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Technical Background Document for the Sewage Sludge Exposure and Hazard Screening Assessment

Prepared for

Office of Water
U.S. Environmental Protection Agency

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List of Abbreviations

3MRA	Multimedia, Multipathway, Multireceptor Risk Assessment
ADD	average daily dose
AUR	air unit risk factor
BAF	bioaccumulation factor
BD	bulk density
CC	critical concentrations
CD	critical dose
CSF	cancer slope factor
CWA	Clean Water Act
DAF	dilution-attenuation factor
EFH	Exposure Factors Handbook
EPA	U.S. Environmental Protection Agency
ERL	effects range-low value
FOC	fraction organic carbon
GIS	geographic information system
GSCM	Generic Soil Column Model
HHB	human health benchmark
HQ	hazard quotient
IRED	Interim Reregistration Eligibility Decision
IRIS	U.S. EPA's Integrated Risk Information System
ISCST3	Industrial Source Complex Short-Term Model, Version 3
IWAIR	Industrial Waste Air Model
LADD	lifetime average daily dose
LAU	land application unit
MIBK	methyl isobutyl ketone
NAS	National Academy of Sciences
NODA	Notice of Data Availability
NSSS	1989 National Sewage Sludge Survey
OPP	U.S. EPA Office of Pesticide Programs
OSW	U.S. EPA Office of Solid Waste
OW	U.S. EPA Office of Water
PAD	population adjusted dose
RED	Reregistration Eligibility Decision
RfC	reference concentration
RfD	reference dose
SIS	Surface Impoundment Study
TRED	Tolerance Reregistration Eligibility Decision
UAC	unit air concentration
URF	unit risk factor
USLE	Universal Soil Loss Equation
WMU	waste management unit

Executive Summary

ES.1 Background

In February 1993, the U.S. Environmental Protection Agency (EPA) published the Standards for the Use or Disposal of Sewage Sludge (40 CFR Part 503). This rule is known as the Round One Sewage Sludge Regulation. 40 CFR Part 503 under section 405 of the Clean Water Act (CWA) contains management practices, pollutant limits for metals, and technology-based operational standards for pathogens that protect public health and the environment from reasonably anticipated adverse effects of pollutants in sewage sludge when the sewage sludge is land applied, placed in a surface disposal unit, or fired in a sewage sludge incinerator.

Section 405 of the CWA required EPA to propose and, after receipt and consideration of public comments, publish a decision to either (1) establish a Round Two regulation under Part 503 for additional pollutants in sewage sludge or (2) issue a finding of "no action" for these Round Two pollutants. In addition, Section 405(d)(2)(C) of the CWA requires that, bienially, EPA review the current literature to determine if additional chemical pollutants are warranted for addition to the Part 503 rule.

EPA also asked the National Research Council (NRC) of the National Academy of Sciences (NAS) to evaluate the technical basis of the Part 503 Round One rulemaking, report its conclusions, and make recommendations for future sewage sludge regulatory efforts. The NRC study took place between January 2001 and June 2002. In July 2002, the NRC published a report entitled *Biosolids Applied to Land: Advancing Standards and Practices* in response to EPA's request. EPA has pursued the following NAS-recommended activities, which are described in this document:

- A literature review to identify potentially toxic chemicals that may be present in sewage sludge but that are not already addressed by EPA rulemaking activities (i.e., chemicals other than the Round One chemicals and the Round Two chlorinated dibenzo-p-dioxins, chlorinated dibenzofurans, and co-planer polychlorinated biphenyls [PCBs]).

- A screening assessment to identify which of these additional chemicals should be subjected to a multipathway exposure and hazard assessment.

These activities thus identify and select additional chemicals for the multipathway screening assessment. The purpose of this document is to present the methodology and results of the screening assessment that was conducted to identify additional pollutants for consideration in potential rulemaking under section 405(d)(2)(C) of the CWA.

