	8.70E-06	3.22E+01	4.83E-02	1.72E+04	3.40E-06	6.73E+04	1.39E+04	3.81E+03	✓
Bis(2-chloroisopropyl) ether	1.1E-04	4.51E-03	6.30E-02	6.40E-06	4.58E+01	6.87E-02	1.70E+03	1.24E-05	3.52E+04	7.28E+03	4.12E+02	✓
Bis(2-ethylhexyl) phthalate	2.7E-07	1.11E-05	1.73E-02	4.18E-06	1.20E+05	1.79E+02	2.70E-01	9.35E-10				
Bis(chloromethyl) ether	2.0E-04	8.20E-03	7.60E-02	1.00E-05	9.70E+00	1.45E-02	2.20E+04	3.41E-05	2.13E+04	4.39E+03	4.16E+03	✓
Boron						3.00E+00						
Bromodichloromethane	2.1E-03	8.61E-02	5.60E-02	1.10E-05	3.18E+01	4.77E-02	3.03E+03	2.04E-04	8.68E+03	1.79E+03	7.01E+02	✓
Bromomethane	6.2E-03	2.54E-01	1.00E-01	1.30E-05	1.32E+01	1.98E-02	1.52E+04	1.11E-03	3.72E+03	7.69E+02	3.40E+03	✓
1,3-Butadiene	7.3E-02	2.99E+00	1.00E-01	1.10E-05	3.96E+01	5.94E-02	7.35E+02	5.07E-03	1.74E+03	3.60E+02	4.35E+02	✓
2-Butanone (Methyl ethyl ketone, MEK)	5.6E-05	2.30E-03	9.10E-02	1.00E-05	4.51E+00	6.77E-03	2.23E+05	1.34E-05	3.39E+04	7.00E+03	4.02E+04	✓
tert-Butyl methyl ether (MTBE)	5.9E-04	2.42E-02	7.50E-02	8.60E-06	1.16E+01	1.73E-02	5.10E+04	9.27E-05	1.29E+04	2.66E+03	9.87E+03	✓
Cadmium						7.50E+01						

Chemical	H (atm- m ³ /mole)	H' (dimensio n-less)	D _a (cm ² /s)	D _w (cm ² /s)	K _{oc} (cm ³ /g)	K _d (cm ³ /g)	S (mg/L- water)	D _A (cm ² /s)	Res./Indus VF (m ³ /kg)	Comm VF (mg ³ /kg)	SAT (mg/kg)	VOC?
Carbon disulfide	1.4E-02	5.74E-01	1.10E-01	1.30E-05	2.17E+01	3.26E-02	1.18E+03	2.26E-03	2.61E+03	5.39E+02	3.24E+02	✓
Carbon tetrachloride	2.7E-02	1.11E+00	5.70E-02	9.80E-06	4.39E+01	6.58E-02	7.93E+02	1.68E-03	3.03E+03	6.26E+02	2.95E+02	✓
Chlordane	4.9E-05	2.01E-03	3.44E-02	4.02E-06	3.38E+04	5.07E+01	5.60E-02	1.63E-08				
2-Chloroacetophenone	3.2E-06	1.31E-04	5.20E-02	8.70E-06	9.89E+01	1.48E-01	1.64E+03	1.28E-06				
2-Chloro-1,3-butadiene	5.6E-02	2.30E+00	8.40E-02	1.10E-05	6.07E+01	9.11E-02	8.75E+02	3.56E-03	2.08E+03	4.30E+02	4.72E+02	✓
1-Chloro-1,1-difluoroethane	5.9E-02	2.42E+00	8.00E-02	1.00E-05	4.39E+01	6.58E-02	1.40E+03	3.65E-03	2.05E+03	4.24E+02	7.41E+02	✓
Chlorobenzene	3.2E-03	1.31E-01	7.20E-02	9.50E-06	2.34E+02	3.51E-01	4.98E+02	1.71E-04	9.50E+03	1.96E+03	2.69E+02	✓
1-Chlorobutane	1.7E-02	6.97E-01	7.80E-02	9.30E-06	7.22E+01	1.08E-01	1.10E+03	1.46E-03	3.25E+03	6.71E+02	4.02E+02	✓
Chlorodifluoromethane	4.1E-02	1.66E+00	1.00E-01	1.30E-05	3.18E+01	4.77E-02	2.77E+03	3.94E-03	1.98E+03	4.09E+02	1.17E+03	✓
Chloroform	3.7E-03	1.50E-01	7.70E-02	1.10E-05	3.18E+01	4.77E-02	7.95E+03	4.73E-04	5.70E+03	1.18E+03	1.90E+03	✓
Chloromethane	8.8E-03	3.62E-01	1.20E-01	1.40E-05	1.32E+01	1.98E-02	5.32E+03	1.80E-03	2.93E+03	6.05E+02	1.26E+03	✓
□-Chloronaphthalene	3.2E-04	1.31E-02	4.50E-02	7.70E-06	2.48E+03	3.72E+00	1.17E+01	1.55E-06	9.97E+04	2.06E+04	4.55E+01	✓
o-Chloronitrobenzene	9.3E-06	3.81E-04	5.10E-02	8.80E-06	3.71E+02	5.56E-01	4.41E+02	7.38E-07				
p-Chloronitrobenzene	4.9E-06	2.00E-04	5.00E-02	8.50E-06	3.63E+02	5.45E-01	2.25E+02	6.06E-07				
2-Chlorophenol	1.1E-05	4.59E-04	6.60E-02	9.50E-06	3.07E+02	4.60E-01	2.85E+04	1.06E-06	1.21E+05	2.49E+04	1.80E+04	✓
2-Chloropropane	1.4E-05	5.74E-04	8.00E-02	1.00E-05	3.18E+01	4.77E-02	2.70E+03	3.81E-06	6.36E+04	1.31E+04	5.97E+02	✓
o-Chlorotoluene	3.6E-03	1.46E-01	6.30E-02	8.70E-06	3.83E+02	5.74E-01	3.74E+02	1.17E-04	1.15E+04	2.37E+03	2.86E+02	✓
Chromium III						1.80E+06						
Chromium VI						1.90E+01	1.69E+06					
Chrysene	5.2E-06	2.14E-04	2.61E-02	6.75E-06	1.81E+05	2.71E+02	2.00E-03	1.19E-09				
Copper						3.50E+01						
Crotonaldehyde	1.9E-05	7.95E-04	9.60E-02	1.10E-05	1.79E+00	2.69E-03	1.81E+05	6.68E-06	4.80E+04	9.92E+03	3.19E+04	✓
Cumene (isopropylbenzene)	1.2E-02	4.72E-01	6.00E-02	7.90E-06	6.98E+02	1.05E+00	6.13E+01	2.16E-04	8.45E+03	1.75E+03	7.83E+01	✓
Cyanide	1.3E-04	5.45E-03	1.24E-01	1.38E-05		9.90E+00	1.00E+06	7.05E-07	1.48E+05	3.05E+04	1.01E+07	✓
Cyanogen	5.4E-03	2.21E-01	1.20E-01	1.40E-05			1.05E+04	1.30E-03	3.44E+03	7.11E+02		✓
Cyanogen bromide			9.80E-02	1.40E-05				3.21E-06	6.93E+04	1.43E+04		✓
Cyanogen chloride	1.9E-03	7.96E-02	1.20E-01	1.40E-05			2.50E+07	5.11E-04	5.49E+03	1.13E+03		✓
DDD	6.6E-06	2.71E-04	4.06E-02	4.74E-06	1.18E+05	1.76E+02	9.00E-02	1.67E-09				
DDE	4.2E-05	1.71E-03	4.08E-02	4.76E-06	1.18E+05	1.76E+02	4.00E-02	4.89E-09				
DDT	8.3E-06	3.41E-04	3.79E-02	4.43E-06	1.69E+05	2.53E+02	5.50E-03	1.19E-09				
Dibenz(a,h)anthracene	1.4E-07	5.78E-06	4.71E-02	5.50E-06	1.91E+06	2.87E+03	1.03E-03	7.71E-11				
1,2-Dibromo-3-chloropropane	1.5E-04	6.03E-03	3.20E-02	8.90E-06	1.16E+02	1.74E-01	1.23E+03	6.39E-06	4.91E+04	1.01E+04	4.28E+02	✓
Dibromochloromethane	7.8E-04	3.21E-02	3.70E-02	1.10E-05	3.18E+01	4.77E-02	2.70E+03	5.32E-05	1.70E+04	3.52E+03	6.07E+02	✓
1,2-Dibromoethane	6.5E-04	2.67E-02	4.30E-02	1.00E-05	3.96E+01	5.94E-02	3.91E+03	4.88E-05	1.78E+04	3.67E+03	9.22E+02	✓
1,4-Dichloro-2-butene	6.6E-04	2.72E-02	7.60E-02	8.90E-06	1.32E+02	1.97E-01	5.80E+02	5.46E-05	1.68E+04	3.47E+03	2.17E+02	✓
1,2-Dichlorobenzene	1.9E-03	7.87E-02	5.60E-02	8.90E-06	3.83E+02	5.74E-01	8.00E+01	5.69E-05	1.65E+04	3.40E+03	6.06E+01	✓

Chemical	H (atm- m ³ /mole)	H' (dimensio n-less)	D _a (cm ² /s)	D _w (cm ² /s)	K _{oc} (cm ³ /g)	K _d (cm ³ /g)	S (mg/L- water)	D _A (cm ² /s)	Res./Indus VF (m ³ /kg)	Comm VF (mg ³ /kg)	SAT (mg/kg)	VOC?
1,4-Dichlorobenzene	2.4E-03	9.88E-02	5.50E-02	8.70E-06	3.75E+02	5.63E-01	8.13E+01	7.09E-05	1.47E+04	3.04E+03		✓
3,3-Dichlorobenzidine	4.0E-09	1.64E-07	4.75E-02	5.55E-06	3.19E+03	4.79E+00	3.10E+00	4.45E-08				
Dichlorodifluoromethane	3.4E-01	1.41E+01	7.80E-02	9.10E-06	4.39E+01	6.58E-02	2.80E+02	5.80E-03	1.63E+03	3.37E+02	5.39E+02	✓
1,1-Dichloroethane	5.6E-03	2.30E-01	8.40E-02	1.10E-05	3.18E+01	4.77E-02	5.04E+03	7.61E-04	4.50E+03	9.30E+02	1.25E+03	✓
1,2-Dichloroethane	1.2E-03	4.84E-02	8.60E-02	1.10E-05	3.96E+01	5.94E-02	5.10E+03	1.71E-04	9.49E+03	1.96E+03	1.22E+03	✓
cis-1,2-Dichloroethene	4.1E-03	1.67E-01	8.80E-02	1.10E-05	3.96E+01	5.94E-02	3.50E+03	5.69E-04	5.21E+03	1.08E+03	8.85E+02	✓
trans-1,2-Dichloroethene	4.1E-03	1.67E-01	8.80E-02	1.10E-05	3.96E+01	5.94E-02	3.50E+03	5.69E-04	5.21E+03	1.08E+03	8.85E+02	✓
1,1-Dichloroethene	2.6E-02	1.07E+00	8.60E-02	1.10E-05	3.18E+01	4.77E-02	2.42E+03	2.61E-03	2.43E+03	5.02E+02	8.46E+02	✓
2,4-Dichlorophenol	4.3E-06	1.76E-04	6.40E-02	7.40E-06	4.92E+02	7.38E-01	4.50E+03	4.42E-07				
1,2-Dichloropropane	2.8E-03	1.16E-01	8.10E-02	9.50E-06	6.07E+01	9.11E-02	2.80E+03	3.28E-04	6.85E+03	1.41E+03	7.79E+02	✓
1,3-Dichloropropene	9.8E-04	4.00E-02	8.20E-02	9.60E-06	7.22E+01	1.08E-01	2.80E+03	1.12E-04	1.17E+04	2.42E+03	8.02E+02	✓
Dicyclopentadiene	6.3E-02	2.56E+00	7.30E-02	8.60E-06	1.51E+03	2.27E+00	5.19E+01	6.63E-04	4.82E+03	9.95E+02	1.43E+02	✓
Dieldrin	1.0E-05	4.10E-04	2.33E-02	6.01E-06	2.01E+04	3.01E+01	2.50E-01	1.09E-08				
Diethyl phthalate	6.1E-07	2.50E-05	2.61E-02	6.72E-06	1.05E+02	1.57E-01	1.08E+03	8.27E-07				
Dimethyl phthalate	4.1E-07	1.68E-05	5.68E-02	6.29E-06	3.16E+01	4.74E-02	4.00E+03	1.17E-06				
Di-n-butyl phthalate (Dibutyl phthalate)	1.8E-06	7.38E-05	2.14E-02	5.33E-06	1.16E+03	1.74E+00	1.12E+01	1.19E-07				
2,4-Dimethylphenol	9.5E-07	3.90E-05	6.20E-02	8.30E-06	4.92E+02	7.38E-01	7.87E+03	3.88E-07				
4,6-Dinitro-o-cresol	1.4E-06	5.74E-05	5.60E-02	6.50E-06	7.54E+02	1.13E+00	1.98E+02	2.22E-07				
2,4-Dinitrophenol	8.6E-08	3.53E-06	4.07E-02	9.08E-06	4.61E+02	6.91E-01	2.79E+03	4.19E-07				
2,4-Dinitrotoluene	5.4E-08	2.21E-06	3.75E-02	7.90E-06	5.76E+02	8.63E-01	2.70E+02	3.03E-07				
2,6-Dinitrotoluene	7.5E-07	3.06E-05	3.70E-02	7.80E-08	5.87E+02	8.81E-01	3.52E+02	1.34E-08				
2,4/2,6-Dinitrotoluene Mixture	4.0E-07	1.63E-05	5.90E-02	6.90E-06	5.87E+02	8.81E-01	2.70E+02	2.69E-07				
1,4-Dioxane	4.8E-06	1.97E-04	8.70E-02	1.10E-05	2.63E+00	3.95E-03	1.00E+06	3.40E-06				
1,2-Diphenylhydrazine	4.8E-07	1.96E-05	3.43E-02	7.25E-06	1.51E+03	2.26E+00	2.21E+02	1.21E-07				
Endosulfan	6.5E-05	2.67E-03	2.25E-02	5.76E-06	6.76E+03	1.01E+01	4.50E-01	7.85E-08				
Endrin	1.0E-05	4.10E-04	3.62E-02	4.22E-06	2.01E+04	3.01E+01	2.50E-01	1.03E-08				
Epichlorohydrin	3.0E-05	1.25E-03	9.30E-02	1.10E-05	9.91E+00	1.49E-02	6.59E+04	8.29E-06	4.31E+04	8.91E+03	1.24E+04	✓
Ethyl acetate	1.3E-04	5.49E-03	8.20E-02	9.70E-06	5.58E+00	8.37E-03	8.00E+04	2.61E-05	2.43E+04	5.02E+03	1.46E+04	✓
Ethyl acrylate	3.4E-04	1.39E-02	7.50E-02	9.10E-06	1.07E+01	1.60E-02	1.50E+04	5.48E-05	1.68E+04	3.46E+03	2.86E+03	✓
Ethyl chloride	1.1E-02	4.55E-01	1.10E-01	1.20E-05	2.17E+01	3.26E-02	6.71E+03	1.89E-03	2.86E+03	5.90E+02	1.75E+03	✓
Ethyl ether	1.2E-03	5.04E-02	8.50E-02	9.40E-06	9.70E+00	1.45E-02	6.04E+04	2.17E-04	8.44E+03	1.74E+03	1.17E+04	✓
Ethyl methacrylate	5.7E-05	2.35E-03	6.50E-02	8.40E-06	1.67E+01	2.50E-02	5.40E+03	9.13E-06	4.11E+04	8.48E+03	1.07E+03	✓
Ethylbenzene	7.9E-03	3.23E-01	6.80E-02	8.50E-06	4.46E+02	6.69E-01	1.69E+02	2.43E-04	7.97E+03	1.65E+03	1.49E+02	✓
Ethylene oxide	1.5E-04	6.07E-03	1.30E-01	1.50E-05	3.24E+00	4.86E-03	1.00E+06	4.61E-05	1.83E+04	3.78E+03	1.79E+05	✓
Fluoranthene	8.9E-06	3.63E-04	2.76E-02	7.18E-06	5.55E+04	8.32E+01	2.60E-01	4.59E-09				
Fluorene	9.6E-05	3.94E-03	4.40E-02	7.88E-06	9.16E+03	1.37E+01	1.89E+00	1.43E-07	3.28E+05	6.77E+04		✓

Chemical	H (atm- m ³ /mole)	H' (dimensio n-less)	D _a (cm ² /s)	D _w (cm ² /s)	K _{oc} (cm ³ /g)	K _d (cm ³ /g)	S (mg/L- water)	D _A (cm ² /s)	Res./Indus VF (m ³ /kg)	Comm VF (mg ³ /kg)	SAT (mg/kg)	VOC?
Fluoride							4.13E+04					
Furan	5.4E-03	2.21E-01	1.00E-01	1.20E-05	8.00E+01	1.20E-01	1.00E+04	6.75E-04	4.78E+03	9.87E+02	3.20E+03	✓
Heptachlor	2.9E-04	1.21E-02	2.23E-02	5.70E-06	4.13E+04	6.19E+01	1.80E-01	4.57E-08				
Hexachlorobenzene	1.7E-03	6.97E-02	2.90E-02	7.85E-06	6.20E+03	9.29E+00	6.20E-03	2.10E-06				
Hexachloro-1,3-butadiene	1.0E-02	4.22E-01	2.67E-02	7.03E-06	8.45E+02	1.27E+00	3.23E+00	7.37E-05				
Hexachlorocyclopentadiene	2.7E-02	1.11E+00	2.72E-02	7.22E-06	1.40E+03	2.11E+00	1.80E+00	1.22E-04				
Hexachloroethane	3.9E-03	1.59E-01	3.21E-02	8.89E-06	1.97E+02	2.95E-01	5.00E+01	1.03E-04				
n-Hexane	1.8E+00	7.38E+01	7.30E-02	8.20E-06	1.32E+02	1.97E-01	9.50E+00	5.98E-03	1.61E+03	3.32E+02	8.77E+01	✓
HMX	8.7E-10	3.55E-08	4.28E-02	5.00E-06	5.32E+02	7.97E-01	9.44E+03	2.05E-07				
Hydrazine anhydride					1.32E+03	1.98E+00	1.00E+06					
Hydrogen cyanide	1.3E-04	5.45E-03	1.70E-01	1.70E-05			1.00E+06	5.55E-05	1.67E+04	3.44E+03		1
Indeno(1,2,3-c,d)pyrene	3.5E-07	1.43E-05	4.48E-02	5.23E-06	1.95E+06	2.93E+03	1.90E-04	7.31E-11				
Iron						2.50E+01						
Isobutanol (Isobutyl alcohol)	9.8E-06	4.01E-04	9.00E-02	1.00E-05	2.92E+00	4.38E-03	8.50E+04	4.20E-06	6.05E+04	1.25E+04	1.51E+04	✓
Isophorone	6.6E-06	2.72E-04	5.30E-02	7.50E-06	6.52E+01	9.77E-02	1.20E+04	1.61E-06				
Lead						9.00E+02						
Lead (tetraethyl-)	5.7E-01	2.33E+01	2.45E-02	6.40E-06	6.48E+02	9.72E-01	2.90E-01	1.46E-03				
Maleic hydrazide	2.7E-11	1.09E-09	8.20E-02	9.50E-06	3.30E+00	4.95E-03	4.51E+03	2.12E-06				
Manganese						6.50E+01						
Mercury (elemental)	1.1E-02	4.67E-01	7.10E-02	3.00E-05		5.20E+01	6.00E-02	6.18E-06	4.99E+04	1.03E+04	3.13E+00	✓
Mercury (methyl)												
Mercury Chloride (Mercury Salts)						5.20E+01	6.90E+04					
Methacrylonitrile	2.5E-04	1.01E-02	9.60E-02	1.10E-05	1.31E+01	1.96E-02	2.54E+04	5.08E-05	1.74E+04	3.60E+03	4.93E+03	✓
Methomyl	2.0E-11	8.08E-10	4.80E-02	8.40E-06	1.00E+01	1.50E-02	5.80E+04	1.77E-06				
Methyl acetate	1.2E-04	4.72E-03	9.60E-02	1.10E-05	3.06E+00	4.60E-03	2.43E+05	2.70E-05	2.39E+04	4.93E+03	4.34E+04	✓
Methyl acrylate	2.0E-04	8.16E-03	8.60E-02	1.00E-05	5.84E+00	8.77E-03	4.94E+04	3.93E-05	1.98E+04	4.09E+03	9.04E+03	✓
Methyl isobutyl ketone	1.4E-04	5.66E-03	7.00E-02	8.30E-06	1.26E+01	1.89E-02	1.90E+04	2.16E-05	2.67E+04	5.52E+03	3.67E+03	✓
Methyl methacrylate	3.2E-04	1.31E-02	7.50E-02	9.20E-06	9.14E+00	1.37E-02	1.50E+04	5.24E-05	1.72E+04	3.54E+03	2.83E+03	✓
Methyl styrene (alpha)	2.3E-03	9.43E-02	7.10E-02	8.00E-06	6.98E+02	1.05E+00	3.00E+02	5.30E-05	1.71E+04	3.52E+03	3.69E+02	✓
Methyl styrene (mixture)	2.6E-03	1.05E-01	7.90E-02	9.20E-06	7.16E+02	1.07E+00	8.90E+01	6.39E-05	1.55E+04	3.21E+03	1.12E+02	✓
Methylcyclohexane	4.4E-01	1.80E+01	7.00E-02	9.00E-06	2.34E+02	3.51E-01	1.40E+01	4.76E-03	1.80E+03	3.71E+02	3.76E+01	✓
Methylene bromide (Dibromomethane)	8.2E-04	3.37E-02	5.50E-02	1.20E-05	2.17E+01	3.26E-02	1.19E+04	8.79E-05	1.32E+04	2.73E+03	2.50E+03	✓
Methylene chloride	3.3E-03	1.33E-01	1.00E-01	1.30E-05	2.17E+01	3.26E-02	1.30E+04	5.87E-04	5.12E+03	1.06E+03	2.88E+03	✓
Molybdenum						2.00E+01						
Naphthalene	4.4E-04	1.80E-02	5.90E-02	8.40E-06	1.54E+03	2.32E+00	3.10E+01	4.27E-06	6.00E+04	1.24E+04		✓
Nickel						6.50E+01						

Chemical	H (atm- m ³ /mole)	H' (dimensio n-less)	D _a (cm ² /s)	D _w (cm ² /s)	K _{oc} (cm ³ /g)	K _d (cm ³ /g)	S (mg/L- water)	D _A (cm ² /s)	Res./Indus VF (m ³ /kg)	Comm VF (mg ³ /kg)	SAT (mg/kg)	VOC?
Nitrate												
Nitrite												
Nitrobenzene	2.4E-05	9.84E-04	6.80E-02	9.40E-06	2.26E+02	3.40E-01	2.09E+03	1.99E-06	8.79E+04	1.82E+04	1.07E+03	✓
Nitroglycerin	8.7E-08	3.55E-06	2.90E-02	7.74E-06	1.16E+02	1.74E-01	1.38E+03	8.89E-07				
N-Nitrosodiethylamine	3.6E-06	1.49E-04	7.40E-02	9.13E-06	8.29E+01	1.24E-01	1.06E+05	1.58E-06				
N-Nitrosodimethylamine	1.8E-06	7.46E-05	9.90E-02	1.20E-05	2.28E+01	3.42E-02	1.00E+06	2.64E-06				
N-Nitrosodi-n-butylamine	1.3E-05	5.41E-04	6.50E-02	7.60E-06	9.15E+02	1.37E+00	1.27E+03	4.16E-07	1.92E+05	3.98E+04	1.96E+03	✓
N-Nitrosodiphenylamine	5.0E-06	2.05E-04	5.60E-02	6.50E-06	2.63E+03	3.95E+00	3.50E+01	8.97E-08				
N-Nitrosopyrrolidine	4.9E-08	2.00E-06	8.00E-01	1.01E-05	9.19E+01	1.38E-01	1.00E+06	1.34E-06				
m-Nitrotoluene	9.3E-06	3.81E-04	5.90E-02	8.70E-06	3.63E+02	5.45E-01	5.00E+02	7.85E-07				
o-Nitrotoluene	1.3E-05	5.13E-04	5.90E-02	8.70E-06	3.71E+02	5.56E-01	6.50E+02	8.76E-07	1.33E+05	2.74E+04	4.74E+02	✓
p-Nitrotoluene	5.6E-06	2.31E-04	5.70E-02	8.40E-06	3.63E+02	5.45E-01	4.42E+02	6.42E-07				
Pentachlorobenzene	7.0E-04	2.88E-02	2.94E-02	7.97E-06	3.71E+03	5.56E+00	8.31E-01	1.49E-06				
Pentachlorophenol	2.5E-08	1.00E-06	2.95E-02	8.01E-06	4.96E+03	7.44E+00	1.40E+01	4.19E-08				
Perchlorate							2.45E+05					
Phenanthrene	1.9E-01	7.71E+00	3.33E-02	7.47E-06	1.67E+04	2.50E+01	1.15E+00	9.54E-05	1.27E+04	2.63E+03		✓
Phenol	3.3E-07	1.37E-05	8.30E-02	1.00E-05	1.87E+02	2.81E-01	8.28E+04	8.99E-07				
Polychlorinatedbiphenyls												
Aroclor 1016	2.0E-04	8.20E-03	4.69E-02	5.48E-06	4.77E+04	7.16E+01	2.77E-01	5.50E-08				
Aroclor 1221	7.4E-04	3.02E-02	5.80E-02	6.70E-06	8.40E+03	1.26E+01	4.83E+00	1.35E-06	1.07E+05	2.21E+04	6.17E+01	✓
Aroclor 1232	7.4E-04	3.02E-02	5.80E-02	6.70E-06	8.40E+03	1.26E+01	4.83E+00	1.35E-06	1.07E+05	2.21E+04	6.17E+01	✓
Aroclor 1242	1.9E-04	7.79E-03	4.32E-02	5.01E-02	7.81E+04	1.17E+02	2.77E-01	1.70E-05				
Aroclor 1248	4.4E-04	1.80E-02	4.32E-02	5.01E-02	7.65E+04	1.15E+02	5.32E-02	1.74E-05				
Aroclor 1254	2.8E-04	1.16E-02	4.01E-02	4.68E-06	1.31E+05	1.96E+02	3.40E-03	2.40E-08				
Aroclor 1260	3.4E-04	1.38E-02	3.53E-02	4.14E-06	3.50E+05	5.25E+02	2.84E-04	9.29E-09				
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	3.0E-06	1.23E-04			3.57E+05	5.35E+02	3.47E-03					
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	2.4E-07	9.84E-06			3.50E+05	5.25E+02	3.85E-03					
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	1.4E-04	5.66E-03	3.53E-02	4.12E-06	3.50E+05	5.25E+02	7.53E-04	4.00E-09				
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	1.6E-04	6.64E-03	3.75E-02	4.38E-06	2.09E+05	3.14E+02	2.23E-03	8.24E-09				
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	1.6E-04	6.64E-03	3.75E-02	4.38E-06	2.14E+05	3.20E+02	1.64E-03	8.07E-09				
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	1.4E-04	5.86E-03	3.75E-02	4.38E-06	2.14E+05	3.20E+02	5.33E-03	7.19E-09				
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	1.6E-04	6.64E-03	3.75E-02	4.38E-06	2.09E+05	3.14E+02	5.10E-04	8.24E-09				
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	1.9E-04	7.79E-03	4.01E-02	4.68E-06	1.31E+05	1.96E+02	1.60E-02	1.64E-08				
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	2.9E-04	1.18E-02	4.01E-02	4.68E-06	1.28E+05	1.92E+02	1.34E-02	2.49E-08				
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	2.8E-04	1.16E-02	4.01E-02	4.68E-06	1.31E+05	1.96E+02	3.40E-03	2.40E-08				
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	1.9E-04	7.79E-03	4.01E-02	4.68E-06	1.31E+05	1.96E+02	1.60E-02	1.64E-08				

Chemical	H (atm- m ³ /mole)	H' (dimensio n-less)	D _a (cm ² /s)	D _w (cm ² /s)	K _{oc} (cm ³ /g)	K _d (cm ³ /g)	S (mg/L- water)	D _A (cm ² /s)	Res./Indus VF (m ³ /kg)	Comm VF (mg ³ /kg)	SAT (mg/kg)	VOC?
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	1.9E-04	7.79E-03	4.01E-02	4.68E-06	1.28E+05	1.92E+02	9.39E-03	1.67E-08				
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	9.4E-06	3.85E-04	4.32E-02	5.04E-06	7.81E+04	1.17E+02	5.69E-04	3.08E-09				
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	2.2E-04	9.14E-03	4.32E-02	5.04E-06	7.81E+04	1.17E+02	5.32E-02	3.43E-08				
Propylene oxide	7.0E-05	2.85E-03	1.30E-01	1.50E-05	5.19E+00	7.79E-03	5.90E+05	2.31E-05	2.58E+04	5.34E+03	1.07E+05	✓
Pyrene	1.2E-05	4.88E-04	2.72E-02	7.24E-06	5.43E+04	8.15E+01	1.35E-01	5.10E-09	1.74E+06	3.59E+05		✓
RDX	2.0E-11	8.20E-10	3.12E-02	8.50E-06	8.91E+01	1.34E-01	5.97E+01	1.10E-06				
Selenium						5.00E+00						
Silver						8.30E+00						
Strontium						3.50E+01						
Styrene	2.7E-03	1.12E-01	7.10E-02	8.80E-06	4.46E+02	6.69E-01	3.10E+02	9.05E-05	1.30E+04	2.70E+03	2.65E+02	✓
2,3,7,8-TCDD	5.0E-05	2.05E-03	4.70E-02	4.73E-06	2.49E+05	3.74E+02	2.00E-04	3.00E-09				
2,3,7,8-TCDF	1.5E-05	6.15E-04			1.40E+05	2.09E+02	6.92E-04					
1,2,4,5-Tetrachlorobenzene	1.0E-03	4.10E-02	3.19E-02	8.75E-06	2.22E+03	3.33E+00	5.95E-01	3.71E-06				
1,1,1,2-Tetrachloroethane	2.5E-03	1.03E-01	4.80E-02	9.10E-06	8.60E+01	1.29E-01	1.07E+03	1.53E-04	1.00E+04	2.07E+03	3.37E+02	✓
1,1,2,2-Tetrachloroethane	3.7E-04	1.50E-02	4.90E-02	9.30E-06	9.49E+01	1.42E-01	2.87E+03	2.37E-05	2.55E+04	5.27E+03	9.11E+02	✓
Tetrachloroethene	1.8E-02	7.26E-01	5.00E-02	9.50E-06	9.49E+01	1.42E-01	2.06E+02	8.85E-04	4.17E+03	8.62E+02	8.30E+01	✓
Tetryl (Trinitrophenylmethylnitramine)	2.7E-09	1.11E-07	2.56E-02	6.67E-06	4.61E+03	6.91E+00	7.40E+01	3.74E-08				
Thallium						7.10E+01						
Toluene	6.6E-03	2.72E-01	7.80E-02	9.20E-06	2.34E+02	3.51E-01	5.26E+02	3.71E-04	6.44E+03	1.33E+03	2.93E+02	✓
Toxaphene	6.0E-06	2.46E-04	3.42E-02	4.00E-06	7.72E+04	1.16E+02	5.50E-01	2.07E-09				
Tribromomethane (Bromoform)	5.4E-04	2.19E-02	3.57E-02	1.04E-05	3.18E+01	6.92E+00	3.10E+03	1.13E-06				
1,1,2-Trichloro-1,2,2-trifluoroethane	5.3E-01	2.16E+01	3.80E-02	8.60E-06	1.97E+02	2.95E-01	1.70E+02	2.73E-03	2.38E+03	4.91E+02	5.20E+02	✓
1,2,4-Trichlorobenzene	1.4E-03	5.82E-02	4.00E-02	8.40E-06	1.36E+03	2.03E+00	4.90E+01	1.03E-05	3.86E+04	7.97E+03	1.09E+02	✓
1,1,1-Trichloroethane	1.7E-02	7.05E-01	6.50E-02	9.60E-06	4.39E+01	6.58E-02	1.29E+03	1.39E-03	3.33E+03	6.87E+02	4.18E+02	✓
1,1,2-Trichloroethane	8.2E-04	3.38E-02	6.70E-02	1.00E-05	6.07E+01	9.11E-02	1.10E+03	8.33E-05	1.36E+04	2.81E+03	2.95E+02	✓
Trichloroethylene	9.9E-03	4.04E-01	6.90E-02	1.00E-05	6.07E+01	9.11E-02	1.28E+03	8.72E-04	4.20E+03	8.68E+02	4.00E+02	✓
Trichlorofluoromethane	9.7E-02	3.98E+00	6.50E-02	1.00E-05	4.39E+01	6.58E-02	1.10E+03	3.63E-03	2.06E+03	4.25E+02	7.88E+02	✓
2,4,5-Trichlorophenol	1.6E-06	6.64E-05	5.60E-02	6.50E-06	1.78E+03	2.67E+00	1.20E+03	1.04E-07				
2,4,6-Trichlorophenol	2.6E-06	1.07E-04	3.10E-02	8.10E-06	1.78E+03	2.67E+00	8.00E+02	1.25E-07				
1,1,2-Trichloropropane	3.2E-04	1.30E-02	5.70E-02	9.30E-06	9.49E+01	1.42E-01	1.90E+03	2.38E-05	2.54E+04	5.26E+03	6.03E+02	✓
1,2,3-Trichloropropane	3.4E-04	1.41E-02	5.70E-02	9.20E-06	1.16E+02	1.74E-01	1.75E+03	2.33E-05	2.57E+04	5.31E+03	6.10E+02	✓
Triethylamine	1.5E-04	6.11E-03	6.60E-02	7.90E-06	5.08E+01	7.62E-02	7.37E+04	1.69E-05	3.02E+04	6.24E+03	1.84E+04	✓
2,4,6-Trinitrotoluene	2.1E-08	8.53E-07	2.95E-02	7.92E-06	2.81E+03	4.22E+00	1.30E+02	7.17E-08				
Uranium (soluble salts)						4.50E+02						
Vanadium						1.00E+03						
Vinyl acetate	5.1E-04	2.10E-02	8.50E-02	1.00E-05	5.58E+00	8.37E-03	2.00E+04	9.59E-05	1.27E+04	2.62E+03	3.68E+03	✓

Chemical	H (atm- m ³ /mole)	H' (dimensio n-less)	D _a (cm ² /s)	D _w (cm ² /s)	K _{oc} (cm ³ /g)	K _d (cm ³ /g)	S (mg/L- water)	D _A (cm ² /s)	Res./Indus VF (m ³ /kg)	Comm VF (mg ³ /kg)	SAT (mg/kg)	VOC?
Vinyl bromide	1.2E-02	5.04E-01	8.60E-02	1.20E-05	2.17E+01	3.26E-02	5.08E+03	1.60E-03	3.10E+03	6.41E+02	1.35E+03	✓
Vinyl chloride	2.8E-02	1.14E+00	1.10E-01	1.20E-05	2.17E+01	3.26E-02	8.80E+03	3.63E-03	2.06E+03	4.26E+02	3.02E+03	✓
<i>m</i> -Xylene	7.2E-03	2.94E-01	6.80E-02	8.40E-06	3.75E+02	5.63E-01	1.61E+02	2.53E-04	7.81E+03	1.61E+03	1.24E+02	✓
<i>o</i> -Xylene	5.2E-03	2.12E-01	6.90E-02	8.50E-06	3.83E+02	5.74E-01	1.06E+02	1.84E-04	9.14E+03	1.89E+03	8.20E+01	✓
Xylenes	5.2E-03	2.12E-01	8.50E-02	9.90E-06	3.83E+02	5.74E-01	1.06E+02	2.27E-04	8.23E+03	1.70E+03	8.20E+01	✓
Zinc						6.20E+01				3.55E+04		

Notes:

MW – Molecular weight

H' – Dimensionless Henry's Law Constant

D_w – Diffusivity in waterK_d – Soil-water partition coefficientD_A – Apparent diffusivity (calculated for VOCs only)

SAT – Soil saturation limit (calculated for VOCs only)

H – Henry's Law Constant

D_a – Diffusivity in airK_{oc} – Soil organic carbon partition coefficient

S – Solubility in water

VF – Volatilization factor (calculated for VOCs only)

VOC – Volatile organic compound

APPENDIX C

TOXICITY DATA

Table C-1: Human Health Benchmarks Used for Calculating SSLs

Chemical	CSF ₀ (mg/kg-day) ⁻¹	Reference	IUR (µg/m ³) ⁻¹	Reference	RfD ₀ (mg/kg-day)	Reference	RfC (mg/m ³)	Reference	Mutagen	GIABS	ABS
Acenaphthene					6.00E-02	IRIS				1	0.13
Acetaldehyde			2.20E-06	IRIS			9.00E-03	IRIS		1	
Acetone					9.00E-01	IRIS	3.10E+01	ATSDR		1	
Acrylonitrile	5.40E-01	IRIS	6.80E-05	IRIS	4.00E-02	ATSDR	2.00E-03	IRIS		1	
Acetophenone					1.00E-01	IRIS				1	
Acrolein					5.00E-04	IRIS	2.00E-05	IRIS		1	
Aldrin	1.72E+01	IRIS	4.90E-03	IRIS	3.00E-05	IRIS				1	0.1
Aluminum					1.00E+00	PPTRV	5.00E-03	PPTRV		1	
Anthracene					3.00E-01	IRIS				1	0.13
Antimony					4.00E-04	IRIS				0.15	
Arsenic	1.50E+00	IRIS	4.30E-03	IRIS	3.00E-04	IRIS	1.50E-05	CalEPA		1	0.03
Barium					2.00E-01	IRIS	5.00E-04	HEAST		0.07	
Benzene	5.50E-02	IRIS	7.80E-06	IRIS	4.00E-03	IRIS	3.00E-02	IRIS		1	
Benzidine	2.30E+02	IRIS	6.70E-02	IRIS	3.00E-03	IRIS			M	1	0.1
Benzo(a)anthracene	7.30E-01	NCEA	1.10E-04	CalEPA					M	1	0.13
Benzo(a)pyrene	7.30E+00	IRIS	1.10E-03	CalEPA					M	1	0.13
Benzo(b)fluoranthene	7.30E-01	NCEA	1.10E-04	CalEPA					M	1	0.13
Benzo(k)fluoranthene	7.30E-02	NCEA	1.10E-04	CalEPA					M	1	0.13
Beryllium			2.40E-03	IRIS	2.00E-03	IRIS	2.00E-05	IRIS		0.007	
a-BHC (HCH)	6.30E+00	IRIS	1.80E-03	IRIS	8.00E-03	ATSDR				1	0.1
b-BHC (HCH)	1.80E+00	IRIS	5.30E-04	IRIS						1	0.1
g-BHC	1.10E+00	CalEPA	3.10E-04	CalEPA	3.00E-04	IRIS				1	0.04
1,1-Biphenyl	8.00E-03	PPTRV			5.00E-02	IRIS	4.00E-04	PPTRV		1	
Bis(2-chloroethyl) ether	1.10E+00	IRIS	3.30E-04	IRIS						1	
Bis(2-chloroisopropyl) ether	7.00E-02	HEAST									
Bis(2-ethylhexyl) phthalate	1.40E-02	IRIS	2.40E-06	CalEPA	2.00E-02	IRIS				1	0.1
Bis(chloromethyl) ether	2.20E+02	IRIS	6.20E-02	IRIS						1	
Boron					2.00E-01	IRIS	2.00E-02	HEAST		1	
Bromodichloromethane	6.20E-02	IRIS	3.70E-05	CalEPA	2.00E-02	IRIS				1	
Bromomethane					1.40E-03	IRIS	5.00E-03	IRIS		1	
1,3-Butadiene	3.40E+00	CalEPA	3.00E-05	IRIS			2.00E-03	IRIS		1	
2-Butanone (Methyl ethyl ketone, MEK)					6.00E-01	IRIS	5.00E+00	IRIS		1	
tert-Butyl methyl ether (MTBE)	1.80E-03	CalEPA	2.60E-07	CalEPA			3.00E+00	IRIS		1	

Chemical	CSF _o (mg/kg-day) ⁻¹	Reference	IUR (µg/m ³) ⁻¹	Reference	RfD _o (mg/kg-day)	Reference	RfC (mg/m ³)	Reference	Mutagen	GIABS	ABS
Cadmium			1.80E-03	IRIS	1.00E-03	IRIS	2.00E-05	CalEPA		0.025	0.001
Carbon disulfide					1.00E-01	IRIS	7.00E-01	IRIS		1	
Carbon tetrachloride	7.00E-02	IRIS	6.00E-06	IRIS	4.00E-03	IRIS	1.00E-01	IRIS		1	
Chlordane	3.50E-01	IRIS	1.00E-04	IRIS	5.00E-04	IRIS	7.00E-04	IRIS		1	0.04
2-Chloroacetophenone							3.00E-05	IRIS		1	0.1
2-Chloro-1,3-butadiene			3.00E-04	IRIS	2.00E-02	HEAST	2.00E-02	IRIS		1	
1-Chloro-1,1-difluoroethane							5.00E+01	IRIS		1	
Chlorobenzene					2.00E-02	IRIS	5.00E-02	PPTRV		1	
1-Chlorobutane					4.00E-02	PPTRV				1	
Chlorodifluoromethane							5.00E+01	IRIS		1	
Chloroform	3.10E-02	CalEPA	2.30E-05	IRIS	1.00E-02	IRIS	9.80E-02	ATSDR		1	
Chloromethane							9.00E-02	IRIS		1	
b-Chloronaphthalene					8.00E-02	IRIS				1	
o-Chloronitrobenzene	3.00E-01	PPTRV			3.00E-03	PPTRV	1.00E-05	PPTRV		1	0.1
p-Chloronitrobenzene	6.30E-03	PPTRV			1.00E-03	PPTRV	6.00E-04	PPTRV		1	0.1
2-Chlorophenol					5.00E-03	IRIS					
2-Chloropropane							1.00E-01	HEAST			
o-Chlorotoluene					2.00E-02	IRIS					
Chromium III					1.50E+00	IRIS				0.013	
Chromium VI	5.00E-01	NJ	8.40E-02	IRIS	3.00E-03	IRIS	1.00E-04	IRIS	M	0.025	
Chrysene	7.30E-03	NCEA	1.10E-05	CalEPA					M	1	0.13
Copper					4.00E-02	HEAST				1	
Crotonaldehyde	1.90E+00	HEAST			1.00E-03	PPTRV				1	
Cumene (isopropylbenzene)					1.00E-01	IRIS	4.00E-01	IRIS		1	
Cyanide					6.00E-04	IRIS				1	
Cyanogen					4.00E-02	IRIS				1	
Cyanogen bromide					9.00E-02	IRIS				1	
Cyanogen chloride					5.00E-02	IRIS				1	
DDD	2.40E-01	IRIS	6.90E-05	CalEPA						1	0.1
DDE	3.40E-01	IRIS	9.70E-05	CalEPA						1	0.1
DDT	3.40E-01	IRIS	9.70E-05	IRIS	5.00E-04	IRIS				1	0.03
Dibenz(a,h)anthracene	7.30E+00	NCEA	1.20E-03	CalEPA					M	1	0.13
1,2-Dibromo-3-chloropropane	8.00E-01	PPTRV	6.00E-03	PPTRV	2.00E-04	PPTRV	2.00E-04	IRIS	M	1	
Dibromochloromethane	8.40E-02	IRIS	2.70E-05	CalEPA	2.00E-02	IRIS				1	0.1
1,2-Dibromoethane	2.00E+00	IRIS	6.00E-04	IRIS	9.00E-03	IRIS	9.00E-03	IRIS		1	
1,4-Dichloro-2-butene			4.20E-03	PPTRV						1	
1,2-Dichlorobenzene					9.00E-02	IRIS	2.00E-01	HEAST		1	

Chemical	CSF ₀ (mg/kg-day) ⁻¹	Reference	IUR (µg/m ³) ⁻¹	Reference	RfD ₀ (mg/kg-day)	Reference	RfC (mg/m ³)	Reference	Mutagen	GIABS	ABS
1,4-Dichlorobenzene	5.40E-03	CalEPA	1.10E-05	CalEPA	7.00E-02	ATSDR	8.00E-01	IRIS		1	
3,3-Dichlorobenzidine	4.50E-01	IRIS	3.40E-04	CalEPA						1	0.1
Dichlorodifluoromethane					2.00E-01	IRIS	1.00E-01	PPTRV		1	
1,1-Dichloroethane	5.70E-03	CalEPA	1.60E-06	CalEPA	2.00E-01	PPTRV				1	
1,2-Dichloroethane	9.10E-02	IRIS	2.60E-05	IRIS	6.00E-03	PPTRV	7.00E-03	PPTRV		1	
<i>cis</i> -1,2-Dichloroethene					2.00E-03	IRIS				1	
<i>trans</i> -1,2-Dichloroethene					2.00E-02	IRIS	6.00E-02	PPTRV		1	
1,1-Dichloroethene					5.00E-02	IRIS	2.00E-01	IRIS		1	
2,4-Dichlorophenol					3.00E-03	IRIS				1	0.1
1,2-Dichloropropane	3.60E-02	CalEPA	1.00E-05	CalEPA	9.00E-02	ATSDR	4.00E-03	IRIS		1	
1,3-Dichloropropene	1.00E-01	IRIS	4.00E-06	IRIS	3.00E-02	IRIS	2.00E-02	IRIS		1	
Dicyclopentadiene					8.00E-03	PPTRV	7.00E-03	PPTRV		1	
Dieldrin	1.60E+01	IRIS	4.60E-03	IRIS	5.00E-05	IRIS				1	0.1
Diethyl phthalate					8.00E-01	IRIS				1	0.1
Dimethyl phthalate					1.00E+01	HEAST				1	0.1
Di-n-butyl phthalate (Dibutyl phthalate)					1.00E-01	IRIS				1	0.1
2,4-Dimethylphenol					2.00E-02	IRIS				1	0.1
4,6-Dinitro-o-cresol					8.00E-05	PPTRV				1	0.1
2,4-Dinitrophenol					2.00E-03	IRIS				1	0.1
2,4-Dinitrotoluene	3.10E-01	CalEPA	8.90E-05	CalEPA	2.00E-03	IRIS				1	0.1
2,6-Dinitrotoluene					1.00E-03	PPTRV				1	0.1
2,4/2,6-Dinitrotoluene Mixture	6.80E-01	IRIS								1	0.1
1,4-Dioxane	1.00E-01	IRIS	7.70E-06	CalEPA	3.00E-02	IRIS	3.00E+00	CalEPA		1	0.1
1,2-Diphenylhydrazine	8.00E-01	IRIS	2.20E-04	IRIS						1	0.1
Endosulfan					6.00E-03	IRIS				1	0.1
Endrin					3.00E-04	IRIS				1	0.1
Epichlorohydrin	9.90E-03	IRIS	1.20E-06	IRIS	6.00E-03	PPTRV	1.00E-03	IRIS		1	
Ethyl acetate					9.00E-01	IRIS				1	
Ethyl acrylate	4.80E-02	HEAST								1	
Ethyl chloride							1.00E+01	IRIS		1	
Ethyl ether					2.00E-01	IRIS				1	
Ethyl methacrylate					9.00E-02	HEAST	3.00E-01	PPTRV		1	
Ethylbenzene	1.10E-02	CalEPA	2.50E-06	CalEPA	1.00E-01	IRIS	1.00E+00	IRIS		1	
Ethylene oxide	3.10E-01	CalEPA	8.80E-05	CalEPA			3.00E-02	CalEPA		1	
Fluoranthene					4.00E-02	IRIS				1	0.13
Fluorene					4.00E-02	IRIS				1	0.13
Fluoride					4.00E-02	CalEPA	1.30E-02	CalEPA		1	