ES.2 Overview of Screening Assessment Methodology

The 40 chemicals selected by EPA for exposure and hazard screening (see Table 1-1) were each evaluated in two sewage sludge management practices: (1) the application to agricultural land scenario, and (2) the sewage sludge lagoon scenario (i.e, surface disposal unit).

For the agricultural land application scenario, EPA assumed that sewage sludge is applied to both pastureland and cropland that are used to raise food for human consumption. The farmer was assumed to apply sewage sludge to pastureland and cropland at the appropriate agronomic rates (i.e, sewage sludge was applied biennially at a rate of 5 to 10 metric tons per hectare dry weight). The agricultural land application scenario considered exposure to humans and wildlife species following the application of sewage sludge containing each of the pollutants to a nationwide distribution of farms. Many parameters were set to higher-end or reasonable upper bound values to ensure that all potentially hazardous pollutants in sewage sludge were identified for an exposure and hazard assessment (see Table ES-1).

Application to both row crops and pasture includes runoff into two waterbody types:

- An index reservoir used as a source of drinking water by the farm family
- A farm pond populated and frequented by ecological receptors and used by the farm family for recreational fishing.

The “index reservoir” is modeled after the Shipman City Lake in Shipman, Indiana, for drinking water exposures. This reservoir covers 13 acres, is 9 ft deep, and has a watershed area of 427 acres. The ratio of drainage area to capacity (volume of water in the lake) is approximately 12 for the index reservoir in this assessment. These areas remain constant in this assessment, and the same index reservoir was assumed to occur in each of the 41 climate regions. Also, in the screening assessment, it was assumed that the 427-acre watershed area contains other farms that also apply sewage sludge occupying 10 to 80 percent of the watershed in aggregate (in addition to the modeled farm).

The second waterbody type is a farm pond and was used to evaluate ecological exposure, and human exposure from fish consumption. It was assumed that the pond’s total drainage basin includes the farm area and that the pond has a drainage-area-to-capacity ratio of five. The farm pond depth is assumed to be constant at 9 feet. The area of the modeled pond is proportional to the area of the farm. EPA also assumed that there is no buffer between the amended agricultural land and the farm pond; thus, EPA assumes that the erosion and runoff from the agricultural land go directly to the farm pond.

The lagoon scenario was the surface disposal unit chosen for the model because sewage sludge disposed of in such an impoundment is likely to have the greatest potential of the various surface disposal configurations to cause groundwater contamination. EPA assumed that sewage sludge is managed in a lagoon or non-aerated surface impoundment that contains 10 percent total suspended solids (TSS) with hydraulic residence times greater than 2 years, and that no food chain or ecological exposures occur from sewage sludge in this surface lagoon scenario. It was assumed that these impoundments are located in a rural industrial setting where residents live

Table ES-1. Reasonable Upper Bound Assumptions Used in the Agricultural Land Application Scenario

Parameter	Assumption
Chemical properties	If no data are found for hydrolysis or degradation, those values are assumed equal to zero.
Concentration	The concentration is assumed to be the 95th percentile measured value from the 1989 National Sewage Sludge Survey (NSSS).
Receptors	Members of the subpopulation defined as subject to RME are assumed to be farmers living immediately adjacent to the farm where sewage sludge is applied. They are assumed to get a significant portion of all their diet items from homegrown products produced on sludge-amended soils and to drink and shower with either untreated surface water from the index reservoir or groundwater from a residential well immediately below the cropland. These individuals are more highly exposed to sewage sludge than the general population.
Site-specific parameters	A distribution of site-specific parameters was used for the 41 climate regions.
Air modeling data	Maximum values for air concentrations of vapors and particles and wet and dry deposition of vapors and particles are assumed to apply to the entire area of the cropland, pasture, buffer, and waterbody.
Groundwater screening	Groundwater ingestion assumes that the well water concentration is the concentration in the leachate at a depth of 1 m beneath the crop soil. The maximum annual concentration is used as the groundwater exposure concentration resulting from leachate.
Waterbody	A small, fixed-size index reservoir is used to evaluate ingestion of surface water receiving runoff. A small farm pond receiving runoff is used to evaluate fish ingestion and potential ecological impact.
Exposure factors	Distributions of values from the *Exposure Factors Handbook* (U.S. EPA, 1997a,b,c) are used to estimate exposure factors.
Ecological hazard	The most sensitive benchmark is used for each receptor/chemical combination. For chemicals and receptors without measured values, a default of one is used as the bioaccumulation factor (BAF). Maximum 1-day, 4-day, 21-day, or annual farm pond concentrations are used for ecological hazard to match with the duration of the study used as the basis of the benchmark. All ecological exposures are assumed to be from the sludge-amended areas. For the ingestion pathway, 100% of each receptor's diet is assumed to come from the sludge-amended field or the farm pond.