Chemical	CSF _o (mg/kg-day) ⁻¹	Reference	IUR (µg/m ³) ⁻¹	Reference	RfD _o (mg/kg-day)	Reference	RfC (mg/m ³)	Reference	Mutagen	GIABS	ABS
Furan					1.00E-03	IRIS				1	
Heptachlor	4.50E+00	IRIS	1.30E-03	IRIS	5.00E-04	IRIS				1	0.1
Hexachlorobenzene	1.60E+00	IRIS	4.60E-04	IRIS	8.00E-04	IRIS				1	0.1
Hexachloro-1,3-butadiene	7.80E-02	IRIS	2.20E-05	IRIS	1.00E-03	PPTRV				1	0.1
Hexachlorocyclopentadiene					6.00E-03	IRIS	2.00E-04	IRIS		1	0.1
Hexachloroethane	4.00E-02	IRIS	4.00E-06	IRIS	7.00E-04	IRIS				1	0.1
n-Hexane					6.00E-02	HEAST	7.00E-01	IRIS		1	
HMX					5.00E-02	IRIS				1	
Hydrazine anhydride	3.00E+00	IRIS	4.90E-03	IRIS			3.00E-05	PPTRV		1	
Hydrogen cyanide					6.00E-04	IRIS	8.00E-04	IRIS		1	
Indeno(1,2,3-c,d)pyrene	7.30E-01	NCEA	1.10E-04	CalEPA					M	1	0.13
Iron					7.00E-01	PPTRV				1	
Isobutanol (Isobutyl alcohol)					3.00E-01	IRIS				1	
Isophorone	9.50E-04	IRIS			2.00E-01	IRIS	2.00E+00	CalEPA		1	0.1
Lead											
Lead (tetraethyl-)					1.00E-07	IRIS				1	0.1
Maleic hydrazide					5.00E-01	IRIS				1	0.1
Manganese					2.40E-02	IRIS	5.00E-05	IRIS		0.04	
Mercury (elemental)							3.00E-04	IRIS		1	
Mercury (methyl)					1.00E-04	IRIS				1	
Mercuric Chloride (Mercury Salts)					3.00E-04	IRIS	3.00E-05	CalEPA		0.07	
Methacrylonitrile					1.00E-04	IRIS	7.00E-04	HEAST		1	
Methomyl					2.50E-02	IRIS				1	0.1
Methyl acetate					1.00E+00	PPTRV				1	
Methyl acrylate					3.00E-02	HEAST				1	
Methyl isobutyl ketone					8.00E-02	HEAST	3.00E+00	IRIS		1	
Methyl methacrylate					1.40E+00	IRIS	7.00E-01	IRIS		1	
Methyl styrene (alpha)					7.00E-02	HEAST				1	
Methyl styrene (mixture)					6.00E-03	HEAST	4.00E-02	HEAST		1	
Methylcyclohexane							3.00E+00	HEAST			
Methylene bromide (Dibromomethane)					1.00E-02	HEAST	4.00E-03	PPTRV		1	
Methylene chloride	2.00E-03	IRIS	1.00E-08	IRIS	6.00E-03	IRIS	6.00E-01	IRIS		1	
Molybdenum					5.00E-03	IRIS				1	
Naphthalene			3.40E-05	CalEPA	2.00E-02	IRIS	3.00E-03	IRIS		1	0.13
Nickel (soluble salts)			2.60E-04	CalEPA	2.00E-02	IRIS	9.00E-05	ATSDR		0.04	
Nitrate					1.60E+00	IRIS				1	
Nitrite					1.00E-01	IRIS				1	

Chemical	CSF _o (mg/kg-day) ⁻¹	Reference	IUR (µg/m ³) ⁻¹	Reference	RfD _o (mg/kg-day)	Reference	RfC (mg/m ³)	Reference	Mutagen	GIABS	ABS
Nitrobenzene			4.00E-05	IRIS	2.00E-03	IRIS	9.00E-03	IRIS		1	
Nitroglycerin	1.70E-02	PPTRV			1.00E-04	PPTRV				1	0.1
N-Nitrosodiethylamine	1.50E+02	IRIS	4.30E-02	IRIS					M	1	0.1
N-Nitrosodimethylamine	5.10E+01	IRIS	1.40E-02	IRIS	8.00E-06	PPTRV	4.00E-05	PPTRV	M	1	0.1
N-Nitrosodi-n-butylamine	5.40E+00	IRIS	1.60E-03	IRIS						1	0.1
N-Nitrosodiphenylamine	4.90E-03	IRIS	2.60E-06	CalEPA						1	0.1
N-Nitrosopyrrolidine	2.10E+00	IRIS	6.10E-04	IRIS						1	0.1
m-Nitrotoluene					1.00E-04	PPTRV				1	
o-Nitrotoluene	2.20E-01	PPTRV			9.00E-04	PPTRV				1	
p-Nitrotoluene	1.60E-02	PPTRV			4.00E-03	PPTRV				1	0.1
Pentachlorobenzene					8.00E-04	IRIS				1	0.1
Pentachlorophenol	4.00E-01	IRIS	5.10E-06	CalEPA	5.00E-03	IRIS				1	0.25
Perchlorate					7.00E-04	IRIS				1	
Phenanthrene					3.00E-02	IRIS				1	0.1
Phenol					3.00E-01	IRIS	2.00E-01	CalEPA		1	0.1
Polychlorinatedbiphenyls											
Aroclor 1016	7.00E-02	IRIS	2.00E-05	IRIS	7.00E-05	IRIS				1	0.14
Aroclor 1221	2.00E+00	IRIS	5.70E-04	IRIS						1	0.14
Aroclor 1232	2.00E+00	IRIS	5.70E-04	IRIS						1	0.14
Aroclor 1242	2.00E+00	IRIS	5.70E-04	IRIS						1	0.14
Aroclor 1248	2.00E+00	IRIS	5.70E-04	IRIS						1	0.14
Aroclor 1254	2.00E+00	IRIS	5.70E-04	IRIS	2.00E-05	IRIS				1	0.14
Aroclor 1260	2.00E+00	IRIS	5.70E-04	IRIS						1	0.14
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	1.30E+01	WHO TEF	3.80E-03	WHO TEF						1	0.14
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	1.30E+00	WHO TEF	3.80E-04	WHO TEF						1	0.14
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	3.90E+00	WHO TEF	1.14E-03	WHO TEF						1	0.14
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	3.90E+00	WHO TEF	1.14E-03	WHO TEF						1	0.14
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	3.90E+00	WHO TEF	1.14E-03	WHO TEF						1	0.14
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	3.90E+00	WHO TEF	1.14E-03	WHO TEF						1	0.14
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	3.90E+03	WHO TEF	1.14E+00	WHO TEF						1	0.14
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	3.90E+00	WHO TEF	1.14E-03	WHO TEF						1	0.14
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	3.90E+00	WHO TEF	1.14E-03	WHO TEF						1	0.14
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	3.90E+00	WHO TEF	1.14E-03	WHO TEF						1	0.14
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	3.90E+00	WHO TEF	1.14E-03	WHO TEF						1	0.14
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	1.30E+04	WHO TEF	3.80E+00	WHO TEF						1	0.14
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	1.30E+01	WHO TEF	3.80E-03	WHO TEF						1	0.14
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	3.90E+01	WHO TEF	1.14E-02	WHO TEF						1	0.14

Chemical	CSF _o (mg/kg-day) ⁻¹	Reference	IUR (µg/m ³) ⁻¹	Reference	RfD _o (mg/kg-day)	Reference	RfC (mg/m ³)	Reference	Mutagen	GIABS	ABS
Propylene oxide	2.40E-01	IRIS	3.70E-06	IRIS			3.00E-02	IRIS		1	
Pyrene					3.00E-02	IRIS				1	0.13
RDX	1.10E-01	IRIS			3.00E-03	IRIS				1	
Selenium					5.00E-03	IRIS	2.00E-02	CalEPA		1	
Silver					5.00E-03	IRIS				0.04	
Strontium					6.00E-01	IRIS				1	
Styrene					2.00E-01	IRIS	1.00E+00	IRIS		1	
2,3,7,8-TCDD	1.30E+05	CalEPA	3.80E+01	CalEPA	1.00E-09	ATSDR	4.00E-08	CalEPA		1	0.03
2,3,7,8-TCDF	1.30E+04	WHO TEF	3.80E+00	WHO TEF						1	0.03
1,2,4,5-Tetrachlorobenzene					3.00E-04	IRIS				1	0.1
1,1,1,2-Tetrachloroethane	2.60E-02	IRIS	7.40E-06	IRIS	3.00E-02	IRIS				1	
1,1,2,2-Tetrachloroethane	2.00E-01	IRIS	5.80E-05	IRIS	2.00E-02	IRIS				1	
Tetrachloroethene	5.40E-01	CalEPA	5.90E-06	CalEPA	1.00E-02	IRIS	2.70E-01	ATSDR		1	
Tetryl (Trinitrophenylmethylnitramine)					4.00E-03	PPTRV				1	0.1
Thallium					1.00E-05	PPTRV				1	
Toluene					8.00E-02	IRIS	5.00E+00	IRIS		1	
Toxaphene	1.10E+00	IRIS	3.20E-04	IRIS						1	0.1
Tribromomethane (Bromoform)	7.90E-03	IRIS	1.10E-06	IRIS	2.00E-02	IRIS				1	0.1
1,1,2-Trichloro-1,2,2-trifluoroethane					3.00E+01	IRIS	3.00E+01	HEAST		1	
1,2,4-Trichlorobenzene	2.90E-02	PPTRV			1.00E-02	IRIS	2.00E-03	PPTRV		1	
1,1,1-Trichloroethane					2.00E+00	IRIS	5.00E+00	IRIS		1	
1,1,2-Trichloroethane	5.70E-02	IRIS	1.60E-05	IRIS	4.00E-03	IRIS	2.00E-04	PPTRV		1	
Trichloroethylene	4.6E-02	IRIS	4.10E-06	IRIS	5.00E-04	IRIS	2.00E-03	IRIS		1	
Trichlorofluoromethane					3.00E-01	IRIS	7.00E-01	HEAST		1	
2,4,5-Trichlorophenol					1.00E-01	IRIS				1	0.1
2,4,6-Trichlorophenol	1.10E-02	IRIS	3.10E-06	IRIS	1.00E-03	PPTRV				1	0.1
1,1,2-Trichloropropane					5.00E-03	IRIS				1	
1,2,3-Trichloropropane	3.00E+01	IRIS			4.00E-03	IRIS	3.00E-04	IRIS	M	1	
Triethylamine							7.00E-03	IRIS		1	
2,4,6-Trinitrotoluene	3.00E-02	IRIS			5.00E-04	IRIS				1	
Uranium (soluble salts)					3.00E-03	IRIS	3.00E-04	ATSDR		1	
Vanadium					5.00E-03	IRIS				1	
Vinyl acetate					1.00E+00	HEAST	2.00E-01	IRIS		1	
Vinyl bromide			3.20E-05	HEAST			3.00E-03	IRIS		1	
Vinyl chloride	7.20E-01	IRIS	4.40E-06	IRIS	3.00E-03	IRIS	1.00E-01	IRIS	M	1	
<i>m</i> -Xylene					2.00E-01	IRIS	1.00E-01	IRIS		1	
<i>o</i> -Xylene					2.00E-01	IRIS	1.00E-01	IRIS		1	

Chemical	CSF_o (mg/kg-day)⁻¹	Reference	IUR (µg/m³)⁻¹	Reference	RfD_o (mg/kg-day)	Reference	RfC (mg/m³)	Reference	Mutagen	GIABS	ABS
Xylenes					2.00E-01	IRIS	1.00E-01	IRIS		1	
Zinc					3.00E-01	IRIS				1	

Notes:

CSF_o – Oral Cancer Slope Factor

IUR – Inhalation Unit Risk

RfD_o – Oral Reference Dose

RfC – Inhalation Reference Concentration

ABS – Dermal absorption coefficient

ATSDR – Agency for Toxic Substances and Disease Registry

Cal EPA – California Environmental Protection Agency

HEAST – Health Effects Assessment Summary Tables

IRIS – Integrated Risk Information System

PPTRV – Provisional Peer Reviewed Toxicity Value

WHO TEF – World Health Organization Toxicity Equivalency Factor

APPENDIX D
New Mexico Environment Department
Hazardous Waste Bureau

**Guidance for Risk-based Remediation of Polychlorinated Biphenyls
(PCBs) at RCRA Corrective Action Sites**

New Mexico Environment Department
Hazardous Waste Bureau

**Guidance for Risk-based Remediation of Polychlorinated Biphenyls (PCBs) at
RCRA Corrective Action Sites¹**

February 2012

¹This document is intended as guidance for employees of the New Mexico Environment Department's (NMED) Hazardous Waste Bureau (HWB) and Resource Conservation and Recovery Act (RCRA)-regulated facilities within the State of New Mexico. This guidance does not constitute rule-making and may not be relied upon to create a right or benefit, substantive or procedural, enforceable at law or in equity, by any person. HWB may take action at variance to this guidance and reserves the right to modify this guidance at any time without public notice.

Guidance for Risk-based Remediation of Polychlorinated Biphenyls (PCBs) at RCRA Corrective Action Sites

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ACRONYMNS AND ABBREVIATIONS

µg/g	microgram per gram
µg/L	microgram per liter
AOC	Area of Concern
AT	Averaging Time
BMP	Best Management Practices
BW	Body Weight
CSF	Cancer Slope Factor
CWA	Clean Water Act
DD	Daily Dose
ECD	Electron Capture Detector
ED	Exposure Duration
EF	Exposure Frequency
ELCD	Electrolytic Conductivity Detector
GC/MS	Gas Chromatography/Mass Spectral Detector
HR	High Resolution
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectral Detector
HWB	Hazardous Waste Bureau
IR	Ingestion Rate
IRIS	Integrated Risk Information System
LADD	Lifetime Average Daily Dose
mg/m ³	milligram per cubic meter
mg/kg	milligram per kilogram
mg/L	milligram per liter
ng/L	nanogram per liter
NMED	New Mexico Environment Department
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzo-dioxins
PCDF	Polychlorinated Dibenzo-furans
pg/L	picogram per liter
ppb	parts per billion
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
SWMU	Solid Waste Management Unit
TCDD	2,3,7,8-tetrachloro-dibenzo-dioxin
TCDF	2,3,7,8-tetrachloro-dibenzo-furan
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalency Quotient

TRV	Toxicity Reference Value
TSS	Total Suspended Solids
US EPA	United States Environmental Protection Agency

Guidance for Risk-based Remediation of Polychlorinated Biphenyls at RCRA Corrective Action Sites

1.0 SCOPE

This document focuses on remedial activities at sites where polychlorinated biphenyls (**PCBs**) have been identified or are suspected of being present as one of the contaminants of potential concern. The intent of this document is to expedite the remedial action process and provide a cost-effective and consistent method for the evaluation and reduction of the risk posed to human health and the environment by PCBs.

This document **does not** discuss the complex regulations governing PCBs or the sampling methodologies for PCBs or other associated contaminants. This document **does** assume that the nature and extent of PCB contamination have been defined using a site conceptual model and **does** discuss and recommend analytical methods applicable to evaluating the risk to human and ecological health for PCBs in environmental media.

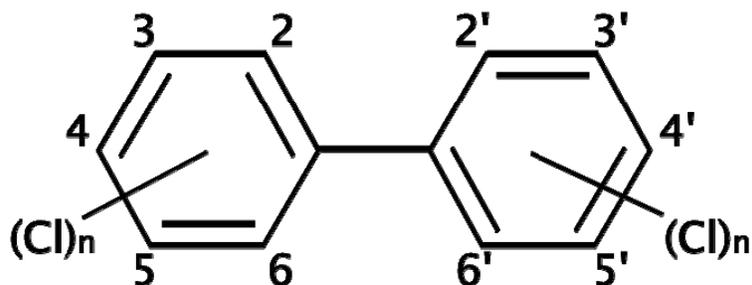
This paper **does not** discuss the risk posed to ground water quality by PCB contamination; state ground water standards and federal drinking water standards² exist for the protection of ground water. No state or federal soil/sediment standards exist to protect ground water from the transport of PCBs from contaminated soil/sediments; however, the risk associated with the transport of PCBs from contaminated soil/sediments to ground water should be evaluated to ensure that state and federal standards for ground water are not exceeded. Methods for the evaluation of this threat to ground water are **not**, at this time, specifically addressed in this document.

2.0 BACKGROUND INFORMATION

PCBs are a class of chlorinated organic compounds which found widespread application since their introduction into commerce in 1923. Their properties include thermal stability; resistance to acids, bases and oxidation; and resistance to direct electrical current. They were commonly used in transformers and capacitors, hydraulic and heat transfer equipment, compressors and vacuum pumps, plasticizers (surface coatings and sealants), and some paints and inks. Domestic production of commercial PCBs ceased in 1977; however, PCBs in existence at that time are still in use today.

The general chemical structure of chlorinated biphenyls is as follows:

²PCBs in ground water may not exceed the Safe Drinking Water Act's maximum contaminant level of 0.5 micrograms per liter ($\mu\text{g/L}$) in drinking water (Title 40 Code of Federal Regulations Parts 141-147 and 149) or the State of New Mexico's Water Quality Control Commission Regulations' standard of 1 $\mu\text{g/L}$ in ground water with 10,000 milligrams per liter (mg/L) or less total dissolved solids (Title 20 New Mexico Annotated Code Chapter 6.2).



The number and position of chlorines in the biphenyl molecule determine the physical and chemical properties of the PCB molecule. There are a total of 209 possible *congeners*³ of PCBs, each one resulting from the chlorination of different substitution positions and varying degrees of chlorination. In general, PCB molecules with higher degrees of chlorination are more resistant to biodegradation and are more persistent in the environment.

PCB congeners may be found in commercial preparations or complex mixtures known by the names Askarel, Aroclor, Clophen, Phenoclor, Kanechlor, and Pyralène. In the United States, PCB mixtures were marketed under the trade name of Aroclor. Each Aroclor has a four-digit numeric designation: the first two digits are "12" (indicating the biphenyl parent molecule) followed by two more digits indicating the percent chlorine content by weight in the mixture. For example, Aroclor 1254 has 54% chlorine by weight. Aroclor 1016 is the exception: it contains 41% chlorine by weight (ATSDR, 1995).

PCBs are a group of environmentally persistent organic chemicals that possess the inherent properties of compounds that bioaccumulate (i.e., high octanol/water partition coefficient and low water solubility). PCBs also have the following properties of environmental relevance: low vapor pressure and low flammability.

PCBs are toxic to humans and other animals (Eisler, 1986; ATSDR, 1995; and US EPA, 1996 and 1997a). PCBs adversely impact reproduction in wildlife and in experimental animals. Other common toxic effects in mammals and birds include thymic atrophy (a wasting syndrome), microsomal enzyme induction, porphyria (manifestations include intermittent nervous system dysfunction and/or sensitivity of skin to sunlight) and related liver damage, chloracne, estrogenic activity, immunosuppression, and tumor promotion. PCBs can be transferred to young mammals (including humans) transplacentally and in breast milk.

The United States Environmental Protection Agency (US EPA) and International Agency for Research on Cancer classified PCBs as Group B2; probable human carcinogens, based on sufficient evidence of carcinogenicity (manifested as hepatocellular carcinomas) in experimental animals and inadequate (due to confounding exposures to other potential carcinogens or lack of exposure quantification), yet suggestive evidence of excess risk of liver cancer in humans (US EPA, 2010). Recent studies have indicated that all PCB mixtures can cause cancer; however,

³*Congener* means any single, unique, well-defined chemical compound in the PCB category.

different mixtures exhibit different carcinogenic potencies (Cogliano, 1998). In addition, environmental processes may alter the PCB mixtures affecting its carcinogenic potency (see *Environmental Processes*).

The stability and lipophilicity of PCBs promote their biomagnification (i.e., the uptake of a chemical through ingestion resulting in the concentration of the chemical in tissue being greater than that of its food) once they enter the aquatic and terrestrial food chains. Through the food chain, living organisms selectively bioaccumulate persistent congeners of PCBs.

Environmentally-aged PCB mixtures appear to be more toxic and persistent in the organism than commercial PCB mixtures. Biomagnification through trophic transfer governs PCB levels in animals, especially those occupying the top of the food web. Therefore, PCBs in food sources represent the most important exposure source to humans and wildlife.

In certain situations, PCBs can become contaminated with the far more toxic polychlorinated dibenzofurans (**PCDFs**) and chlorinated dibenzo-dioxins (**PCDDs**). Therefore, the presence of PCDFs and PCDDs should always be investigated if any of the following processes existed or are suspected of existing:

- combustion or incineration of PCB-contaminated waste or waste oils, or highly variable waste streams (such as municipal and commercial waste for which PCB contamination is suspected);
- manufacture of PCBs⁴;
- pyrolysis of PCBs;
- photolysis of PCBs;
- incidental fire of transformers and capacitors containing PCBs; or
- treatment with chlorinating compounds (e.g., hydrochloric acid, chlorine, etc.).

3.0 ENVIRONMENTAL PROCESSES

PCBs occur as mixtures of congeners in the environment. *Partitioning*⁵, chemical and biological transformation, and preferential bioaccumulation may change the composition of the PCB mixture over time: the environmentally-aged PCB mixture may vary considerably from the original congener composition (US EPA, 1996b and ATSDR, 1995). Altered PCB mixtures have been known to persist in the environment for many years.

PCBs adsorb to organic matter, sediments, and soil. Their affinity to adsorb increases with the chlorine content of the PCBs and the amount of organic matter present. PCBs can volatilize or disperse as aerosols providing an effective means of transport in the environment. Congeners with low chlorine content tend to be more volatile and more water soluble.

⁴The concentration of PCDFs in commercial PCB samples ranged from 0.2 micrograms per gram ($\mu\text{g/g}$) to 13.6 $\mu\text{g/g}$ (ATSDR, 1993). Eisler (1986) reported PCDFs impurities ranging from 0.8 to 33 milligrams per kilogram (mg/kg) in some domestic and foreign PCB mixtures.

⁵*Partitioning* includes environmental processes by which different fractions of a mixture separate into air, water, sediment, and soil.

The highly chlorinated Aroclors (Aroclor 1248, 1254, and 1260) resist both chemical and biological transformation (i.e., degradation) in the environment. Biological degradation of highly chlorinated Aroclors to lower chlorinated PCBs can occur under anaerobic conditions⁶. The extent of this dechlorination⁷ is limited by the PCB chlorine content and soil/sediment PCB concentrations. Anaerobic bacteria in soil/sediments remove chlorines from low chlorinated PCBs (1 to 4 chlorines) and open the carbon rings through oxidation. PCBs with higher chlorine content are extremely resistant to oxidation and hydrolysis. Photolysis can also slowly break down highly chlorinated PCB congeners.

PCBs bioaccumulate and biomagnify through the food chain because they are highly lipid-soluble. The mixture of congeners found in biotic tissue will differ dramatically from the mixture of congeners originally released to the environment because bioaccumulation and biomagnification concentrate PCB congeners of higher chlorine content up through the food chain. This is because different congeners can exhibit different rates of metabolism and elimination in living organisms (Van den Berg, et al., 1998 and Coglianò, 1998).

By altering the congener composition of PCB mixtures, these environmental processes can substantially increase or decrease the toxicity of environmental PCBs mixture (Coglianò, 1998). Therefore, information on these environmental processes along with the results of congener-specific analyses of environmental and biota samples should be used to substantiate modeling of exposure to and health risks resulting from environmental PCBs.

4.0 PCB CLEANUP LEVELS

PCB-contaminated soil/sediments should be remediated to either 1) a default concentration of 1 mg/kg or part per million (**ppm**) *total PCBs* (defined as the sum of congeners, Aroclors or *homologues*⁸), 2) a risk-based generic screening level (see media-specific screening levels in Appendix A of Volume 1) or 3) a *site-specific risk-based PCB concentration level*⁹ established through performing a health risk evaluation. Site-specific risk-based PCB concentrations may be calculated from equations presented in *Risk Evaluation*. Once the calculations have been completed for all receptors, the lowest computed risk-based PCB concentration in a medium would represent the PCB remediation goal for that medium. These PCB remediation goals may be refined, if necessary, in the higher-level, site-specific risk assessment.

Table D-1 presents the corrective action cleanup options for the remediation of PCB-contaminated soil/sediments and data quality recommendations regarding the PCB analyses of environmental media samples.

⁶However, certain fungi have been demonstrated to degrade PCBs under aerobic conditions.

⁷Note that dechlorination is not synonymous with detoxification because it may result in the formation of carcinogenic congeners.

⁸A *homologue* is a subcategory of PCBs having an equal number of chlorine substituents. *Substituent* means an atom or group that replaces another atom or group in a molecule. PCB homologues can be quantified using EPA Method 680 or estimated using regression equations such as those found in NOAA, 1993.

⁹A *risk-based PCB concentration level* means the PCB concentration above which some adverse health effects may be produced in human and/or ecological receptors, and below which adverse health effects are unlikely to occur.

Table D-1. PCB Cleanup Options In Soil/Sediment and Data Quality Recommendations¹⁰

Cleanup Option	Corrective Action Steps		Data Quality Recommendations
Default Option 1	1	Delineate the nature and horizontal and vertical extent of contamination	Estimate total PCBs as the sum of Aroclors or homologues (using a quantitation limit of 50 parts per billion [ppb] or 1 ppb, respectively) in environmental media
	2	Remediate to 1 ppm	
	3	Conduct post-remediation monitoring, as necessary	
Default Option 2	1	Delineate the nature and horizontal and vertical extent of contamination	Estimate total PCBs as the sum of Aroclors or homologues (using a quantitation limit of 50 parts per billion [ppb] or 1 ppb, respectively) in environmental media
	2	Remediate to generic risk-based screening level (See Appendix A of Volume 1))	
	3	Conduct post-remediation monitoring, as necessary	
Site-Specific, Risk-Based	1	Delineate the nature and horizontal and vertical extent of contamination	Estimate total PCBs as the sum of Aroclors or homologues (using a quantitation limit of 50 ppb or 1 ppb, respectively) and/or congener-specific environmental and biota concentrations (using a quantitation limit in the low parts per trillion)
	2	Perform health risk evaluation	
	3	Establish risk-based concentrations for all human and environmental receptors	
	4	Remediate to the lowest risk-based concentration	
	5	Conduct post-remediation monitoring, as necessary	

The following is a listing of potential PCB target analytes¹¹. The 12 PCB congeners indicated in boldface italics are those which are recommended for quantitation as potential target analytes when performing a risk-based cleanup. The 16 additional congeners listed in plain text may provide valuable information, but are not required for the evaluation of risk. The analyses of all 209 congeners would greatly improve the estimate of total PCB concentrations.

¹⁰Modified from Valoppi, et al., 1999.

¹¹The number in parentheses refers to the identification system used to specify a particular congener.

Table D-2. Potential PCB Target Analytes

2,4'-Dichlorobiphenyl (8)	2,2',3,4,4',5'-Hexachlorobiphenyl (138)
2,2',5-Trichlorobiphenyl (18)	2,2',4,4',5,5'-Hexachlorobiphenyl (153)
2,4,4'-Trichlorobiphenyl (28)	2,3,3',4,4',5-Hexachlorobiphenyl (156)
2,2',3,5'-Tetrachlorobiphenyl (44)	2,3,3',4,4',5'-Hexachlorobiphenyl (157)
2,2',5,5'-Tetrachlorobiphenyl (52)	2,3',4,4',5,5'-Hexachlorobiphenyl (167)
2,3',4,4'-Tetrachlorobiphenyl (66)	3,3',4,4',5,5'-Hexachlorobiphenyl (169)
3,3',4,4'-Tetrachlorobiphenyl (77)	2,2',3,3',4,4',5-Heptachlorobiphenyl (170)
3,4,4',5-Tetrachlorobiphenyl (81)	2,2',3,4,4',5,5'-Heptachlorobiphenyl (180)
2,2',4,5,5'-Pentachlorobiphenyl (101)	2,2',3,4',5,5',6-Heptachlorobiphenyl (187)
2,3,3',4,4'-Pentachlorobiphenyl (105)	2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)
2,3,4,4',5-Pentachlorobiphenyl (114)	2,2',3,3',4,4',5,6-Octachlorobiphenyl (195)
2,3',4,4',5-Pentachlorobiphenyl (118)	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (206)
2',3,4,4',5'-Pentachlorobiphenyl (123)	2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (209)
3,3',4,4',5-Pentachlorobiphenyl(126)	2,2',3,3',4,4'-
Hexachlorobiphenyl (128)	

The 16 PCB congeners in plain text have been indicated as target analytes by the National Oceanic and Atmospheric Administration based on their toxicity, ubiquitousness in the marine environment, presence in commercial Aroclor mixtures, etc. (NOAA, 1993).

5.0 ANALYTICAL METHODS

Aroclors are often used to characterize PCB exposures; however, the use of Aroclors in estimating the human health or ecological risk can be both imprecise and inappropriate because the PCB mixtures to which humans and other biota may be exposed may be considerably different from the original Aroclor mixtures released to the environment. In addition, traditional analytical methods for Aroclor analyses produce estimates that are prone to errors. Both qualitative and quantitative errors may arise from interpreting gas chromatography (GC) data.

GCs configured with electron capture detectors (ECD) or electrolytic conductivity detectors (ELCD) are particularly prone to error. The GC/ECD and GC/ELCD produce a chromatogram that is compared with the characteristic chromatographic patterns of the different Aroclors (US EPA, 1996a). For environmentally weathered and altered mixtures, an absence of these characteristic patterns can suggest the absence of Aroclors even if some congeners are present in high concentrations. Additionally, and commonly, the presence of interferences may also mask the characteristic response pattern of the Aroclors. The “pattern recognition” technique is inherently subjective, and different analysts may reach different conclusions regarding the presence or absence of Aroclors.

GCs configured with mass spectral detectors (GC/MS) allow identification of individual chemical compounds. GC/MS also produces a chromatogram, and additionally includes mass spectral information about the chemical identity of each peak in the chromatogram. Therefore, GC/MS adds a qualitative line of evidence above that included in GC/ECD or GC/ELCD techniques. GC/MS may be subject to interference, misinterpretation, or other problems.

High resolution (**HR**) isotope dilution GC/high resolution MS (**HRGC/HRMS**), while not as common technique as GC-ECD or GC-MS, is a specific GC/MS technique that has proven reliable for PCB analysis. In HRGC/HRMS exhaustive sample clean-up techniques are employed, and isotopic tracers are used to support identification.

Therefore, the HWB recommends the use of HRGC/HRMS analyses in evaluating health risks to humans and the environment. If HRGC/HRMS methods are not employed, then site specific data must be used to demonstrate that the methods employed are appropriate to the site, or HRGC/HRMS confirmation must be integrated into the analytical plan, for instance on a one in 20 sample basis, or a for a minimum number of samples, or as otherwise agreed. Both detections and non-detections should be confirmed.

Results of GC techniques may be expressed as Aroclors, congeners, homologues, or as total PCBs in units of weight/weight [mg/kg, µg/kg, nanogram per kilogram (ng/kg)] or weight/volume [µg/L or pictogram per liter (pg/L)]. It is necessary to specify the reporting requirements prior to analysis and negotiate the analytical list and reporting limits. Results must be reported on a dry weight basis for soil, sediment and waste samples (excluding liquids).

In addition to the traditional GC analysis, a number of biological and immunological assays are now available, as well as field GC. These may be suited for use as screening methods to guide day-to-day remediation efforts, but are not suited to evaluating health risks to humans and the environment as stand-alone methodologies.

Table D-3. Analytical Methods for PCBs

Method	Technology	Report As ¹	Approximate Detection Limits	Comments
SW-846 8082A	GC/ECD or GC/ELCD	Aroclors Congeners	50-100 µg/kg	Must supply site-specific performance data or use HRGC/HRMS confirmation
SW-8270D	GC/MS	Aroclors	>1000 µg/kg ²	Detection limits may not support project data quality objectives
SW-846 8275A	GC/MS	Congeners	200 µg/kg	
Method 1668B	HRGC/HRMS	Congeners	<1µg/kg, often in the ng/kg range ²	Use this method for confirmation

NOTES:
¹Reporting types have been limited to those mentioned in the subject methods. Laboratories may offer additional reporting modalities, such as homologues and total PCBs.
²Detection Limits not specified in the method. Various sample preparation options and matrix effects may affect results

6.0 STORM WATER RUNOFF MONITORING RECOMMENDATIONS

The potential for transport to human or ecological receptors (including ground and surface water) should be evaluated for all corrective action sites impacted or suspected of being impacted by PCBs. PCB concentrations in storm water runoff resulting from contaminated soil/sediments should be monitored **and** the soils remediated to ensure that there is no release or runoff from the Solid Waste Management Unit (SWMU) or Area of Concern (AOC) which results in a total PCB concentration in excess of the State of New Mexico Human Health-Organism Only criterion of 0.00064 ug/L¹² (unfiltered water) to a *water of the State*.¹³ Likewise, concentrations of PCB-contaminated stream bottom, lake or reservoir deposits should not result in total PCB concentrations in unfiltered water which exceeds the State of New Mexico Human Health-Organism Only criterion of 0.00064 ug/L.

The evaluation of a site's PCB concentrations and erosion potential will aid in determining and prioritizing the corrective actions and best management practices (BMPs) necessary to protect surface water quality. Each facility should develop a method for evaluating the erosion potential¹⁴ and present the methodology to the NMED HWB for approval prior to implementation. This evaluation should be conducted on all known or suspected PCB sites. All PCB sites with elevated erosion potentials should implement BMPs to reduce transport of PCB-contaminated sediments and soils. BMP effectiveness should be evaluated and monitored regularly through a formalized inspection and maintenance program. BMPs should be implemented as interim actions or stabilization measures which are consistent with a final remedy and should not be misconstrued as a final remedy.

NMED's HWB believes that controlling the suspended sediment concentration (SSC) load of storm water runoff may effectively control PCB migration in surface water because PCBs are hydrophobic, tend to adsorb to soil and organic particles, and are transported in suspended sediments during storm runoff events. Therefore, the SSC should be monitored to aid in predicting and, therefore, potentially controlling the transport of PCBs into *watercourses*¹⁵.

Storm water samples should be collected from storm water events which are greater than 0.1 inches in magnitude (US EPA, 1992) in 30 minutes. Grab samples should be collected within the first 30 minutes or as soon as practical, but not more than 1 hour after runoff discharge begins. A sufficient quantity of runoff should be collected (i.e., 3 liters) because additional analyses for PCBs may be required based upon the TSS analytical results. The runoff samples should be analyzed for SSC using ASTM D3977 - 97(2007) Standard Test Methods for Determining Sediment Concentration in Water Samples..

¹²This concentration is the [numeric](http://ftp.nmenv.state.nm.us/www/swqb/Standards/2011/20.6.4NMAC-IntegratedStandards-CWAStatus2011-04-18.pdf) criteria for HH-OO of 0.00064 approved by both the New Mexico Water quality Control Commission and EPA. <http://ftp.nmenv.state.nm.us/www/swqb/Standards/2011/20.6.4NMAC-IntegratedStandards-CWAStatus2011-04-18.pdf>

¹³*Water(s) of the State* means all interstate and intrastate water including, natural ponds and lakes, playa lakes, reservoirs, perennial streams and their tributaries, intermittent streams, sloughs, prairie potholes and wetlands (Title 20 New Mexico Annotated Code Chapter 6.1).

¹⁴NMED HWB recommends the approach to evaluating erosion potential presented in the *Matrix Approach to Contaminant Transport Potential* (Mays and Veenis, 1998).

¹⁵*Watercourse* means any river, creek, arroyo, canyon, draw, or wash, or any other channel having definite banks and beds with visible evidence of the occasional flow of water (Title 20 New Mexico Annotated Code Chapter 6.1).

Grab samples should be used for monitoring. Composite samples may **not** be used for monitoring; however, flow-weighted composite samples may be used in the development and validation of storm water contaminant transport modeling.

The likelihood of a remediated site to discharge stormwater should be evaluated prior to choosing the default remediation concentration of 1 mg/kg (ppm). If a site is remediated to the default concentration of 1 mg/kg, **any** detectable levels of suspended sediment in stormwater discharges will most likely result in an exceedance of the surface water quality criteria of 0.00064 ug/L. Table D-4 demonstrates the levels of suspended sediment for various remediation concentrations that if exceeded, will result in an exceedance of the criteria:

Table D-4. Allowable Suspended Sediment Concentrations in Stormwater Runoff from Sites Remediated to Various PCB in Soil Concentrations

Remediation Level mg/kd (ppm)	Allowable SSC Concentration in Stormwater Runoff from Remediated Site mg/L (ppm)	Resulting Total PCB in Water ug/L (ppb)
0.00005	<12,800	<0.00064
0.0001	<6,400	<0.00064
0.001	<640	<0.00064
0.01	<64	<0.00064
0.1	<6.4	<0.00064
1	<.64	<0.00064

The following bullets describe recommended trigger levels and actions based on the analytical results of SSC analyses:

- If SSC is less than 1 mg/L or below the ASTM D3977 – 97 method reporting limit, no action is required.
- If SSC is greater than 1 mg/L the effectiveness of existing BMPs should be evaluated and repaired as necessary, and additional BMPs may need to be implemented to reduce SSC loading. The remaining aliquot of stormwater should be analyzed for PCBs using EPA Method 1668C¹⁶ to verify compliance with the NM HH-OO criteria.

7.0 RISK EVALUATION

The risk to human health and the environment must be evaluated for all corrective action *solid waste management units/areas of contamination*¹⁷ (SWMU/AOCs) impacted or suspected of

¹⁶ The Method can be found at the following link: http://water.epa.gov/scitech/methods/cwa/upload/M1668C_11June10-PCB_Congeners.pdf

¹⁷SWMU means “any discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at a facility at which solid wastes have been routinely and systematically released.” AOC “...refers to releases which warrant investigation or remediation under the authorities discussed above, regardless of whether they are associated with a specific SWMU...”

being impacted by PCBs and having a potential for transport to a human or ecological receptor. The risk posed by PCBs at these SWMU/AOCs may be modeled (based on adequate available data) and should be monitored to ensure an acceptable level of risk¹⁸ (see *Storm Water Runoff Monitoring Recommendations*).

As discussed in *Environmental Processes*, the congener composition of environmentally-aged PCBs can dramatically differ from the original Aroclor mixture released to the environment. Consequently, environmental processes can affect both exposure to, and toxicity of, environmental PCBs. Therefore, the approach to evaluating health risks from environmental PCBs differs depending upon whether the PCB congener- or Aroclor-specific (or homologue-specific) data are available for the environmental media (see also *PCB Cleanup Levels*).

PCB congeners with chlorine atoms in positions 2 and 6 (ortho) are generally more readily metabolized, while those with chlorines in positions 4 and 4' (para) or positions 3, 4 or 3, 4, 5 on one or both rings tend to be more toxic and are retained mainly in fatty tissues (Eisler, 1986). Persistent congeners may retain biological activity long after the exposure. The most toxic PCB congeners can assume a conformation, generally similar to that of 2, 3, 7, 8-tetrachloro-dibenzo-dioxin (**TCDD**), and are approximate stereo analogs of this compound (Hoffman, et al., 1996).

These dioxin-like congeners share a common mechanism of toxicity involving binding to the aryl hydrocarbon receptor; the same mechanism of action is believed to induce the toxicity of PCDDs and PCDFs. These congeners were assigned toxicity equivalency factors (**TEFs**) expressed as a fraction of the toxicity of 2,3,7,8-TCDD. Therefore, when PCB congener-specific analytical data are available, risk evaluation of human and ecological health should consider both dioxin-like and other adverse health effects. Two sections within this document (*Human Health, Carcinogenic Effects, Dioxin-like Toxicity Approach* and *Ecological Health, Dioxin-like PCBs*) provide guidance for applying these TEFs where congener-specific analyses are available. If only Aroclor/homologue concentrations are available for a site, total PCB concentrations reported as the sum of Aroclor/homologue concentrations should be used to estimate the risk to human health and the environment.

If a health risk evaluation is based on total PCB concentrations (estimated as the sum of Aroclors or PCB homologues) and the individual congeners comprising the PCB mixtures cannot be identified, the uncertainty and potential bias in the resulting risk estimates should be described in the risk assessment report. For example, if total PCB concentrations have been estimated based on Aroclor analyses, conservative assumptions should be made about the mixture composition and toxicity: the assumption that congeners with greater than four chlorines per PCB molecule comprise greater than 0.5% of total PCBs present in a given abiotic medium at the site triggers the selection of the highest cancer slope factor from Table D-3. Whereas, total PCB concentrations estimated based on the results of PCB homologue analyses may allow for a refinement of these conservative assumptions. More detailed information on an approach to evaluating the health risk from environmental PCBs and PCB data requirements can be found in US EPA (1996b); Van den Berg, et al. (1998); Cogliano (1998); Giesy and Kannan (1998) and Valoppi, et al. (1999).

¹⁸A risk or hazard is considered *acceptable* if an estimated risk/hazard is below pre-established target risk and/or hazard levels.

7.1 Human Health

Since PCBs may cause both carcinogenic and non-carcinogenic adverse human health effects, separate risk assessments must be performed for each of these health effects.

7.1.1 *Carcinogenic Effects*

The evaluation of carcinogenic risk from exposure to PCB mixtures (i.e., represented by total PCBs or PCB congeners) should follow the slope factor approach described in *PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures* (US EPA, 1996b) and as outlined below. This approach distinguishes among toxic potencies of different PCB mixtures by utilizing information regarding environmental processes. In the absence of PCB congener- or homologue-specific analyses (i.e., if total PCB concentrations were estimated based on Aroclor analyses), this approach requires conservative assumptions about the risk and persistence of PCB mixtures at the site.

If congener-specific concentrations are available and congener analyses indicate that congeners with more than 4 (four) chlorines comprise greater than 0.5 percent of total PCBs in a given medium, the slope factor approach should be supplemented by the analysis of dioxin toxicity equivalency quotient (TEQ). Risk from *dioxin-like congeners*¹⁹ should be added to the risk estimated for the rest of the PCB mixture which does not exhibit dioxin-like toxicity.

If other dioxin-like compounds (i.e., PCDDs and/or PCDFs) are present at a site in addition to PCBs, TEQs for dioxin-like PCBs should be added to TEQs calculated for those other dioxin-like compounds to yield a total TEQ. A slope factor for 2,3,7,8-TCDD should be applied to this total TEQ. Under these circumstances, the concentrations of dioxin-like PCBs should be subtracted from the total PCB concentration to avoid overestimating risks from dioxin-like PCBs by evaluating them twice.

7.1.1.1 Slope Factor Approach

Site-specific carcinogenic risk evaluations should be performed using PCB cancer potency or slope factors specific to the exposure scenarios and pathways at a particular site. Table D-3 provides the criteria for using these slope factors (categorized into high, medium, and low levels of risk and PCB persistence) that address a variety of exposure scenarios and the toxicity of PCB mixtures in the environment. A review of recent research on PCB toxicity that formed the basis for the derivation of these slope factors and a discussion of uncertainties surrounding toxicity information can be found in US EPA (1996b) and Cogliano (1998).

The slope factors in Table D-4 represent the upper-bound slopes that are recommended for evaluating human health risk from carcinogenic effects of PCBs. Both the upper-bound and

¹⁹*Dioxin-like congeners* of PCBs are those with dioxin-like health effects and are evaluated using dioxin TEQs (Van den Berg, et al., 1998 and Van den Berg, et al., 2006). A complete listing of PCB congeners can be found at <http://www.epa.gov/osw/hazard/tsd/pcbs/pubs/congenertable.pdf>

central-estimate slopes are available from the US EPA’s Integrated Risk Information System (IRIS). The central-estimate slopes can be used to support the analysis of uncertainties inherent in available toxicity information on PCBs.

Table D-4. PCB Cancer Slope Factor Values by Level of Risk and Persistence²⁰

CRITERIA FOR USE	LEVEL OF RISK AND PERSISTENCE	PCB CANCER SLOPE FACTOR VALUES ²¹ [risk per mg/kg-day]
Food chain exposure	High	2.0
Sediment/soil ingestion		
Dust/aerosol inhalation		
Dermal exposure (if an absorption factor has been applied)		
Presence of dioxin-like, tumor-promoting, or persistent congeners		
Early-life (less than 6 years old) exposure by all pathways and to all mixtures		
Congeners with greater than four chlorines per PCB molecule comprise greater than 0.5% of the total PCBs present		
Congeners with greater than four chlorines per PCB molecule comprise less than 0.5% of the total PCBs present (all pathways except soil ingestion by adults)		
Ingestion of water-soluble (less chlorinated) congeners	Medium	0.4
Inhalation of evaporated (less chlorinated) congeners		
Dermal exposure (if no absorption factor has been applied)		
Congeners with greater than four chlorines per PCB molecule comprise less than 0.5% of the total PCBs present (soil ingestion by adults only)	Low	0.07

The cancer slope factors in Table D-3 characterize the toxic potency of different environmental mixtures of PCBs. Information on potential exposure pathways and PCB mixture composition at a given site guides in the selection of the appropriate cancer slope factors for risk assessment.

²⁰Modified from Cogliano, 1998 and US EPA, 1996b and 1998c.

²¹See IRIS (US EPA, 2011).

The highest slope factor in Table D-3 (2.0 per mg/kg-day) corresponds to the high risk and persistence of environmental PCB mixtures and, as such, should be selected for pathways (including food chain exposures, ingestion of soil and sediment, inhalation of dust or aerosol, exposure to dioxin-like, tumor-promoting or persistent congeners, and early-life exposure) where environmental processes act to increase risk.

A lower slope factor (0.4 per mg/kg-day) corresponds to the low risk and persistence of environmental PCB mixtures and is appropriate for exposure pathways (such as ingestion of water-soluble congeners and inhalation of evaporated congeners) where environmental processes act to decrease risk.

Finally, the lowest slope factor in Table D-3 (0.07 per mg/kg-day) corresponds to the lowest risk and persistence of environmental PCB mixtures and should be selected for soil ingestion by adults when congener or homologue analyses confirm that congeners with greater than four chlorine atoms per PCB molecule comprise less than 0.5% of the total PCBs present at the site.

Once the appropriate slope factor has been selected, it is multiplied by a lifetime average daily dose (**LADD**) to estimate the risk of cancer (see US EPA, 1996b for sample risk calculations). Because the use of Aroclors to characterize PCB exposures can be both imprecise and inappropriate, total PCBs or congener analyses should be used in the following LADD calculation:

$$\mathbf{LADD = (C_T \times IR \times ED \times EF) / (BW \times AT)} \qquad \text{Equation D-1}$$

Where:

- LADD = Lifetime average daily dose (mg/kg-day)
- C_T = Total PCBs or total non-dioxin-like congener concentration in a medium (mg/L [water], mg/kg [soil], or milligram per cubic meter (mg/m³) [air])
- IR = Intake rate (L/day [water], mg/day [soil], or mg/m³ [air])
- ED = Exposure duration (years)
- EF = Exposure frequency (days/year)
- BW = Average body weight of the receptor over the exposure period (kg)
- AT = Averaging time - the period over which exposure is averaged (days)²²

The cancer slope factors and recommended Aroclor fate and transport properties (Table D-5), should be used to evaluate the carcinogenic risk posed by PCB mixtures or PCB congeners which do not exhibit a dioxin-like toxicity.