within a distribution of distances relatively close to the lagoon, where they might be exposed to ambient air contaminated by sludge pollutants or where they might ingest drinking water from residential groundwater wells. These modeled residents also use their residential wells as a source of drinking water and for other household uses, such as showering. Many parameters were set to higher-end or reasonable upper bound values to ensure that potentially hazardous pollutants in sewage sludge were identified for an exposure and hazard assessment (see Table ES-2).

Table ES-2. Reasonable Upper Bound Assumptions Used in the Sewage Sludge Lagoon Scenario

Parameter	Assumption
Chemical properties	If no data are found for hydrolysis or degradation, those values are assumed equal to zero.
Concentration	The concentration is the 95th percentile measured value from the 1989 NSSS.
Receptors	Modeled residents are members of a rural family who live downwind (based on prevailing winds) from the sewage sludge lagoon and have a residential well that is used for drinking water and showering.
Site-specific parameters	A distribution of site-specific parameters was used for the surface impoundment sites.
Air modeling data	Maximum values were used for air concentrations of at each receptor distance.
Groundwater screening	Residential well water concentration is one-half the concentration in the leachate immediately beneath the sludge lagoon. The maximum annual leachate concentration is used for noncancer endpoints. The maximum concentration in leachate for the exposure duration is used for cancer endpoints.
Exposure factors	Distributions of values from the *Exposure Factors Handbook* (U.S. EPA, 1997a,b,c) are used to estimate exposure factors.

For modeling exposure to humans, members of the subpopulation are defined as subject to reasonable maximum exposure (RME) and include a farm family (child and adult). For the agricultural land application scenario, the farm family is assumed to live on a farm and consume farm-raised foods where land-applied sewage sludge is used as fertilizer or a soil amendment and, therefore, are more highly exposed to sewage sludge than the general population. The farm family's diet is assumed to include a significant portion of home-produced foods, including exposed and protected fruits and vegetables, root vegetables, beef, and milk. Ecological species modeled include invertebrate and vertebrate animals and plants that may be exposed to contaminants through agricultural application of sewage sludge as a fertilizer or soil amendment.

The total ingestion dose from all ingestion pathways was compared with the critical dose to yield ingestion pathway screening results. For inhalation exposures, the annual average ambient air concentration and annual average shower air concentration were the exposure concentrations of concern and were compared with the critical concentrations to yield the inhalation screening results. Ecological receptors were assumed to forage on the agricultural land and in and around the farm pond. The ecological exposure concentrations or doses were compared with ecological benchmarks for the same time scale (1-day, 4-day, 21-day, or annual) to yield ecological screening results. Dermal exposure was not evaluated because dermal exposure is considered minimal for purposes of this screening assessment.

ES.3 Summary of Results

A screening assessment was performed for 40 selected pollutants using the two management scenarios. This section presents the list of pollutants that resulted in hazard quotients (HQs) greater than one for human health and greater than or equal to one for ecological species[1] at the 95th percentile of the HQ distribution. For this assessment, HQ is the ratio between the environmental concentration and the critical concentration, or the ratio between the receptor dose and the critical dose.