²²For carcinogens, the averaging time is 25,550 days based on a lifetime exposure of 70 years.

Table D-5. Cancer Slope Factors and Fate & Transport Properties For PCBs

	CRITERIA: Congeners with equal to or greater than four (4) chlorines comprise . . .	CARCINOGENIC EFFECTS	
		Dioxin-like PCBs	Other PCB Congeners²³
CANCER SLOPE FACTORS²⁴ (mg/kg-day)⁻¹	. . . greater than 0.5% of the total PCBs present	1.3E+05 ²⁵	2.0
	. . . less than 0.5% of the total PCBs present	NA ²⁶	0.07
FATE & TRANSPORT PROPERTIES	. . . greater than 0.5% of the total PCBs present	Aroclor 1254	Aroclor 1254
	. . . less than 0.5% of the total PCBs present	Aroclor 1016	Aroclor 1016

For example, if a PCB mixture contains 45% congeners with greater than four chlorines, the cancer slope factor for 2,3,7,8-TCDD and the fate and transport properties of Aroclor 1254 would be used.

If the following special exposure conditions exist, a slope factor of 0.4 may be applied to PCBs which do not exhibit dioxin-like toxicity: ingestion of water-soluble congeners, inhalation of evaporated congeners or dermal exposure (with no applied absorption factor).

7.1.1.2 Dioxin-like Toxicity Approach

Dioxin-like PCBs are some of the moderately chlorinated PCB congeners (see Table D-5) which have been demonstrated to produce dioxin-like effects²⁷ in humans. The dioxin-like toxicity approach should be implemented **only** when congener-specific concentrations are available for environmental media at a site. In this approach, individual dioxin-like PCB congener concentrations are multiplied by TEFs that represent the potency of a given congener relative to 2,3,7 8-TCDD (see Table 2-2 in Volume I).

²³Other PCB congeners mean those congeners which do not exhibit dioxin-like toxicity.

²⁴PCB cancer slope factors can be found in IRIS (US EPA, 2010).

²⁵US EPA, 2011

²⁶NA means not applicable. Do not evaluate dioxin-like PCBs if they comprise less than 0.5% of the total PCBs present; evaluate the other PCB congeners.

²⁷Dioxin-like congeners can react with the aryl hydrocarbon receptor, the toxicity mechanism that is believed to initiate the adverse effects of PCDDs and PCDFs.

Table 2-2 of Volume I lists the TEF values derived for dioxin-like PCB congeners. Using TEF values in the risk evaluation allows for the estimation of a combined risk resulting from an exposure to a mixture of dioxin-like PCB congeners (assuming that the risks are additive).

The carcinogenic risk resulting from exposure to dioxin-like PCBs should be estimated by calculating the TEQ. The TEQ is the sum of each congener-specific concentration in the medium multiplied by its corresponding congener-specific TEF value. Multiplying the congener-specific medium concentration by the corresponding congener-specific TEF value provides a relative (i.e., “toxicity-weighted”) measure of the dioxin concentration within a medium.

The TEQ for dioxin-like PCBs should be calculated as indicated in the following equation:

$$\text{TEQ} = \Sigma (\text{C}_{\text{mi}} \times \text{TEF}_i) \quad \text{Equation D-2}$$

Where:

- TEQ = Toxicity equivalency quotient (mg/L [water] or mg/kg [soil or sediment])
- C_{mi} = Concentration of *i*th congener in medium (mg/L [water] or mg/kg [soil or sediment])
- TEF_i = Toxicity equivalency factor for *i*th congener (unitless)

Once the dioxin TEQ has been determined, the LADD should be calculated using the following equation:

$$\text{LADD} = (\text{TEQ} \times \text{IR} \times \text{ED} \times \text{EF}) / (\text{BW} \times \text{AT}) \quad \text{Equation D-3}$$

Where:

- LADD = Lifetime average daily dose (mg/kg-day)
- TEQ = Toxicity equivalency quotient (mg/L [water], mg/kg [soil], or mg/m³ [air])
- IR = Intake rate (L/day [water], mg/day [soil], or mg/m³ [air])
- ED = Exposure duration (years)
- EF = Exposure frequency (days/year)
- BW = Average body weight of the receptor over the exposure period (kg)
- AT = Averaging time - the period over which exposure is averaged (days)

The following equation can be used to estimate carcinogenic risk from dioxin-like PCBs:

$$\text{Cancer Risk} = \text{LADD} \times \text{CSF}_{\text{TCDD}} \quad \text{Equation D-4}$$

Where:

- LADD = Lifetime average daily dose (mg/kg-day)
- CSF_{TCDD} = Cancer slope factor for 2,3,7,8-TCDD²⁸

²⁸The cancer slope factor for 2,3,7,8-TCDD should be obtained from the most recent IRIS (US EPA, 2010) or HEAST (US EPA, 1997b). The current oral cancer slope factor for 2,3,7,8-TCDD of 1.3E+05 (mg/kg-day)⁻¹ is based on the administered dose from a 105-week dietary rat study and was adopted for inhalation exposure (US EPA, 2011).

7.1.2 Non-Carcinogenic Effects

For Aroclors having reference doses (**RfDs**) specified in IRIS (e.g., Aroclor 1254, 1016, etc.), the non-carcinogenic risk should also be evaluated. The evaluation of non-carcinogenic risk should follow the approach typical for other non-PCB chemicals. However, fate and transport properties of the recommended Aroclor (see Table D-6) should be used to evaluate the risk posed.

Table D-6. Toxicological and Fate & Transport Properties For PCBs With Human Health Non-Carcinogenic Effects and Ecological Health Non-Dioxin-Like Effects

CRITERIA: Congeners with equal to or greater than four (4) chlorines comprise ...	NON-CARCINOGENIC EFFECTS AND FATE AND TRANSPORT PROPERTIES
... greater than 0.5% of the total PCBs present	Aroclor 1254
... less than 0.5% of the total PCBs present	Aroclor 1016

The RfD derived for Aroclor 1254 should typically be used when conducting a risk assessment. The RfD derived for Aroclor 1016 can be used when at least 99.5% of the mass of the PCB mixture has fewer than four (4) chlorine atoms per molecule as determined by a chromatography/spectroscopy analytical method. Using Table D-6, determine which Aroclor most accurately represents the PCB mixture of concern. Use the RfD and fate and transport properties of this Aroclor as a surrogate to evaluate the non-carcinogenic effects of the PCB mixture.

7.2 Ecological Health

Since PCBs adversely impact both community- and class-specific guild measurement receptors, risks must be estimated for each receptor within both groups. Plants and invertebrates should be evaluated as community measurement receptors (see *Exposure Assessment for Community Measurement Receptors*).

When congener-specific concentrations are available, risk from exposure to dioxin-like PCBs should be estimated separately and added to the risk estimated for the remainder of the PCB mixture which does not exhibit dioxin-like toxicity. The resulting risk is likely to be overestimated if toxicity data from total PCBs is applied to those congeners which do not exhibit dioxin-like toxicity. This overestimation of risk should be addressed within the uncertainty analysis of the risk assessment report.

In the absence of PCB congener-specific data, total PCB concentrations, reported as the sum of Aroclor or homologue concentrations, should be used to estimate receptor exposure to PCBs and the toxicity value of the most toxic Aroclor present should be used in the site-specific ecological risk assessment.

7.2.1 Dioxin-like PCBs

Ecological risks to community- and class-specific guild measurement receptors from dioxin-like PCBs should be estimated by calculating a TEQ and then dividing it by the toxicity value for 2,3,7,8-TCDD (which is assumed to be the most toxic dioxin).

If in addition to PCBs, other dioxin-like compounds (i.e., PCDDs and/or PCDFs) are present at a site, TEQs for dioxin-like PCBs should be added to the TEQs calculated for those other dioxin-like compounds to yield a total TEQ. The 2,3,7,8-TCDD toxicity value should be applied to this total TEQ. For this evaluation, the concentrations of dioxin-like PCBs should be subtracted from the total PCB concentrations to avoid overestimating risks from dioxin-like PCBs by evaluating them twice.

The TEF values listed in Table 2-1 of Volume I and in Table D-7 below should be used in the TEQ calculation to convert the exposure media concentration of individual congeners to a relative measure of concentration within a medium.

Table D-7. Fish Toxicity Equivalency Factor Values For Dioxin-Like PCBs²⁹

CONGENER	FISH TOXICITY EQUIVALENCY FACTOR VALUES ³⁰
3,3',4,4'-Tetrachlorobiphenyl (77) ¹¹	0.0001
3,4,4',5-Tetrachlorobiphenyl (81)	0.0005
2,3,3',4,4'-Pentachlorobiphenyl (105)	<0.000005 ³¹
2,3,4,4',5-Pentachlorobiphenyl (114)	<0.000005
2,3',4,4',5-Pentachlorobiphenyl (118)	<0.000005
2',3,4,4',5'-Pentachlorobiphenyl (123)	<0.000005
3,3',4,4',5-Pentachlorobiphenyl (126)	0.005
2,3,3',4,4',5-Hexachlorobiphenyl (156)	<0.000005
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	<0.000005
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	<0.000005
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	<0.000005
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	<0.000005

Because congener-specific fate and transport data are not available for each of the dioxin-like PCBs listed in Table 2-1 of Volume I and Table D-7, the fate and transport properties of Aroclor 1254 should be used in exposure modeling.

7.2.1.1 Exposure Assessment for Community Measurement Receptors

To evaluate the exposure of water, sediment and soil communities to dioxin-like PCBs, a media-specific TEQ should be calculated. The TEQ is the sum of each congener-specific concentration (in the respective media to which the community is exposed) multiplied by its corresponding congener-specific TEF value derived for fish (Table D-7).

The TEQ for community measurement receptors exposed to dioxin-like PCBs should be calculated as indicated in the following equation:

$$\text{TEQ} = \Sigma (\text{C}_{\text{mi}} \times \text{TEF}_i) \quad \text{Equation D-5}$$

Where:

²⁹Modified from the *Report from the Workshop on the Application of 2,3,7,8-TCDD Toxicity Equivalency Factors to Fish and Wildlife* (US EPA, 1998b).

³⁰The surrogate TEF values for fish are presented because invertebrate-specific TEF values have not yet been developed.

³¹For all fish TEFs of "<0.000005," use the value of 0.000005 as a conservative estimate.

- TEQ = Toxicity equivalency quotient ($\mu\text{g/L}$ [water] or $\mu\text{g/kg}$ [dry weight soil or sediment])
- C_{mi} = Concentration of *i*th congener in abiotic media ($\mu\text{g/L}$ [water] or $\mu\text{g/kg}$ [dry weight soil or sediment])
- TEF_i = Toxicity equivalency factor (fish) for *i*th congener (unitless) (Table D-7)

Risk to the water, sediment or soil community is subsequently evaluated by comparing the media-specific TEQ to the media-specific toxicity value for 2,3,7,8-TCDD:

$$\text{Risk} = \text{TEQ} / \text{TRV}_{\text{TCDD}} \quad \text{Equation D-6}$$

where:

- TEQ = Toxicity equivalency quotient ($\mu\text{g/L}$ [water] or $\mu\text{g/kg}$ [dry weight soil or sediment])
- TRV_{TCDD} = Toxicity reference value for 2,3,7,8-TCDD ($\mu\text{g/L}$ [water] or $\mu\text{g/kg}$ [dry weight soil or sediment])

7.2.1.2 Exposure Assessment for Class-Specific Guild Measurement Receptors

To evaluate the exposure of class-specific guild measurement receptors to dioxin-like PCBs, congener-specific daily doses of food items (i.e., abiotic media, plants, animals, etc.) ingested by a measurement receptor (DD_i) should be converted to a TEQ-based daily dose (DD_{TEQ}). This DD_{TEQ} can subsequently be compared to the 2,3,7,8-TCDD toxicity values for an evaluation of the risk posed to class-specific guild measurement receptors.

The DD_{TEQ} for each measurement receptor should be calculated as shown in the following equation:

$$\text{DD}_{\text{TEQ}} = \sum \text{DD}_i \times \text{TEF}_{\text{MR}} \quad \text{Equation D-7}$$

Where:

- DD_{TEQ} = Daily dose of PCB TEQ ($\mu\text{g/kg}$ fresh body weight-day)
- DD_i = Daily dose of *i*th congener ($\mu\text{g/kg}$ fresh body weight-day)
- TEF_{MR} = Toxicity equivalency factor (specific to measurement receptor) (unitless) (Table D-8)

Risk to the class-specific guild being evaluated can be estimated by dividing the DD_{TEQ} by the toxicity reference value for 2,3,7,8-TCDD:

$$\text{Risk} = \text{TEQ} / \text{TRV}_{\text{TCDD}} \quad \text{Equation D-8}$$

³²The congener-specific daily doses of food items ingested by a measurement receptor should be calculated in accordance with the most current EPA and/or State guidance.

Where:

DD_{TEQ} = Daily dose of PCB TEQ ($\mu\text{g}/\text{kg}$ fresh body weight-day)
 TRV_{TCDD} = Toxicity reference value for 2,3,7,8-TCDD ($\mu\text{g}/\text{kg}$ fresh body weight-day)

7.2.2 Other PCB Congeners

In addition to the dioxin-like PCB congeners, the remaining PCBs should be evaluated like other bioaccumulating organic contaminants by assessing ecological risks to community- and class-specific guild measurement receptors. The fate and transport properties of Aroclor 1254³³ should be used in the exposure modeling when evaluating the risk from PCB mixtures containing congeners with equal to or greater than 4 chlorines in quantities **greater** than 0.5% of the total PCBs. And, the fate and transport properties of Aroclor 1016³⁴ should be used in the exposure modeling when evaluating risks from PCB mixtures containing **less** than 0.5 % of PCB congeners with more than 4 chlorines (see Table D-6).

8.0 CONCLUSION

PCBs, which are a class of organic compounds that are persistent in the environment, are toxic to both humans and biota. PCBs may in certain instances become contaminated with more toxic PCDFs and PCDDs. Therefore, the potential presence of these compounds should also be evaluated and possibly investigated.

Based on federal and state regulations and standards, the HWB recommends that PCB-contaminated sediment/soils be remediated to either 1 mg/kg total PCBs or the most stringent of the calculated health risk-based concentrations in order to adequately protect human health and the environment.

Unless soil/sediments are remediated to 1 mg/kg total PCBs, the risk posed by PCBs to human health and the environment should be evaluated using a risk-based approach. All corrective action SWMU/AOCs impacted or suspected of being impacted by PCBs and having a potential for transport to a human or ecological receptor should be evaluated and monitored, as necessary, to protect human health and the environment.

PCB concentrations in soil/sediments should also be protective of both surface water and ground water resources; PCB concentrations in surface water should not exceed 0.00064 $\mu\text{g}/\text{L}$ and PCB concentrations in ground water cannot exceed 0.5 $\mu\text{g}/\text{L}$ (drinking water) or 1 $\mu\text{g}/\text{L}$ in ground water with 10,000 mg/L or less total dissolved solids).

³³Approximately 77% of Aroclor 1254 is composed of PCB congeners with more than 4 chlorines.

³⁴Approximately 99% of Aroclor 1016 is comprised of PCB congeners with 4 or less chlorines.

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VOLUME 2

**TIER 1: SCREENING-LEVEL ECOLOGICAL RISK
ASSESSMENT**

**PHASE I
Scoping Assessment**

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Attachments

- Attachment A: Screening Level Ecological Risk Assessment Scoping Assessment Site Assessment Checklist
- Attachment B: Ecological Site Exclusion Criteria Checklist and Decision Tree

Acronymns and Abbreviations

AUF	Area Use Factor
bgs	below ground surface
COPEC	Constituent of Potential Ecological Concern
ft	foot
GAERPC	Guidance for Assessing Ecological Risks Posed by Chemicals
HI	Hazard Index
HQ	Hazard Quotient
kg	kilogram
LOAEL	Lowest-observed adverse effect level
LULC	land use and land cover
mg	milligram
NMED	New Mexico Environment Department
NOAEL	No-observed adverse effect level
PCSEM	Preliminary Conceptual Site Exposure Model
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
T&E	Threatened and Endangered
TRV	Toxicity Reference Value
US EPA	United States Environmental Protection Agency

1.0 INTRODUCTION

The purpose of an ecological risk assessment is to evaluate the potential adverse effects that chemical contamination has on the plants and animals that make up ecosystems. The risk assessment process provides a way to develop, organize and present scientific information so that it is relevant to environmental decisions.

The New Mexico Environment Department Hazardous Waste Bureau (NMED) has developed a tiered procedure for the evaluation of ecological risk. This procedure is outlined in the *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment* (GAERPC) (NMED, 2000). Briefly, the tiers of the procedure are organized as follows:

TIER 1: PHASE I - QUALITATIVE ASSESSMENT

- Scoping Assessment
- Screening Assessment

TIER 2: PHASE II - QUANTITATIVE ASSESSMENT

- Site-Specific Ecological Risk Assessment

As discussed above and illustrated in Figure 1, the Scoping Assessment is the first phase of the Tier I Screening-Level Ecological Risk Assessment process as defined by the NMED GAERPC. This document provides specific procedures to assist the facility in conducting the first step (Scoping Assessment) of the Tier I, Screening-Level Ecological Risk Assessment process outlined in the GAERPC. The purpose of the Scoping Assessment is to gather information, which will be used to determine if there is “any reason to believe that ecological receptors and/or complete exposure pathways exist at or in the locality of the site” (NMED, 2000). The scoping assessment step also serves as the initial information-gathering phase for sites clearly in need of a more detailed assessment of potential ecological risk. This document outlines the methodology for conducting a Scoping Assessment, and includes a Site Assessment Checklist (Attachment A), which serves as tool for gathering information about the facility property and surrounding areas. Although the GAERPC provides a copy of the US Environmental Protection Agency (US EPA) Checklist for Ecological Assessment/Sampling (US EPA, 1997), the attached Site Assessment Checklist provides an expanded, user-friendly template, which both guides the user as to what information to collect and furnishes an organized structure in which to enter the information.

After the Site Assessment Checklist has been completed, the assessor must use the collected information to generate a Scoping Assessment Report and Preliminary Conceptual Site Exposure Model (PCSEM). Guidance for performing these tasks is provided in this document, and in the GAERPC. The Scoping Assessment Report and PCSEM are subsequently used to address the first in a series of Technical Decision Points of the tiered GAERPC process. Technical Decision Points are questions which must be answered by the assessor after the completion of certain phases in the process. The resulting answer to the question determines the next step to be

undertaken by the facility. The first Technical Decision Point, as illustrated in Figure 1, is to decide: *Is Ecological Risk Suspected?*

If the answer to the first Technical Decision Point is “no” (that is, ecological risk is not suspected), the assessor may use the Exclusion Criteria Checklist and Decision Tree (Attachment B) to help confirm or deny that possibility. However, it is unlikely that any site containing potential ecological habitat or receptors will meet the Site Exclusion Criteria.

If ecological risk is suspected, the facility will usually be directed to proceed to the next phase of Tier I, which is a Screening Level Ecological Risk Assessment (SLERA). A SLERA is a simplified risk assessment that can be conducted with limited site-specific data by defining assumptions for parameters that lack site-specific data (US EPA, 1997). Values used for screening are consistently biased in the direction of overestimating risk to ensure that sites that might pose an ecological risk are properly identified. The completed Site Assessment Checklist is a valuable source of information needed for the completion of the SLERA. Instructions for performing a SLERA can be found in the GAERPC and in a number of EPA guidance documents (e.g., US EPA, 1997; US EPA, 1998).

2.0 SCOPING ASSESSMENT

The Scoping Assessment serves as the initial information gathering and evaluation phase of the Tier I process. A Scoping Assessment consists of the following steps:

- Compile and Assess Basic Site Information (using Site Assessment Checklist)
- Conduct Site Visit
- Identify Preliminary Contaminants of Potential Ecological Concern
- Develop a Preliminary Conceptual Site Exposure Model
- Prepare a Scoping Assessment Report

The following subsections provide guidance for completing each step of the Scoping Assessment. For additional guidance, readers should refer to the GAERPC (NMED, 2000).

2.1 Compile and Assess Basic Site Information

The first step of the Scoping Assessment process is to compile and assess basic site information. Since the purpose of the Scoping Assessment is to determine if ecological habitats, receptors, and complete exposure pathways are likely to exist at the site, those items are the focus of the information gathering. The Site Assessment Checklist (Attachment A) should be used to complete this step. The questions in the Site Assessment Checklist should be addressed as completely as possible with the information available before conducting a site visit.

In many cases, a large portion of the Site Assessment Checklist can be completed using reference materials and general knowledge of the site. A thorough file search should be conducted to compile all potential reference materials. Resource Conservation and Recovery Act (RCRA)

Facility Assessment (RFA) and Facility Investigation (RFI) reports, inspection reports, RCRA Part B Permit Applications, and facility maps can all be good sources of the information needed for the Site Assessment Checklist.

Habitats and receptors which may be present at the site can be identified by contacting local and regional natural resource agencies. Habitat types may be determined by reviewing land use and land cover maps (LULC), which are available via the Internet at <http://www.nationalatlas.gov/scripts>. Additional sources of general information for the identification of ecological receptors and habitats are listed in the introduction section of the Site Assessment Checklist (Attachment A).

After all available information has been compiled and entered into the Site Assessment Checklist, the assessor should review the checklist and identify data gaps. Plans should then be made to obtain the missing information by performing additional research and/or by observation and investigation during the site visit.

2.2 Site Visit

When performing a Scoping Assessment, at least one site visit should be conducted to directly assess ecological features and conditions. As discussed in the previous section, completion of the Site Assessment Checklist should have begun during the compilation of basic site information. The site visit allows for verification of the information obtained from the review of references and other information sources. The current land and surface water usage and characteristics at the site can be observed, as well as direct and indirect evidence of receptors. In addition to the site, areas adjacent to the site and all areas where ecological receptors are likely to contact site-related chemicals (i.e., all areas which may have been impacted by the release or migration of chemicals from the site) should be observed or visited and addressed in the Site Assessment Checklist. The focus of the habitat and receptor observations should be on a community level. That is, dominant plant and animal species and habitats (e.g., wetlands, wooded areas) should be identified during the site visit. Photographs should be taken during the site visit and attached to the Scoping Assessment Report. Photographs are particularly useful for documenting the nature, quality, and distribution of vegetation, other ecological features, potential exposure pathways, and any evidence of contamination or impact. While the focus of the survey is on the community level, the U.S. Fish and Wildlife Service and the New Mexico Natural Heritage Program should be contacted prior to the site visit. The intent is to determine if state listed and/or federal listed Threatened & Endangered (T&E) species or sensitive habitats may be present at the site, or if any other fish or wildlife species could occur in the area (as indicated in the Site Assessment Checklist, Section IIID). A trained biologist or ecologist should conduct the biota surveys to appropriately characterize major habitats and to determine whether T&E species are present or may potentially use the site. The site assessment should also include a general survey for T&E species and any sensitive habitats (e.g. wetlands, perennial waters, breeding areas), due to the fact that federal and state databases might not be complete.

Site visits should be conducted at times of the year when ecological features are most apparent (i.e., spring, summer, early fall). Visits during winter might not provide as much evidence of the presence or absence of receptors and potential exposure pathways.

In addition to observations of ecological features, the assessor should note any evidence of chemical releases (including visual and olfactory clues), drainage patterns, areas with apparent erosion, signs of groundwater discharge at the surface (such as seeps or springs), and any natural or anthropogenic site disturbances.

2.3 Identify Contaminants of Potential Ecological Concern

Contaminants of Potential Ecological Concern (COPECs) are chemicals which may pose a threat to individual species or biological communities. For the purposes of the Scoping Assessment, all chemicals known or suspected of being released at the site are considered COPECs. The identification of COPECs is usually accomplished by the review of historical information in which previous site activities and releases are identified, or by sampling data which confirm the presence of contaminants in environmental media at the site. If any non-chemical stressors such as mechanical disturbances or extreme temperature conditions are known to be present at the site, they too are to be considered in the assessment.

After the COPECs have been identified, they should be summarized and organized (such as in table or chart form) for presentation in the Scoping Assessment Report.

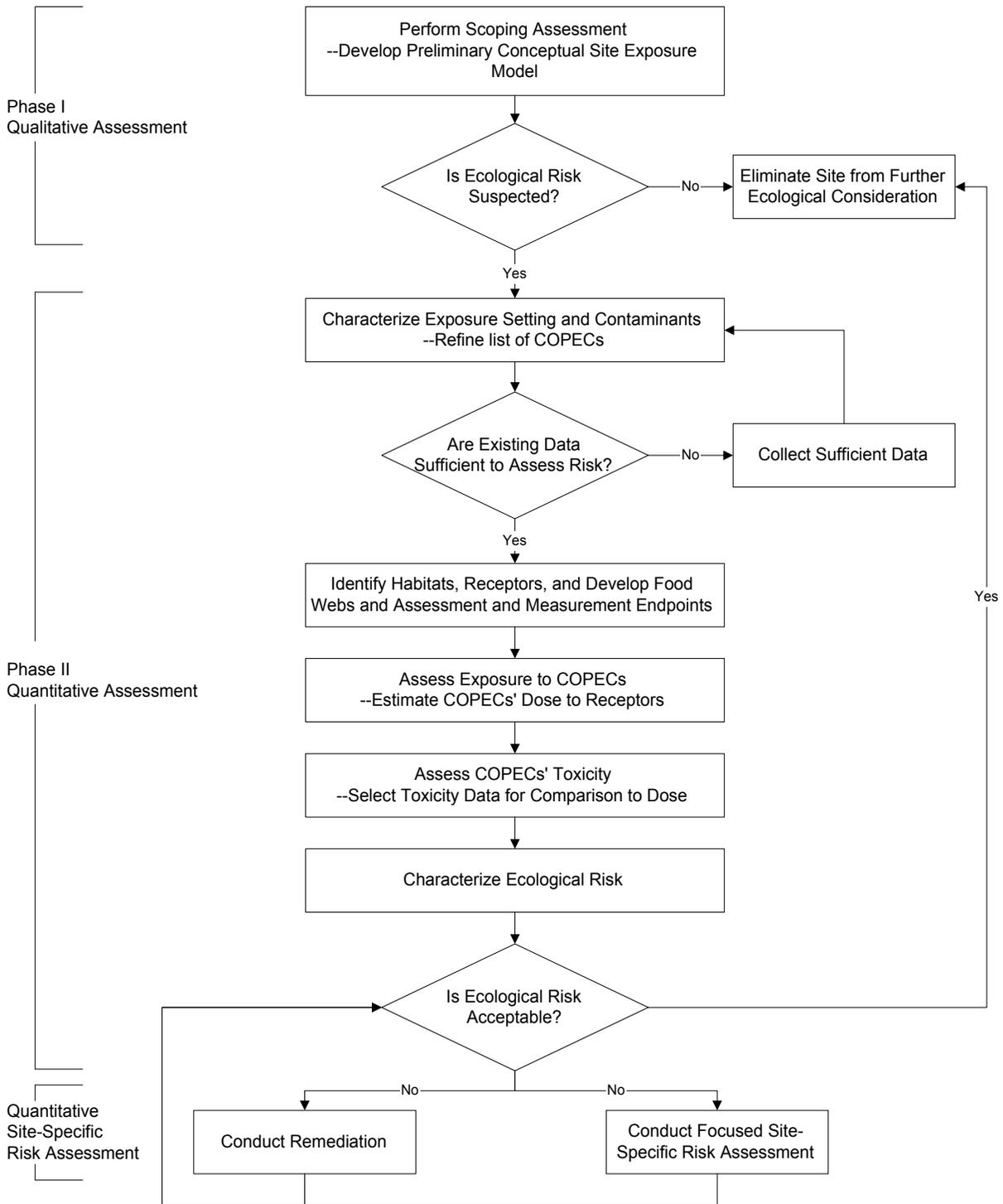
2.4 Developing the Preliminary Conceptual Site Exposure Model

A PCSEM provides a summary of potentially complete exposure pathways, along with potentially exposed receptor types. The PCSEM, in conjunction with the scoping report, is used to determine whether further ecological assessment (i.e., Screening-Level Assessment, Site-Specific Assessment) and/or interim measures are required.

A complete exposure pathway is defined as a pathway having all of the following attributes (US EPA, 1998; NMED, 2000):

- A source and mechanism for hazardous waste/constituent release to the environment
- An environmental transport medium or mechanism by which a receptor can come into contact with the hazardous waste/constituent
- A point of receptor contact with the contaminated media or via the food web, and
- An exposure route to the receptor.

If any of the above components are missing from the exposure pathway, it is not a complete pathway for the site. A discussion regarding all possible exposure pathways and the rationale/justification for eliminating any pathways should be included in the PCSEM narrative and in the Scoping Assessment Report.



Adapted from GAERPC (NMED 2000).

Figure 1. NMED Ecological Risk Assessment Process

The PCSEM is presented as both a narrative discussion and a diagram illustrating potential contaminant migration and exposure pathways to ecological receptors. A sample PCSEM diagram is presented in Figure 2. On the PCSEM diagram, the components of a complete exposure pathway are grouped into three main categories: sources, release mechanisms, and potential receptors. As a contaminant migrates and/or is transformed in the environment, sources and release mechanisms can be defined as primary, secondary, and tertiary.

For example, Figure 2 depicts releases from a landfill that migrate into soils, and reach nearby surface water and sediment via storm water runoff. In this situation, the release from the landfill is considered the primary release, with infiltration as the primary release mechanism. Soil becomes the secondary source, and storm water runoff is the secondary release mechanism to surface water and sediments, the tertiary source.

Subsequent ecological exposures to terrestrial and aquatic receptors will result from this release. The primary exposure routes to ecological receptors are direct contact, ingestion, and possibly inhalation. For example, plant roots will be in direct contact with contaminated sediments, and burrowing mammals will be exposed via dermal contact with soil and incidental ingestion of contaminated soil. In addition, exposures for birds and mammals will occur as they ingest prey items through the food web.

Although completing the Site Assessment Checklist will not provide the user with a readymade PCSEM, a majority of the components of the PCSEM can be found in the information provided by the Site Assessment Checklist. The information gathered for the completion of Section II of the Site Assessment Checklist, can be used to identify sources of releases. The results of Section III, Habitat Evaluation, can be used to both identify secondary and tertiary sources and to identify the types of receptors which may be exposed. The information gathered for completion of Section IV, Exposure Pathway Evaluation, will assist users in tracing the migration pathways of releases in the environment, thus helping to identify release mechanisms and sources.

Once all of the components of the conceptual model have been identified, complete exposure pathways and receptors that have the potential for exposure to site releases can be identified.

For further guidance on constructing a PCSEM, consult the GAERPC (NMED, 2000), and EPA's Office of Solid Waste and Emergency Response's *Soil Screening Guidance: User's Guide* (1996).

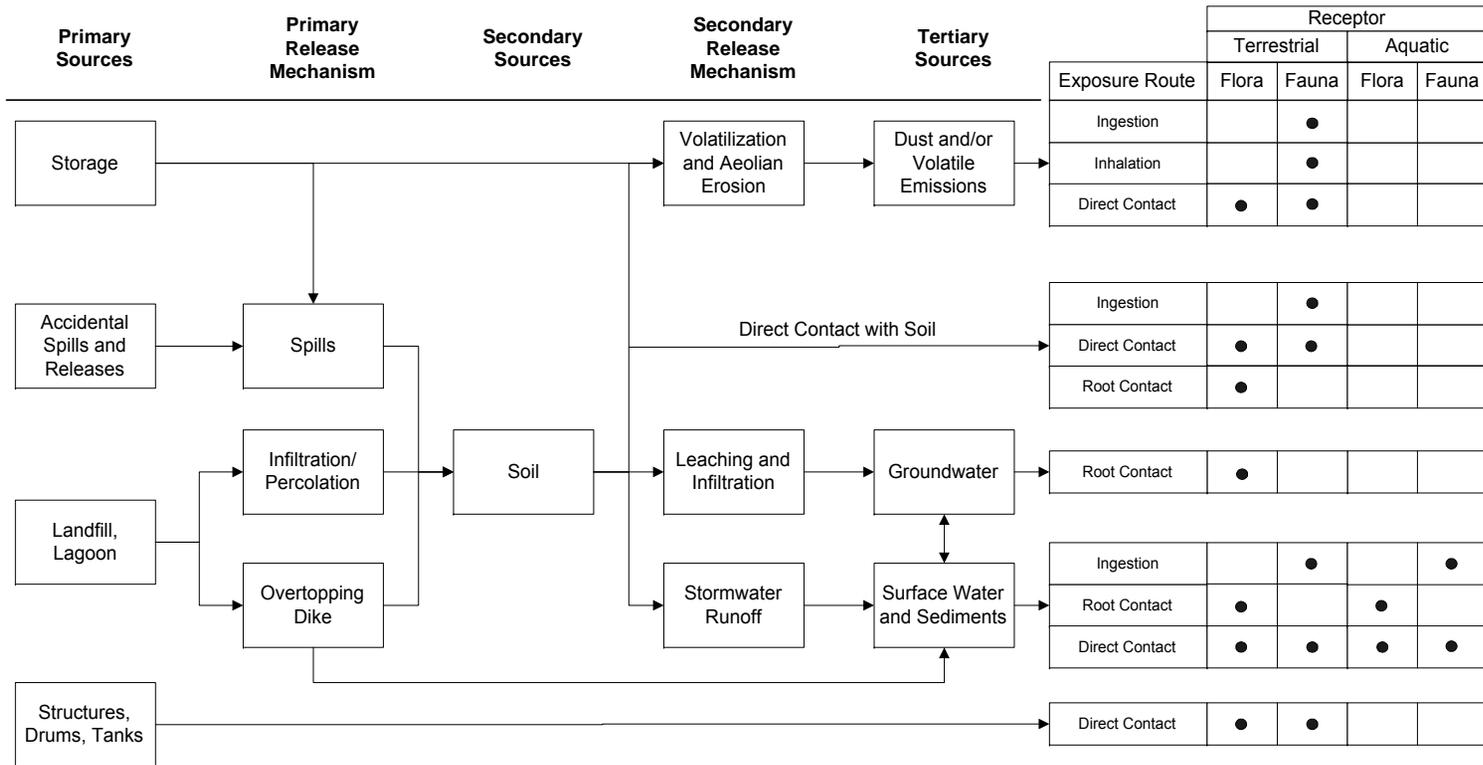
2.5 Assembling the Scoping Assessment Report

After completion of the previously described activities of the scoping assessment, the Scoping Assessment Report should be assembled to summarize the site information and present an evaluation of receptors and pathways at the site. The Scoping Assessment Report should be designed to support the decision made regarding the first Technical Decision Point (Is Ecological Risk Suspected?). The Scoping Assessment Report should, at a minimum, contain the following information:

- Existing Data Summary
- Site Visit Summary (including a completed Site Assessment Checklist)

- Evaluation of Receptors and Pathways
- Recommendations
- Attachments (e.g. photographs, field notes, telephone conversation logs with natural resource agencies)
- References/Data Sources

After completion, the Scoping Assessment Report and PCSEM should be submitted to NMED for review and approval. These documents will serve as a basis for decisions regarding future actions at the site.



Adapted from GAERPC (NMED 2000).

Figure 2. Example Preliminary Conceptual Site Exposure Model Diagram for a Hypothetical Site

3.0 SITE EXCLUSION CRITERIA

If the assessor believes that the answer to the first Technical Decision Point (Is Ecological Risk Suspected?) is “no” based on the results of the PCSEM and Scoping Assessment Report, it should be determined whether the facility meets the NMED Site Exclusion Criteria.

Exclusion criteria are defined as those conditions at an affected property which eliminate the need for a SLERA. The three criteria are as follows:

- Affected property does not include viable ecological habitat.
- Affected property is not utilized by potential receptors.
- Complete or potentially complete exposure pathways do not exist due to affected property setting or conditions of affected property media.

The Exclusion Criteria Checklist and associated Decision Tree (Attachment B) can be used as a tool to help the user determine if an affected site meets the exclusion criteria. The checklist assists in making a conservative, qualitative determination of whether viable habitats, ecological receptors, and/or complete exposure pathways exist at or in the locality of the site where a release of hazardous waste/constituents has occurred. Thus, meeting the exclusion criteria means that the facility can answer “no” to the first Technical Decision Point.

If the affected property meets the Site Exclusion Criteria, based on the results of the checklist and decision tree, the facility must still submit a Scoping Assessment Report to NMED which documents the site conditions and justification for how the criteria have been met. Upon review and approval of the exclusion by the appropriate NMED Bureau, the facility will not be required to conduct any further evaluation of ecological risk. However, the exclusion is not permanent; a future change in circumstances may result in the affected property no longer meeting the exclusion criteria.

4.0 TECHNICAL DECISION POINT: IS ECOLOGICAL RISK SUSPECTED?

As discussed in the beginning of this document, the Scoping Assessment is the first phase of the GAERPC ecological risk assessment process (Figure 1). Following the submission of the Scoping Assessment Report and PCSEM, NMED will decide upon one of the following three recommendations for the site:

- No further ecological investigation at the site, or
- Continue the risk assessment process, and/or
- Undertake a removal or remedial action.

If the information presented in the Scoping Assessment Report supports the answer of “no” to the first Technical Decision Point, and the site meets the exclusion criteria, the site will likely be excused from further consideration of ecological risk. However, this is only true if it can be documented that a complete exposure pathway does not exist and will not exist in the future at

the site based on current conditions. For those sites where valid pathways for potential exposure exist or are likely to exist in the future, further ecological risk assessment (usually in the form of a SLERA) will be required. However, if the Scoping Assessment indicates that a detailed assessment is warranted, the facility would not be required to conduct a SLERA. Instead the facility would move directly to Tier II–Site-Specific Ecological Risk Assessment.

5.0 SCREENING LEVELS ECOLOGICAL RISK ASSESSMENT (SLERA)

If the PSCM indicates complete exposure pathways, a SLERA is most likely the next step. The data collected during the scoping assessment is used to define facility-wide conditions and define the steps needed for the SLERA and includes the below items. The SLERA should contain a detailed discussion of each of these items.

- Characterization of the environmental setting, including current and future land uses. Ecological assessments must include the evaluation of present day conditions and land uses but also evaluate future land uses.
- Identification of known or likely chemical stressors (chemicals of potential ecological concern, COPECs). The characterization data from the site (e.g., facility investigation) is evaluated to determine what constituents are present in which media. Selection of COPEC should follow the same methodology as outlined in Volume I.
- Identification of the fate and transport pathways that are complete. This includes an understanding of how COPECs may be mobilized from one media to another.
- Identification of the assessment endpoints that should be used to assess impact of the receptors; what is the environmental value to be protected.
- Identification of the complete exposure pathways and exposure routes (as identified in the example in Figure 2). What are the impacted media (soil, surface water, sediment, groundwater, and/or plants) and how might the representative receptors be exposed (direct ingestion, inhalation, and/or direct contact)?
- Species likely to be impacted and selection of representative receptors. From the list of species likely to be present on-site, what species are to be selected to represent specific trophic levels?

5.1 Selection of Representative Species

Sites may include a wide range of terrestrial, semi-aquatic, and aquatic wildlife. A generalized food web is shown in Figure 3. Wildlife receptors for the SLERA should be selected to represent the trophic levels and habitats present or potentially present at the site.

5.2 Exposure Pathways

Typically the exposure pathways for a SLERA are generalized.

For soil, two soil intervals should be evaluated:

- For all non-burrowing receptors, the soil interval to be considered is between zero (0) and five (5) feet below ground surface (ft bgs).
- For all burrowing receptors and plants, the soil interval to be evaluated is 0 – 10 ft bgs.

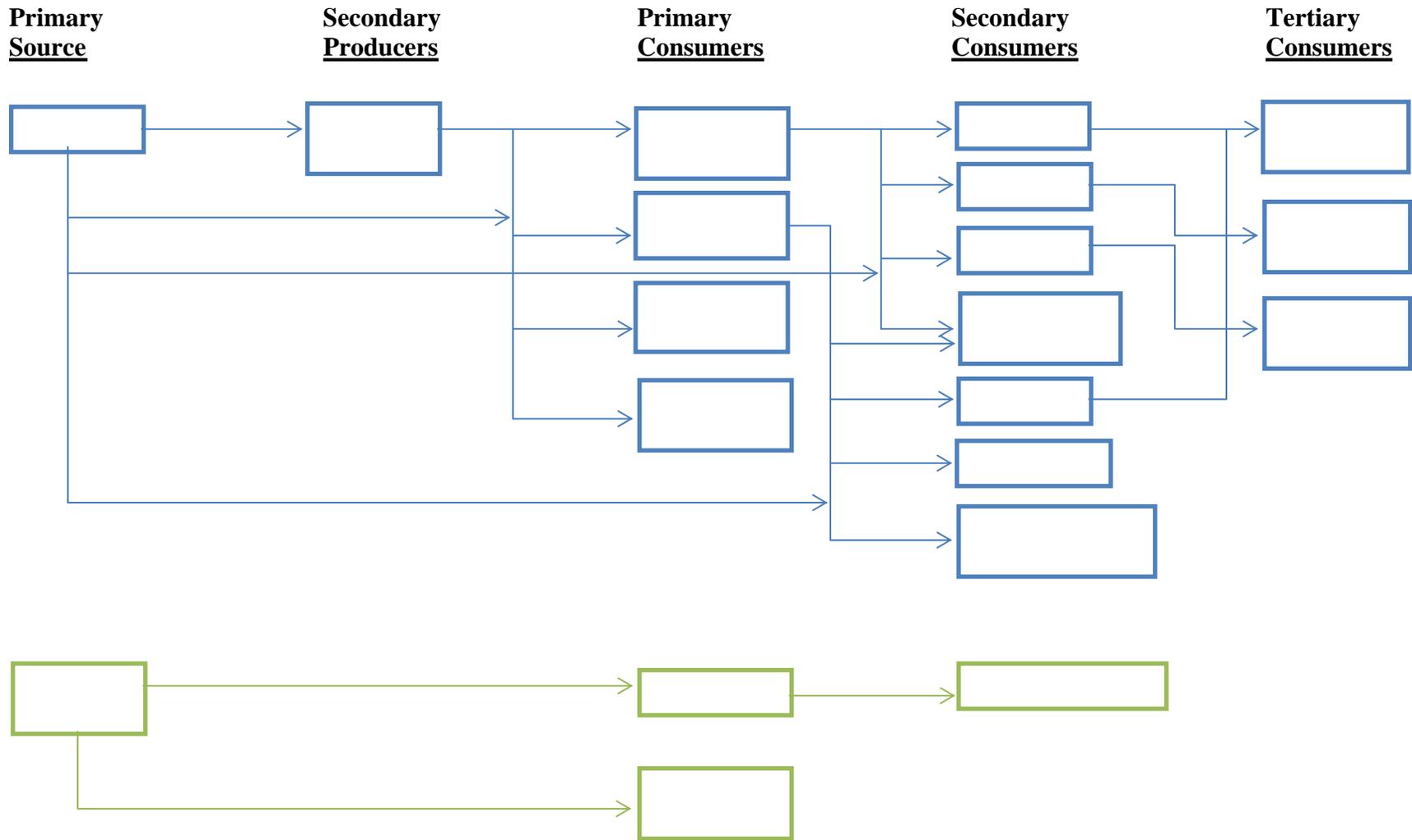


Figure 3. Generic Food Web.

Surface water, sediment, and groundwater should be evaluated based on site-specific conditions.

5.3 SLERA Exposure Estimation

For the initial SLERA, conservative assumptions should be applied as follows:

- 100% of the diet is assumed to contain the maximum concentration of each COPEC detected in the site media.
- Minimum reported body weights should be applied.
- Maximum dietary intake rates should be used.
- Foraging ranges are initial set equal to the size of the site being evaluated. This means that the area use factor (AUF) in the SLERA is set to a value of one.

Exposure doses for the various media should be calculated separately using the following equation:

$$Dose = \frac{C \times IR \times AUF}{BW} \quad \text{(Equation 1)}$$

Where:

- Dose = Screening level exposure dose (mg/kg-day)
- C = Exposure point concentration, which is equal to the maximum detected concentration for the COPEC (mg/kg)
- IR = Ingestion rate set equal to the maximum total dietary intake rate (kg/day)
- AUF = Area use factor is assumed to be equal to the size of the site and set to a value of one (unitless)
- BW = Body weight set equal to the minimum reported body weight (kg).

5.4 Effects Assessment

The effects assessment evaluated the potential toxic effects on the receptors being exposed to the COPECs. The effects assessment includes selection of appropriate toxicity reference values (TRVs) for the characterization and evaluation of risk.

For the initial SLERA, the preference for TRVs is based on chronic or long term exposure, when available. The TRVs should be selected from peer-reviewed toxicity studies and from primary literature. Initial risk characterization should be conducted using the lowest appropriate chronic no-observed adverse effect level (NOAEL) for non-lethal or reproductive effects.

5.5 Risk Characterization

Risk is determined by dividing the receptor-specific dose determined using Equation 1 by the appropriate TRV, as follows:

$$HQ = \frac{Dose}{TRV} \quad \text{Equation 2}$$

Where:

- HQ = Hazard quotient, calculated for each receptor and COPEC (unitless)

Dose = Screening level exposure dose, calculated for each receptor (mg/kg-day)
TRV = Toxicity reference value, chemical-specific NOAEL (mg/kg-day)

HQs are calculated for each receptor and each COPEC. For each receptor, additive risk must be evaluated. For the initial screening assessment, it is assumed that all COPECs have equal potential risk to the receptor. The overall hazard index (HI) is then calculated for each receptor using Equation 3:

$$HI = HQ_x + HQ_y + \dots + HQ_z \quad \text{Equation 3}$$

Where:

HI = Hazard Index (unitless)
HQ_x = Hazard quotient for each COPEC (unitless)

NMED applies a target risk level for ecological risk assessments of 1.0. If the HI for any receptor is above this target risk level, then there is a potential for adverse effects on ecological receptors and additional evaluation and possibly a site-specific ecological risk assessment may be warranted.

Some additional lines of evidence that may be used to assess risk when the HI is above the target level include:

- Modification of the TRV to reflect the lowest lowest-observed adverse effect level (LOAEL),
- Use of more refined exposure algorithms that incorporate more realistic exposure assumptions (such as specific ingestion rates for plants, soil, and/or water),
- Use of site-specific area use factors and population use factors,
- Evaluation of bioaccumulation, and
- Evaluation of risk by mechanism of effect.

As with all risk assessments, the SLERA should include a discussion of the uncertainties. More detailed information may be found in the *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment* (NMED, 2000).

6.0 TIER 2: PHASE II - QUANTITATIVE ASSESSMENT

In the event that the SLERA does not show that levels of contamination in the impacted media are below the target level of 1.0, additional quantitative analyses may be warranted. This may include incorporation of biota studies to evaluate impact at the site. NMED should be consulted prior to conducting a Tier 2 assessment.

7.0 REFERENCES

Los Alamos National Laboratory (LANL), 1997. *Administrative Procedure 4.5*, Draft

New Mexico Environment Department (NMED), 2000. *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment*, Hazardous and Radioactive Materials Bureau, Final, March.