Table ES-3 presents the list of pollutants that had HQs greater than one in the human health screen. Table ES-4 presents the list of pollutants that had HQs greater than or equal to one in the ecological screen for the land application scenario. Table ES-5 presents the list of pollutants that had HQs greater than one for the human health screen in the sewage sludge lagoon scenario.

Table ES-3. Human Hazard Quotient Values Greater Than One at the 95th Percentile of the HQ Distribution by Pathway for the Agricultural Land Application Scenario

CASRN	Chemical	Pathway	Receptor	HQ
14797-65-0	Nitrite	Ingestion of Surface Water	Child	1.1
		Total Ingestion	Child	1.3
7440-22-4	Silver	Ingestion of Milk	Adult	3.8
			Child	12.0
		Total Ingestion	Adult	4.0
			Child	12.3

[1] Exposure at or below the human health benchmark values are considered protective of human health. Hence, the HQ values greater than one are considered to have failed the human health screen. Exposure at or above the ecological benchmarks or values are considered to exceed a level considered to be protective of wildlife species and the environment. Hence, the HQ values equal to or greater than one are considered to have failed the ecological screen.

Table ES-4. Hazard Quotient Values Greater Than or Equal to One at the 95th Percentile of the HQ Distribution for Aquatic and Terrestrial Wildlife Via Direct Contact Pathways[a]

CASRN	Chemical	Receptor[b]	HQ
67-64-1	Acetone	Sediment Biota	356.2
120-12-7	Anthracene	Sediment Biota	2.9
7440-39-3	Barium	Aquatic Community	235.7
7440-41-7	Beryllium	Aquatic Community	7.8
75-15-0	Carbon disulfide	Sediment Biota	1.9
106-47-8	4-Chloroaniline	Aquatic Invertebrates	1.3
333-41-5	Diazinon	Sediment Biota	1.1
206-44-0	Fluoranthene	Aquatic Community Sediment Biota	10.7 4.2
7439-96-5	Manganese	Aquatic Community	13.9
78-93-3	Methyl Ethyl Ketone	Sediment Biota	5.8
108-95-2	Phenol	Sediment Biota	102.4
129-00-0	Pyrene	Aquatic Community Sediment Biota Soil Biota	41.9 21.1 4.5
7440-22-4	Silver	Aquatic Community Aquatic Invertebrates Fish	246.6 28.2 4.8

[a] No pollutant resulted in an HQ equal to or greater than one for any wildlife species based on ingestion pathways.

[b] Sediment biota organisms include sediment invertebrates; aquatic community organisms include fish, aquatic invertebrates, aquatic plants, and amphibians; soil biota organisms include soil invertebrates.

Table ES-5. Human Hazard Quotient Values Greater Than One at the 95th Percentile of the HQ Distribution by Pathway for the Sewage Sludge Lagoon Scenario

CASRN	Chemical	Pathway	Receptor	HQ
7440-39-3	Barium	Drinking Water from Groundwater	Adult	1.5
			Child	3.5
106-47-8	4-Chloroaniline	Drinking Water from Groundwater	Adult	2.7
			Child	6.4
7439-96-5	Manganese	Drinking Water from Groundwater	Adult	32.3
			Child	76.3
14797-65-0	Nitrite	Drinking Water from Groundwater	Adult	13.6
			Child	33.8
14797-55-8	Nitrate	Drinking Water from Groundwater	Adult	9.2
			Child	23.0

ES.4 Document Organization

This background document is organized into the following sections:

- Section 1, *Planning, Scoping, and Problem Formulation*, describes the background and purpose of the screening assessment; the pollutants, sources, sites, receptors, exposure pathways, and endpoints considered in the assessment; and the conceptual model and analysis plan used to conduct the assessment.