U.S. Environmental Protection Agency (US EPA), 1996. *Soil Screening Guidance: User's Guide*. Office of Solid Waste and Emergency Response. Washington, DC. EPA-540-R-96/018. July.

U.S. EPA, 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, Environmental Response Team, Interim Final, June 5.

U.S.EPA, 1998. *Guidelines for Ecological Risk Assessment*, Risk Assessment Forum, Final, April. EPA/630/R-95/002F; <http://www.epa.gov/ncea/ecorisk.htm>.

ATTACHMENT A

SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT
SCOPING ASSESSMENT
SITE ASSESSMENT CHECKLIST

INTRODUCTION

This checklist has been developed as a tool for gathering information about the facility property and surrounding areas, as part of the scoping assessment. Specifically, the checklist assists in the compilation of information on the physical and biological aspects of the site including the site environmental setting, usage of the site, releases at the site, contaminant fate and transport mechanisms, and the area's habitats, receptors, and exposure pathways. The completed checklist can then be used to construct the preliminary conceptual site exposure model (PCSEM) for the site. In addition, the checklist and PCSEM will serve as the basis for the scoping assessment report. Section III of this document provides further information on using the completed checklist to develop the PCSEM.

In general, the checklist is designed for applicability to all sites, however, there may be unusual circumstances which require professional judgment in order to determine the need for further ecological evaluation (*e.g.*, cave-dwelling receptors). In addition, some of the questions in the checklist may not be relevant to all sites. Some facilities may have large amounts of data available regarding contaminant concentrations and hydrogeologic conditions at the site, while other may have only limited data. In either case, the questions on the checklist should be addressed as completely as possible with the information available.

Habitats and receptors, which may be present at the site, can be identified by direct or indirect³⁵ observations and by contacting local and regional natural resource agencies. Habitat types may be determined by reviewing land use and land cover maps (LULC), which are available via the Internet at <http://www.nationalatlas.gov/mapit.html>. With regard to receptors, it should be noted that receptors are often present at a site even when they are not observed. Therefore, for the purposes of this checklist, it should be assumed that receptors are present if viable habitat is present. The presence of receptors should be confirmed by contacting one or several of the organizations listed below.

Sources of general information available for the identification of ecological receptors and habitats include:

- U.S. Fish and Wildlife Service (<http://www.fws.gov>)
- Biota Information System of New Mexico (BISON-M) maintained by the New Mexico Department of Game and Fish (NMGF) (<http://151.199.74.229/states/nm.htm>)
- U.S. Forest Service (USFS) (<http://www.fs.fed.us/>)
- New Mexico Forestry Division (NMF) of the Energy, Minerals and Natural Resources Department (<http://www.emnrd.state.nm.us/forestry/index.htm>)
- U.S. Bureau of Land Management (USBLM) (<http://www.blm.gov/nhp/index.htm>) or (http://www.nm.blm.gov/www/new_home_2.html)

³⁵ Examples of indirect observations that indicate the presence of receptors include: tracks, feathers, burrows, scat

- United States Geological Service (USGS) (<http://www.usgs.gov>)
- National Wetland Inventory Maps (<http://wetlands.fws.gov>)
- National Audubon Society (<http://www.audobon.com>)
- National Biological Information Infrastructure (<http://biology.usgs.gov>)
- Sierra Club (<http://www.sierraclub.org>)
- National Geographic Society (<http://www.nationalgeographic.com>)
- New Mexico Natural Heritage Program (<http://nmnhp.unm.edu/>)
- State and National Parks System
- Local universities
- Tribal organizations

INSTRUCTIONS FOR COMPLETING THE CHECKLIST

The checklist consists of four sections: Site Location, Site Characterization, Habitat Evaluation, and Exposure Pathway Evaluation. Answers to the checklist should reflect existing conditions and should not consider future remedial actions at the site. Completion of the checklist should provide sufficient information for the preparation of a PCSEM and scoping report and allow for the identification of any data gaps.

Section I - Site Location, provides general site information, which identifies the facility being evaluated, and gives specific location information. Site maps and diagrams, which should be attached to the completed checklist, are an important part of this section. The following elements should be clearly illustrated: 1) the location and boundaries of the site relative to the surrounding area, 2) any buildings, structures or important features of the facility or site, and 3) all ecological areas or habitats identified during completion of the checklist. It is possible that several maps will be needed to clearly and adequately illustrate the required elements. Although topographical information should be illustrated on at least one map, it is not required for every map. Simplified diagrams (preferably to scale) of the site and surrounding areas will usually suffice.

Section II - Site Characterization, is intended to provide additional temporal and contextual information about the site, which may have an impact on determining whether a certain area should be characterized as ecologically viable habitat or contains receptors. Answers to the questions in Section II will help the reviewer develop a broader and more complete evaluation of the ecological aspects of a site.

Section III - Habitat Evaluation, provides information regarding the physical and biological characteristics of the different habitat types present at or in the locality of the site. Aquatic features such as lakes, ponds, streams, arroyos and ephemeral waters can be identified by reviewing aerial photographs, LULC and topographic maps and during site reconnaissance visits. In New Mexico, there are several well-defined terrestrial communities, which occur naturally. Typical communities include wetlands, forest (e.g., mixed conifer, ponderosa pine and pinyon juniper), scrub/shrub, grassland, and desert. Specific types of vegetation characterize each of these communities and can be used to identify them. Field guides are often useful for identifying vegetation types. A number

of sites may be in areas that have been disturbed by human activities and may no longer match any of the naturally occurring communities typical of the southwest. Particularly at heavily used areas at facilities, the two most common of these areas are usually described as “weed fields” and “lawn grass”. Vegetation at “weed fields” should be examined to determine whether the weeds consist primarily of species native to the southwest or introduced species such as *Kochia*. Fields of native weeds and lawn grass are best evaluated using the short grass prairie habitat guides.

The applicable portions of Section III of the checklist should be completed for each individual habitat identified. For example, the questions in Section III.A of the checklist should be answered for each wetland area identified at or in the locality of the site and the individual areas must be identified on a map or maps.

Section IV- Exposure Pathway Evaluation, is used to determine if contaminants at the site have the potential to impact habitat identified in Section III. An exposure pathway is the course a chemical or physical agent takes from a source to an exposed organism. Each exposure pathway includes a source (or release from a source), an environmental transport mechanism, an exposure point, and an exposure route. A complete exposure pathway is one in which each of these components, as well as a receptor to be exposed, is present. Essentially, this section addresses the fate and transport of contaminants that are known or suspected to have been released at the site. In most cases, without a complete exposure pathway between contaminants and receptors, additional ecological evaluation is not warranted.

Potential transport pathways addressed in this checklist include migration of contaminants via air dispersion, leaching into groundwater, soil erosion/runoff, groundwater discharge to surface water, and irradiation. Due to New Mexico’s semi-arid climate, vegetation is generally sparse. The sparse vegetation, combined with the intense nature of summer storms in New Mexico, results in soil erosion that occurs sporadically over a very brief time frame. Soil erosion may be of particular concern for sites located in steeply sloped areas. Several questions within Section IV of this checklist have been developed to aid in the identification of those sites where soil erosion/runoff would be an important transport mechanism.

7.1 Using the Checklist to Develop the Preliminary Conceptual Site Exposure Model

The completed Site Assessment Checklist can be used to construct the PCSEM. An example PCSEM diagram is presented in Figure 1. The CSM illustrates actual and potential contaminant migration and exposure pathways to associated receptors. The components of a complete exposure pathway are simplified and grouped into three main categories: sources, release mechanisms, and potential receptors. As a contaminant migrates and/or is transformed in the environment, sources and release mechanisms may expand into primary, secondary, and tertiary levels. For example, Figure 1 illustrates releases from inactive lagoons (primary sources) through spills (primary release mechanism), which migrate to surface and subsurface soils (secondary sources), which are then leached (secondary release mechanism) to groundwater (tertiary source). Similarly, exposures of various trophic levels to the contaminant(s) and consequent

exposures via the food chain may lead to multiple groups of receptors. For example, Figure 1 illustrates groups of both aquatic and terrestrial receptors which may be exposed and subsequently serve as tertiary release mechanisms to receptors which prey on them.

Although completing the checklist will not provide the user with a readymade PCSEM, a majority of the components of the PCSEM can be found in the answers to the checklist. It is then up to the user to put the pieces together into a comprehensive whole. The answers from Section II of the checklist, Site Characterization, can be used to identify sources of releases. The answers to Section IV, Exposure Pathway Evaluation, will assist users in tracing the migration pathways of releases in the environment, thus helping to identify release mechanisms and sources. The results of Section III, Habitat Evaluation, can be used to both identify secondary and tertiary sources and to identify the types of receptors which may be exposed. Appendix B of the NMED's *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Assessment* also contains sample food webs which may be used to develop the PCSEM.

Once all of the components have been identified, one can begin tracing the steps between the primary releases and the potential receptors. For each potential receptor, the user should consider all possible exposure points (e.g., prey items, direct contact with contaminated soil or water, etc.) then begin eliminating pathways, which are not expected to result in exposure to the contaminant at the site. Gradually, the links between the releases and receptors can be filled in, resulting in potential complete exposure pathways.

For further guidance on constructing a PCSEM, consult the NMED's *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Assessment* (2000), and EPA's Office of Solid Waste and Emergency Response's *Soil Screening Guidance: User's Guide* (1996).

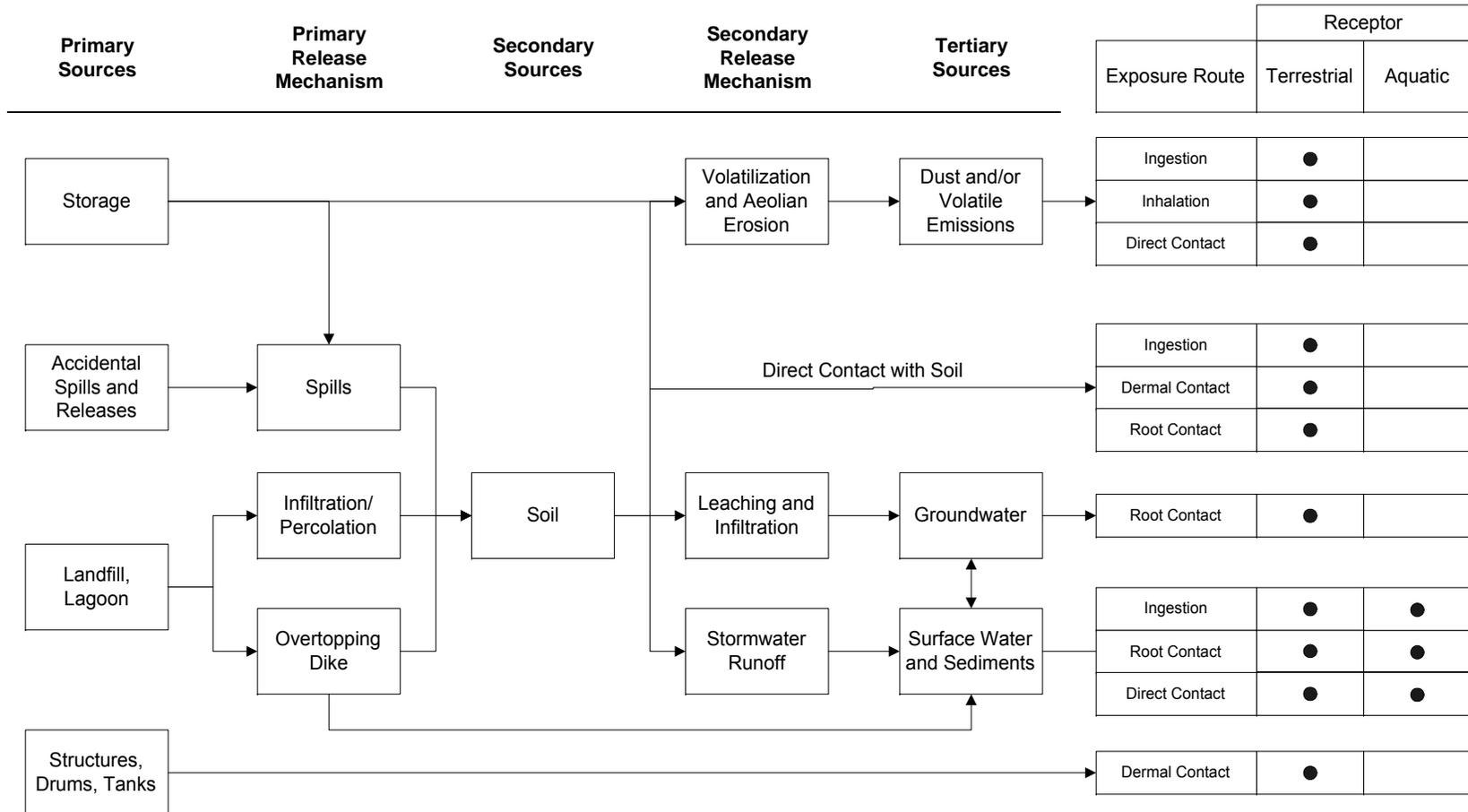


Figure 1. Example Preliminary Conceptual Site Exposure Model Diagram

**NEW MEXICO ENVIRONMENT DEPARTMENT
SITE ASSESSMENT CHECKLIST**

I. SITE LOCATION

1. Site
Name: _____
US EPA I.D.
Number: _____
Location: _____
County: _____
City: _____ State: _____
2. Latitude: _____
Longitude: _____
3. Attach site maps, including a topographical map, a diagram which illustrates the layout of the facility (e.g., site boundaries, structures, etc.), and maps showing all habitat areas identified in Section III of the checklist. Also, include maps which illustrate known release areas, sampling locations, and any other important features, if available.

II. SITE CHARACTERIZATION

1. Indicate the approximate area of the site (i.e., acres or sq. ft)

2. Provide an approximate breakdown of the land uses on the site:
_____ % Heavy Industrial _____ % Light Industrial _____ % Urban
_____ % Residential _____ % Rural _____ % Agricultural^b
_____ % Recreational^a _____ % Undisturbed _____ % Other^c

^aFor recreational areas, please describe the usage of the area (e.g., park, playing field, etc.):

^bFor agricultural areas, please list the crops and/or livestock which are present:

^cFor areas designated as "other", please describe the usage of the area:

3. Provide an approximate breakdown of the land uses in the area surrounding the site.

Indicate the radius (in miles) of the area described: _____

_____ % Heavy Industrial	_____ % Light Industrial	_____ % Urban
_____ % Residential	_____ % Rural	_____ % Agricultural ^b
_____ % Recreational ^a	_____ % Undisturbed	_____ % Other ^c

^aFor recreational areas, please describe the usage of the area (e.g., park, playing field, golf course, etc.):

^bFor agricultural areas, please list the crops and/or livestock which are present:

^cFor areas designated as “other”, please describe the usage of the area:

4. Describe reasonable and likely future land and/or water use(s) at the site.

5. Describe the historical uses of the site. Include information on chemical releases that may have occurred as a result of previous land uses. For each chemical release, provide information on the form of the chemical released (i.e., solid, liquid, vapor) and the known or suspected causes or mechanism of the release (i.e., spills, leaks, material disposal, dumping, explosion, etc.).

6. If any movement of soil has taken place at the site, describe the degree of the disturbance. Indicate the likely source of any disturbances (e.g., erosion, agricultural, mining, industrial activities, removals, etc.) and estimate when these events occurred.

-
7. Describe the current uses of the site. Include information on recent (previous 5 years) disturbances or chemical releases that have occurred. For each chemical release, provide information on the form of the chemical released and the causes or mechanism of the release.

8. Identify the location or suspected location of chemical releases at the site. Provide an estimate of the distance between these locations and the areas identified in Section III.

9. Identify the suspected contaminants of concern (COCs) at the site. If known, include the maximum contaminant levels. Please indicate the source of data cited (e.g., RFI, confirmatory sampling, etc.).

10. Identify the media (e.g., soil (surface or subsurface), surface water, air, groundwater) which are known or suspected to contain COCs. _____

11. Indicate the approximate depth to groundwater (in feet below ground surface [(bgs)]).

12. Indicate the direction of groundwater flow (e.g., north, southeast, etc.)

III. HABITAT EVALUATION

III.A Wetland Habitats

Are any wetland³⁶ areas such as marshes or swamps on or adjacent to the site?

Yes No

If yes, indicate the wetland area on the attached site map and answer the following questions regarding the wetland area. If more than one wetland area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual wetland area. Distinguish between wetland areas by using names or other designations (such as location), and clearly identify each area on the site map. Also, obtain and attach a National Wetlands Inventory Map (or maps) to illustrate each wetland area.

Identify the sources of the observations and information (e.g., National Wetland Inventory, Federal or State Agency, USGS topographic maps) used to make the determination that wetland areas are or are not present.

If no wetland areas are present, proceed to Section III.B.

Wetland Area Questions

Onsite Offsite

Name or Designation: _____

1. Indicate the approximate area of the wetland (acres or ft²) _____

2. Identify the type(s) of vegetation present in the wetland.

- Submergent (i.e., underwater) vegetation
- Emergent (i.e., rooted in the water, but rising above it) vegetation
- Floating vegetation
- Scrub/shrub

³⁶Wetlands are defined in 40 CFR §232.2 as “ Areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions.” Examples of typical wetlands plants include: cattails, cordgrass, willows and cypress trees. National wetland inventory maps may be available at <http://nwi.fws.gov>. Additional information on wetland delineation criteria is also available from the Army Corps of Engineers.

- Wooded
- Other (Please describe): _____

3. Estimate the vegetation density of the wetland area.

- Dense (i.e., greater than 75% vegetation)
- Moderate (i.e., 25% to 75% vegetation)
- Sparse (i.e., less than 25% vegetation)

4. Is standing water present? Yes No

If yes, is the water primarily: Fresh or Brackish

Indicate the approximate area of the standing water (ft²):

Indicate the approximate depth of the standing water, if known (ft. or in.) _____

5. If known, indicate the source of the water in the wetland.

- Stream/River/Creek/Lake/Pond
- Flooding
- Groundwater
- Surface runoff

6. Is there a discharge from the facility to the wetland? Yes No

If yes, please

describe: _____

Wetland Area Questions (Continued)

7. Is there a discharge from the wetland? Yes No
If yes, indicate the type of aquatic feature the wetland discharges into:

- Surface stream/River (Name: _____)
- Lake/Pond (Name: _____)
- Groundwater
- Not sure

8. Does the area show evidence of flooding? Yes No
If yes, indicate which of the following are present (mark all that apply):

- Standing water
- Water-saturated soils
- Water marks
- Buttressing
- Debris lines
- Mud cracks
- Other (Please describe): _____

9. Animals observed in the wetland area or suspected to be present based on indirect evidence or file material:

- Birds
- Fish
- Mammals
- Reptiles (e.g., snakes, turtles)
- Amphibians (e.g., frogs, salamanders)
- Sediment-dwelling invertebrates (e.g., mussels, crayfish, insect nymphs)

Specify species, if known:

III.B Aquatic Habitats

III.B.1 Non-Flowing Aquatic Features

Are any non-flowing aquatic features (such as ponds or lakes) located at or adjacent to the site?

Yes No

If yes, indicate the aquatic feature on the attached site map and answer the following questions regarding the non-flowing aquatic features. If more than one non-flowing aquatic feature is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual aquatic feature. Distinguish between aquatic features by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.B.2.

Non-Flowing Aquatic Feature Questions

Onsite Offsite

Name or Designation: _____

1. Indicate the type of aquatic feature present:

- Natural (e.g., pond or lake)
- Man-made (e.g., impoundment, lagoon, canal, etc.)

2. Estimate the approximate size of the water body (in acres or sq. ft.) _____

3. If known, indicate the depth of the water body (in ft. or in.). _____

Non-Flowing Aquatic Feature Questions (Continued)

4. Indicate the general composition of the bottom substrate. Mark all sources that apply from the following list.

- | | | |
|--|--|-----------------------------------|
| <input type="checkbox"/> Bedrock | <input type="checkbox"/> Sand | <input type="checkbox"/> Concrete |
| <input type="checkbox"/> Boulder (>10 in.) | <input type="checkbox"/> Silt | <input type="checkbox"/> Debris |
| <input type="checkbox"/> Cobble (2.5 - 10 in.) | <input type="checkbox"/> Clay | <input type="checkbox"/> Detritus |
| <input type="checkbox"/> Gravel (0.1 - 2.5 in.) | <input type="checkbox"/> Muck (fine/black) | |
| <input type="checkbox"/> Other (please specify): _____ | | |

5. Indicate the source(s) of the water in the aquatic feature. Mark all sources that apply from the following list.

- River/Stream/Creek
- Groundwater
- Industrial Discharge
- Surface Runoff
- Other (please specify): _____

6. Is there a discharge from the facility to the aquatic feature? Yes No
If yes, describe the origin of each discharge and its migration path:

7. Does the aquatic feature discharge to the surrounding environment? Yes No

If yes, indicate the features from the following list into which the aquatic feature discharges, and indicate whether the discharge occurs onsite or offsite:

- | | | |
|--|---------------------------------|----------------------------------|
| <input type="checkbox"/> River/Stream/Creek | <input type="checkbox"/> onsite | <input type="checkbox"/> offsite |
| <input type="checkbox"/> Groundwater | <input type="checkbox"/> onsite | <input type="checkbox"/> offsite |
| <input type="checkbox"/> Wetland | <input type="checkbox"/> onsite | <input type="checkbox"/> offsite |
| <input type="checkbox"/> Impoundment | <input type="checkbox"/> onsite | <input type="checkbox"/> offsite |
| <input type="checkbox"/> Other (please describe) _____ | | |

Non-Flowing Aquatic Feature Questions (Continued)

8. Animals observed in the vicinity of the aquatic feature or suspected to be present based on indirect evidence or file material:

- Birds
- Fish
- Mammals
- Reptiles (e.g., snakes, turtles)
- Amphibians (e.g., frogs, salamanders)
- Sediment-dwelling invertebrates (e.g., mussels, crayfish, insect nymphs)

Specify species, if known:

III.B.2 Flowing Aquatic Features

Are any flowing aquatic features (such as streams or rivers) located at or adjacent to the site?

Yes No

If yes, indicate the aquatic feature on the attached site map and answer the following questions regarding the flowing aquatic features. If more than one flowing aquatic feature is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual aquatic feature. Distinguish between aquatic features by using names or other designations, and clearly identify each area on the site map

If no, proceed to Section III.C.

Flowing Aquatic Feature Questions

Onsite Offsite

Name or Designation: _____

1. Indicate the type of flowing aquatic feature present.

- River
- Stream
- Creek
- Brook
- Dry wash
- Arroyo
- Intermittent stream
- Artificially created (ditch, etc.)
- Other (specify)
-

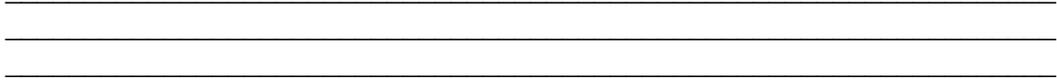
2. Indicate the general composition of the bottom substrate.

- | | | |
|--|--|-----------------------------------|
| <input type="checkbox"/> Bedrock | <input type="checkbox"/> Sand | <input type="checkbox"/> Concrete |
| <input type="checkbox"/> Boulder (>10 in.) | <input type="checkbox"/> Silt | <input type="checkbox"/> Debris |
| <input type="checkbox"/> Cobble (2.5 - 10 in.) | <input type="checkbox"/> Clay | <input type="checkbox"/> Detritus |
| <input type="checkbox"/> Gravel (0.1 - 2.5 in.) | <input type="checkbox"/> Muck (fine/black) | |
| <input type="checkbox"/> Other (please specify): _____ | | |

3. Describe the condition of the bank (e.g., height, slope, extent of vegetative cover) of the aquatic feature.

4. Is there a discharge from the facility to the aquatic feature? Yes No
If yes, describe the origin of each discharge and its migration path:

5. Indicate the discharge point of the water body. Specify name, if known.



Flowing Aquatic Feature Questions (Continued)

6. If the flowing aquatic feature is a dry wash or arroyo, answer the following questions.

- Check here if feature is not a dry wash or arroyo

If known, specify the average number of days in a year in which flowing water is present in the feature: _____

Is standing water or mud present? Check all that apply.

- Standing water
- Mud
- Neither standing water or mud

Does the area show evidence of recent flow (e.g., flood debris clinging to vegetation)?

- Yes
- No
- Not sure

7. Animals observed in the vicinity of the aquatic feature or suspected to be present based on indirect evidence or file material:

- Birds
- Fish
- Mammals
- Reptiles (e.g., snakes, turtles)
- Amphibians (e.g., frogs, salamanders)
- Sediment-dwelling invertebrates (e.g., mussels, crayfish, insect nymphs)

Specify species, if known:

III.C Terrestrial Habitats

III.C.1 Wooded

Are any wooded areas on or adjacent to the site? Yes No

If yes, indicate the wooded area on the attached site map and answer the following questions. If more than one wooded area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual wooded area. Distinguish between wooded areas by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.2.

Wooded Area Questions

On-site Off-site

Name or Designation: _____

1. Estimate the approximate size of the wooded area (in acres or sq. ft.) _____

2. Indicate the dominant type of vegetation in the wooded area.

- Evergreen
- Deciduous
- Mixed

Dominant plant species, if known: _____

3. Estimate the vegetation density of the wooded area.

- Dense (i.e., greater than 75% vegetation)
- Moderate (i.e., 25% to 75% vegetation)
- Sparse (i.e., less than 25% vegetation)

4. Indicate the predominant size of the trees at the site. Use diameter at chest height.

- 0-6 inches
- 6-12 inches
- >12 inches
- No single size range is predominant

5. Animals observed in the wooded area or suspected to be present based on indirect evidence or file material:

- Birds
- Mammals
- Reptiles (e.g., snakes, lizards)
- Amphibians (e.g., toads, salamanders)

Specify species, if known:

III.C.2 Shrub/Scrub

Are any shrub/scrub areas on or adjacent to the site? Yes No

If yes, indicate the shrub/scrub area on the attached site map and answer the following questions. If more than one shrub/scrub area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual shrub/scrub area. Distinguish between shrub/scrub areas, using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.3.

Shrub/Scrub Area Questions

Onsite Offsite

Name or Designation: _____

1. Estimate the approximate size of the shrub/scrub area (in acres or sq. ft.). _____

2. Indicate the dominant type of shrub/scrub vegetation present, if known.

3. Estimate the vegetation density of the shrub/scrub area.

- Dense (i.e., greater than 75% vegetation)
- Moderate (i.e., 25% to 75% vegetation)
- Sparse (i.e., less than 25% vegetation)

4. Indicate the approximate average height of the scrub/shrub vegetation.

- 0-2 feet
- 2-5 feet
- >5 feet

5. Animals observed in the shrub/scrub area or suspected to be present based on indirect evidence or file material:

- Birds
- Mammals
- Reptiles (e.g., snakes, lizards)
- Amphibians (e.g., toads, salamanders)

Specify species, if known:

III.C.3 Grassland

Are any grassland areas on or adjacent to the site? Yes No

If yes, indicate the grassland area on the attached site map and answer the following questions. If more than one grassland area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual grassland area. Distinguish between grassland areas by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.4.

Grassland Area Questions

Onsite Offsite

Name or Designation: _____

1. Estimate the approximate size of the grassland area (in acres or sq. ft.). _____

2. Indicate the dominant plant type, if known.

3. Estimate the vegetation density of the grassland area.

- Dense (i.e., greater than 75% vegetation)
- Moderate (i.e., 25% to 75% vegetation)
- Sparse (i.e., less than 25% vegetation)

4. Indicate the approximate average height of the dominant plant type (in ft. or in.)_

5. Animals observed in the grassland area or suspected to be present based on indirect evidence or file material:

- Birds
- Mammals
- Reptiles (e.g., snakes, lizards)
- Amphibians (e.g., toads, salamanders)

Specify species, if known:

III.C.4 Desert

Are any desert areas on or adjacent to the site? Yes No

If yes, indicate the desert area on the attached site map and answer the following questions. If more than one desert area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual desert area. Distinguish between desert areas by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.5.

Desert Area Questions

Onsite Offsite

Name or Designation: _____

1. Estimate the approximate size of the desert area (in acres or sq. ft.). _____
2. Describe the desert area (e.g., presence or absence of vegetation, vegetation types, presence/size of rocks, sand, etc.)

3. Animals observed in the desert area or suspected to be present based on indirect evidence or file material:

- Birds
- Mammals
- Reptiles (e.g., snakes, lizards)
- Amphibians (e.g., toads, salamanders)

Specify species, if known:

2. Are any areas on or near (i.e., within 0.5 miles) the site which are owned or used by local tribes? If yes, describe. *Contact the Tribal Liaison in the Office of the Secretary (505)827-2855 to obtain this information.*

4. Does the site serve or potentially serve as a habitat, foraging area, or refuge by rare, threatened, endangered, candidate and/or proposed species (plants or animals), or any otherwise protected species? If yes, identify species. *This information should be obtained from the U.S. Fish and Wildlife Service and appropriate State of New Mexico division.*

5. Is the site potentially used as a breeding, roosting or feeding area by migratory bird species? If yes, identify which species.

6. Is the site used by any ecologically³⁸, recreationally, or commercially important

38 Ecologically important species include populations of species which provide a critical (i.e., not replaceable) food resource for higher organisms and whose function as such would not be replaced by more tolerant species; or perform a critical ecological function (such as organic matter decomposition) and whose functions will not be replaced by other species. Ecologically important species include pest and opportunistic species that populate an area if they serve as a food source for other species, but do not include domesticated animals (e.g., pets and livestock) or plants/animals whose existence is maintained by continuous human interventions (e.g., fish hatcheries, agricultural crops, etc.,)

species? If yes, explain.

IV. EXPOSURE PATHWAY EVALUATION

1. Do existing data provide sufficient information on the nature, rate, and extent of contamination at the site?

- Yes
- No
- Uncertain

Please provide an explanation for your answer: _____

2. Do existing data provide sufficient information on the nature, rate, and extent of contamination in offsite affected areas?

- Yes
- No
- Uncertain
- No offsite contamination

Please provide an explanation for your answer: _____

3. Do existing data address potential migration pathways of contaminants at the site?

- Yes
- No
- Uncertain

Please provide an explanation for your
answer: _____

—

4. Do existing data address potential migration pathways of contaminants in offsite affected areas?

- Yes
- No
- Uncertain
- No offsite contamination

Please provide an explanation for your answer: _____

5. Are there visible indications of stressed habitats or receptors on or near (i.e., within 0.5 miles) the site that may be the result of a chemical release? If yes, explain. Attach photographs if available.

6. Is the location of the contamination such that receptors might be reasonably expected to come into contact with it? For soil, this means contamination in the soil 0 to 5 feet below ground surface (bgs). If yes, explain.

7. Are receptors located in or using habitats where chemicals exist in air, soil, sediment or surface water? If yes, explain.

8. Could chemicals reach receptors via groundwater? Can chemicals leach or dissolve to groundwater? Are chemicals mobile in groundwater? Does groundwater discharge into receptor habitats? If yes, explain.

9. Could chemicals reach receptors through runoff or erosion? Answer the following questions:

What is the approximate distance from the contaminated area to the nearest watercourse or arroyo?

- 0 feet (i.e., contamination has reached a watercourse or arroyo)
- 1-10 feet
- 11-20 feet
- 21-50 feet
- 51-100 feet
- 101-200 feet
- > 200 feet
- > 500 feet
- > 1000 feet

What is the slope of the ground in the contaminated area?

- 0-10%
- 10-30%
- > 30%

What is the approximate amount of ground and canopy vegetative cover in the contaminated area?

- < 25%
- 25-75%
- > 75%

Is there visible evidence of erosion (e.g., a rill or gully) in or near the contaminated area?

- Yes
- No
- Do not know

Do any structures, pavement, or natural drainage features direct run-on flow (i.e., surface flows originating upstream or uphill from the area of concern) into the contaminated area?

- Yes
- No
- Do not know

10. Could chemicals reach receptors through the dispersion of contaminants in air (e.g., volatilization, vapors, fugitive dust)? If yes, explain.

11. Could chemicals reach receptors through migration of non-aqueous phase liquids (NAPLs)? Is a NAPL present at the site that might be migrating towards receptors or habitats? Could NAPL discharge contact receptors or their habitat?

12. Could receptors be impacted by external irradiation at the site? Are gamma emitting radionuclides present at the site? Is the radionuclide contamination buried or at the surface?

TABLE 1
EXAMPLES OF SENSITIVE ENVIRONMENTS

National Parks and National Monuments

Designated or Administratively Proposed Federal Wilderness Areas

National Preserves

National or State Wildlife Refuges

National Lakeshore Recreational Areas

Federal land designated for protection of natural ecosystems

State land designated for wildlife or game management

State designated Natural Areas

Federal or state designated Scenic or Wild River

All areas that provide or could potentially provide critical habitat¹ for state and federally listed Threatened or Endangered Species, those species that are currently petitioned for listing, and species designated by other agencies as sensitive or species of concern

All areas that provide or could potentially provide habitat for state protected species as defined in the Wildlife Code, Chapter 17 of the New Mexico Statutes

All areas that provide or could potentially provide habitat for migratory birds as protected by the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712)

All areas that provide or could potentially provide habitat for bald eagles and golden eagles as protected by the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d)

1 Critical habitats are defined by the Endangered Species Act (50 CFR §424.02(d)) as:

- 1) Specific areas within the geographical area currently occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (i) essential to the conservation of the species and (ii) that may require special management considerations or protection, and
- 2) Specific areas outside the geographical area occupied by a species at the time it is listed upon a determination by the Secretary [of Interior] that such areas are essential for the conservation of the species.

All areas that provide or could potentially provide habitat for song birds as protected by the State of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-13)

All areas that provide or could potentially provide habitat for hawks, vultures and owls as protected by the State of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-14)

All areas that provide or could potentially provide habitat for horned toads and Bullfrogs as protected by the State of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-15 and 16, resp.)

All perennial waters (e.g., rivers, lakes, playas, sloughs, ponds, etc)

All ephemeral drainage (e.g., arroyos, puddles/pools, intermittent streams, etc) that provide significant wildlife habitat or that could potentially transport contaminants off site to areas that provide wildlife habitat

All riparian habitats

All perennial and ephemeral wetlands (not limited to jurisdictional wetlands)

All areas that are potentially important breeding, staging, and overwintering habitats as well as other habitats important for the survival of animals during critical periods of their life cycle.

ATTACHMENT B
ECOLOGICAL SITE EXCLUSION CRITERIA CHECKLIST AND
DECISION TREE

NEW MEXICO ECOLOGICAL EXCLUSION CRITERIA CHECKLIST

The following questions are designed to be used in conjunction with the Ecological Exclusion Criteria Decision Tree (Figure 1). After answering each question, refer to the Decision Tree to determine the appropriate next step. In some cases, questions will be omitted as the user is directed to another section as indicated by the flow diagram in the Decision Tree. For example, if the user answers “yes” to Question 1 of Section I, he or she is directed to proceed to Section II.

I. Habitat

In the following questions, “affected property” refers to all property on which a release has occurred or is believed to have occurred, including off-site areas where contamination may have occurred or migrated.

1. Are any of the below-listed sensitive environments at, adjacent to, or in the locality¹ of the affected property?
 - National Park or National Monument
 - Designated or administratively proposed Federal Wilderness Area
 - National Preserve
 - National or State Wildlife Refuge
 - Federal or State land designated for wildlife or game management
 - State designated Natural Areas
 - All areas that are owned or used by local tribes
 - All areas that are potentially important breeding, staging, and overwintering habitats as well as other habitats important for the survival of animals during critical periods of their life cycle
 - All areas that provide or could potentially provide habitat for state and federally listed Threatened or Endangered Species, those species that are currently petitioned for listing, and species designated by other agencies as sensitive or species of concern
 - All areas that provide or could potentially provide habitat for state protected species as defined in the Wildlife Code, Chapter 17 of the New Mexico Statutes
 - All areas that provide or could potentially provide habitat for migratory birds as protected by the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712)
 - All areas that provide or could potentially provide habitat for bald eagles and golden eagles as protected by the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d)
 - All areas that provide or could potentially provide habitat for song birds as protected by the state of New Mexico statute (New Mexico Statute, 1978, Chapter

1 *Locality* of the site refers to any area where an ecological receptor is likely to contact site-related chemicals. The locality of the site considers the likelihood of contamination migrating over time and places the site in the context of its general surrounding. Therefore, the locality is typically larger than the site and the areas adjacent to the site.

17, Game and Fish, 17-2-13)

- All areas that provide or could potentially provide habitat for hawks, vultures and owls as protected by the state of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-14)
- All areas that provide or could potentially provide habitat for horned toads and bullfrogs as protected by the state of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-15 and 16, respectively)

2. Does the affected property contain land areas which were not listed in Question 1, but could be considered viable ecological habitat? The following are examples (but not a complete listing) of viable ecological habitats:

- Wooded areas
- Shrub/scrub vegetated areas
- Open fields (prairie)
- Other grassy areas
- Desert areas
- Any other areas which support wildlife and/or vegetation, excluding areas which support only opportunistic species (such as house mice, Norway rats, pigeons, etc.) that do not serve as prey to species in adjacent habitats.

The following features are not considered ecologically viable:

- Pavement
- Buildings
- Paved areas of roadways
- Paved/concrete equipment storage pads
- Paved manufacturing or process areas
- Other non-natural surface cover or structure

3. Does the affected property contain any perennial or ephemeral aquatic features which were not listed in Question 1?

II. Receptors

1. Is any part of the affected property used for habitat, foraging area, or refuge by any rare, threatened, or endangered species (plant *or* animal), or otherwise protected species (e.g., raptors, migratory birds)?
2. Is any part of the affected property used for habitat, foraging area, or refuge by any species used as a recreational (e.g., game animals) and/or commercial resource?

3. Is any part of the affected property used for habitat, foraging area, or refuge by any plant or animal species? This includes plants considered “weeds” and opportunistic insect and animal species (such as cockroaches and rats) if they are used as a food source for other species in the area.

III. Exposure Pathways

1. Could receptors be impacted by contaminants via direct contact?
Is a receptor located in or using an area where it could contact contaminated air, soil³, or surface water?

For Questions 2 and 3, note that one must answer “yes” to all three bullets in order to be directed to the “exclusion denied” box of the decision tree. This is because answering “no” to one of the questions in the bullet list indicates that a complete exposure pathway is not present. For example, in Question 2, if the chemical cannot leach or dissolve to groundwater (bullet 1), there is no chance of ecological receptors being exposed to the chemical through contact with contaminated groundwater. Similarly, the responses to the questions in Question 4 determine whether a complete pathway exists for exposure to NAPL.

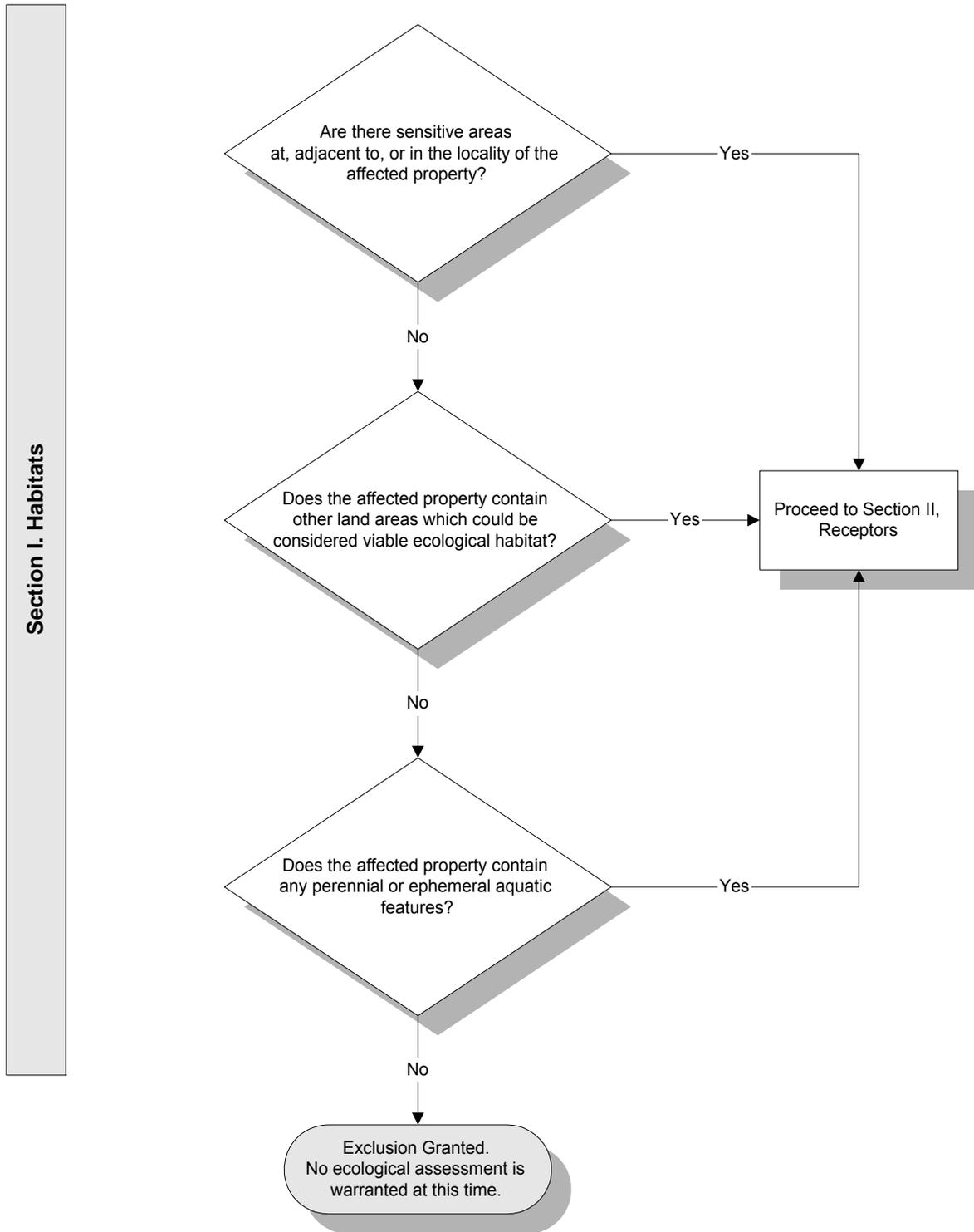
2. Could receptors contact contaminants via groundwater?
 - Can the chemical leach or dissolve to groundwater⁴?
 - Can groundwater mobilize the chemical?
 - Could (does) contaminated groundwater discharge into known or potential receptor habitats?
3. Could receptors contact contaminants via runoff (i.e., surface water and/or suspended sediment) or erosion by water or wind?
 - Are chemicals present in surface soils?
 - Can the chemical be leached from or eroded with surface soils?
 - Is there a receptor habitat located downgradient of the leached/eroded surface soil?
4. Could receptors contact contaminants via migration of non-aqueous phase liquids (NAPL)?
 - Is NAPL present at the site?
 - Is NAPL migrating toward potential receptors or habitats?
 - Could NAPL discharge impact receptors or habitats?

³ For soil, this means contamination less than 5 feet below ground surface (bgs).

⁴ Information on the environmental fate of specific chemicals can be found on the Internet at <http://www.epa.gov/opptintr/chemfact/> or at a local library in published copies of the *Hazardous Substances Data Bank*.

Figure 1 -Ecological Exclusion Criteria Decision Tree
(Refer to corresponding checklist for the full text of each question)

Figure 1 - Exclusion Criteria Decision Tree (continued)



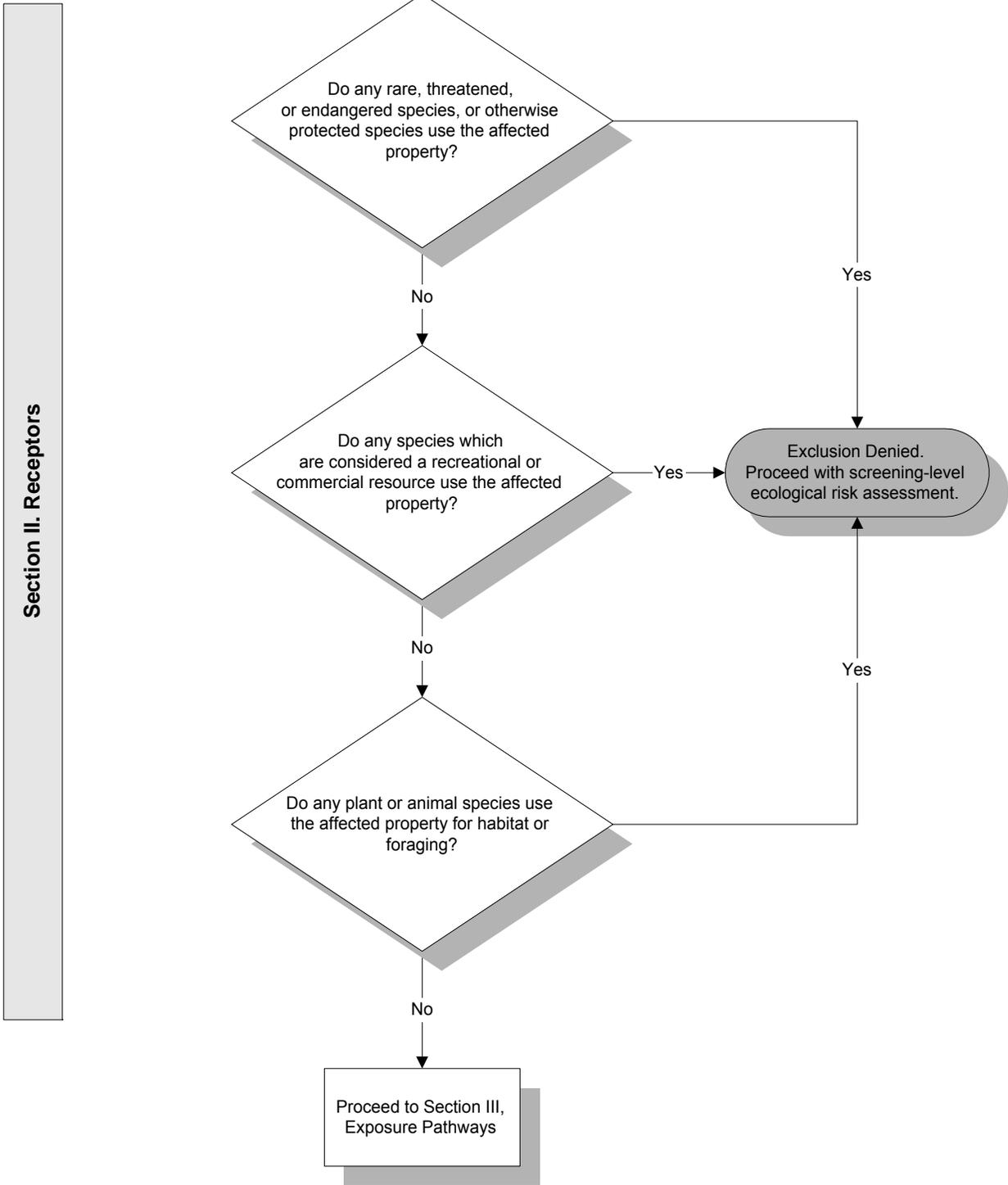


Figure 1 - Exclusion Criteria Decision Tree (continued)