- Section 2, *Analysis Phase*, describes the technical approach, assumptions, and data underlying the source modeling, fate and transport modeling, exposure modeling, and screening criteria development for the assessment.

- Section 3, *Screening Results*, presents the results of the screening assessment and discusses sources of variability and uncertainty in the assessment.

The following appendices, A through S, provide more detailed technical information on the data, models, and methods used in the screening assessment, as well as more detailed information on the results of the assessment:

- Appendix A, Characterization of Surface Impoundments

- Appendix B, Farm Size and Location

- Appendix C, Meteorological Data
- Appendix D, Soil Data
- Appendix E, Chemical Data
- Appendix F, Biota Data
- Appendix G, Surface Impoundment Model Documentation
- Appendix H, Source Model for Land Application Units
- Appendix I, Air Dispersion and Deposition Data and Modeling Input Files
- Appendix J, Surface Water Model
- Appendix K, Fate, Transport, and Hazard Calculations for Human Health and Ecological Effects
- Appendix L, Human Exposure Factors
- Appendix M, Bioaccumulation Factors and Bioconcentration Factors Used in the Ecological Screening Assessment
- Appendix N, Ecological Exposure Factors
- Appendix O, Human Health-Based Chemical Selection Process
- Appendix P, Ecological Benchmarks
- Appendix Q, Human Health Results
- Appendix R, Ecological Results
- Appendix S, Sensitivity Analysis Results.

1.0 Planning, Scoping, and Problem Formulation

The planning, scoping, and problem formulation phase of a screening assessment defines the objectives, basic framework, and plan for a subsequent risk assessment phase. This initial screening of pollutants in sewage sludge is designed to identify those pollutants that may pose risks to human health and the environment when sewage sludge is land applied or disposed in a sludge lagoon. The pollutants identified by the screening assessment will be further assessed through a more refined risk assessment and risk characterization and potentially included in the Standards for the Use or Disposal of Sewage Sludge (40 CFR Part 503).

This section begins with the regulatory background and purpose of this screening assessment (Section 1.1). The properties of sewage sludge are described in Section 1.2. Sewage sludge, along with the common sludge management practices (Section 1.3), defines the source term for this screening. The environmental settings and site layouts where these practices may occur are described in Section 1.4. Section 1.5 describes the conceptual model used in the screening. Section 1.6 describes the exposure pathways by which receptors can be exposed to sewage sludge pollutants, and Section 1.7 describes the human and ecological receptors of concern for the screening assessment. The human health and ecological endpoints selected for the assessment are described in Section 1.8. As the final output of the problem formulation phase, the analysis plan (Section 1.9) describes how this screening process was conducted to provide the U.S. Environmental Protection Agency (EPA) with the information needed to select the pollutants in need of further evaluation for possible inclusion in the sewage sludge management standards.

1.1 Background and Purpose

In February 1993, the EPA published the Standards for the Use or Disposal of Sewage Sludge (40 CFR Part 503). This rule is known as the Round One Sewage Sludge Regulation. Part 503 contains management practices, pollutant limits, and technology-based operational standards that protect public health and the environment from reasonably anticipated adverse effects of pollutants in sewage sludge when the sewage sludge is land applied, placed in a surface disposal unit, or fired in a sewage sludge incinerator.

Section 405 of the Clean Water Act (CWA) required EPA to propose and, after receipt and consideration of public comments, publish a decision to either (1) establish a Round Two regulation under Part 503 for additional pollutants in sewage sludge or (2) issue a finding of “no action” for these Round Two pollutants. In addition, Section 405(d)(2)(C) of the CWA requires that, bienially, EPA review the current literature to determine if additional chemical pollutants are warranted for addition to the Part 503 rule. In May 1993, EPA provided a preliminary list of 31 pollutants for the Round Two activity. EPA then conducted preliminary exposure analyses to determine which of these 31 pollutants to include on the final Round Two pollutant list. Based on the results of those analyses, three groups of pollutants were placed on the Round Two candidate list of pollutants:

- Polychlorinated dibenzo-p-dioxins (7 congeners)
- Polychlorinated dibenzofurans (10 congeners)
- Coplanar polychlorinated biphenyls (PCBs) (12 congeners).

EPA evaluated these pollutants (collectively known as dioxin and dioxin-like compounds ["dioxins"]) for the management practices of land application, disposal in surface impoundments, and incineration and issued subsequent rules for dioxins.

EPA also asked the National Research Council (NRC) of the National Academy of Sciences (NAS) to evaluate the technical basis of the Part 503 rulemaking, report its conclusions, and make recommendations for future sewage sludge regulatory efforts. The NRC study took place between January 2001 and June 2002. In July 2002, the NRC published a report entitled *Biosolids Applied to Land: Advancing Standards and Practices* in response to EPA's request. On April 9, 2003 (68 Federal Register 17379-17395), EPA published its plan to respond to the NAS recommendations, along with its rationale and a solicitation for public comments. Since then, EPA has pursued the following NAS-recommended activities, which are described in this document:

- A literature review to identify potentially toxic chemicals that may be present in sewage sludge but that are not already addressed by EPA rulemaking activities.

- A screening assessment to identify which additional chemicals should be subjected to further evaluation or potentially considered in future rulemaking.

These activities thus identify and select additional chemicals for the multipathway exposure and hazard assessment. The purpose of this document is to present the screening methodology and results used to identify additional pollutants that require further evaluation and potential inclusion in future rulemaking activities under Part 503.

1.2 Characterization of Sewage Sludge

The characterization of sewage sludge includes the identification of the potential pollutants in the sludge, and the specification of other physical and chemical properties of sludge that are required to conduct a screening assessment.

1.2.1 Pollutants in Sewage Sludge

To identify pollutants for the screening assessment, EPA first compiled a list of more than 800 chemicals that occur in sewage sludge, then narrowed this list down to 40 pollutants by removing chemicals that had insufficient data for screening or that were otherwise unsuitable for the screening assessment.

EPA conducted an extensive literature search to obtain publicly available information on chemicals that may occur in sewage sludge, both at the national level and at the international level. The literature search covered 1990–2002 and identified a substantial number of chemicals found in sewage sludge from 25 countries. In addition, the 1989 National Sewage Sludge Survey (NSSS) (U.S. EPA, 1996) monitored about 400 chemicals. The list of chemicals from the NSSS was combined with the list of chemicals identified in the literature search, giving a total of 803 candidate chemicals for the screening assessment. These chemicals are listed in Table 1 of Appendix O.

EPA then applied a series of screening criteria to the list of 803 chemicals to eliminate chemicals that had insufficient data or were otherwise unsuitable for screening from further consideration. Each of these screening steps is described below.

- **Chemicals with no human health benchmarks or not occurring in sewage sludge—**EPA eliminated 571 chemicals based on the absence of health benchmark or occurrence information. EPA assessed the availability of human health benchmarks from a variety of sources (see Appendix O for a complete list). Chemicals with no human health benchmarks from any of those data sources were removed from consideration, because further hazard screening is not possible in the absence of toxicity values. In addition, if a chemical was not found in the literature search and was monitored but not detected in the NSSS, it was deleted from further consideration, because it appears not to be present in sewage sludge.

- **Chemicals already regulated in Round One—**EPA eliminated 9 metals that were regulated in Round One of the Part 503 sewage sludge standards.

- **Chemicals evaluated and determined not to be a hazard**—EPA eliminated 15 chemicals that are unlikely to pose a hazard from their presence in sewage sludge. Calcium and magnesium are essential nutrients. Phthalic anhydride degrades extremely rapidly in soil. Chromium is present in sewage sludge as the less toxic chromium III species and is unlikely to present a hazard. The remaining 11 chemicals in this category (aldrin, chlordane, DDD, DDE, DDT, dieldrin, heptachlor, heptachlor epoxide, hexachlorobenzene, lindane and toxaphene) are banned or severely restricted pesticides. These organochlorine pesticides were evaluated in 1992 and were not considered to present a health hazard from their presence in sewage sludge.

- **Chemicals not occurring in U.S. sewage**—Only concentration values that have been measured in U.S. sewage sludge are considered appropriate for estimating exposure of the U.S. population to chemicals in sewage sludge. Therefore, EPA eliminated 129 chemicals not detected or not monitored in the NSSS and with no literature concentration values in U.S. sewage sludge.

- **Chemicals without chronic human health benchmarks from IRIS or OPP—**Of the health assessment databases EPA used to identify human health benchmarks, EPA considered the Integrated Risk Information System (IRIS) and Office of Pesticide Programs (OPP) databases best suited for the Agency's potential regulatory activities for this screening assessment. Therefore, EPA eliminated 17 chemicals that did not have IRIS or OPP human health benchmarks. In addition, EPA eliminated one chemical that does have an IRIS benchmark (strontium) because available data on the environmental properties of strontium are inadequate to conduct exposure screening. Note that the availability of ecological benchmarks was not a criterion for selecting or eliminating pollutants. Ecological benchmarks were identified or developed for the selected pollutants to the extent supported by available data when sufficient human health-related data existed.

- **Chemicals with an ongoing IRIS or OPP assessment—**IRIS and OPP are currently conducting a detailed review of recent scientific information for 20 chemicals. In addition, at the request of EPA, the NRC is conducting a review of the toxicological, epidemiological, clinical, and exposure data on oral ingested fluoride from drinking water and other sources. Because the results of these new health assessments are not yet available or may change, EPA has eliminated these 21 chemicals at this time.

This process resulted in the list of 40 chemicals that have been screened in the assessment described in this document. A more detailed discussion of the chemical selection process is presented in Appendix O. Table 1-1 lists the pollutants, their frequency of detection in sewage sludge, and their measured concentrations in sewage sludge. The screening concentration used in this assessment was the 95^{th} percentile of the measured concentration in sludge in the 1989 NSSS.

Table 1-1. Pollutants Selected for Sewage Sludge Exposure and Hazard Screening Assessment

Chemical	CASRN[a]	95^{th} Percentile of Concentration Range NSSS (mg/kg)[b]	Detect in NSSS (%)
Acetone	67-64-1	116	58
Acetophenone	98-86-2	32.9	2
Anthracene	120-12-7	32.9	2
Azinphos methyl	86-50-0	0.311	2
Barium	7440-39-3	1730	100
Benzoic acid	65-85-0	167	4
Beryllium	7440-41-7	8.00	22
Biphenyl, 1,1-	92-52-4	33.3	1
Butyl benzyl phthalate	85-68-7	32.9	9
Carbon disulfide	75-15-0	3.13	10
Chloroaniline, 4-	106-47-8	33.3	5
Chlorobenzene; phenyl chloride	108-90-7	3.13	2

(continued)

Table 1-1. (continued)

Chemical	CASRN[a]	95th Percentile of Concentration Range NSSS (mg/kg)[b]	Detect in NSSS (%)
Chlorobenzilate	510-15-6	0.0967	7
Chlorpyrifos	2921-88-2	0.157	3
Cresol, o- (2-methylphenol)	95-48-7	42.8	6
Diazinon	333-41-5	0.150	2
Dichloroethene, 1,2-trans-	156-60-5	2.94	1
Dichloromethane	75-09-2	31.3	42
Dioxane, 1,4-	123-91-1	3.13	2
Endrin	72-20-8	0.0415	6
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104-64-5	0.124	2
Fluoranthene	206-44-0	32.9	5
Hexachlorocyclohexane, alpha-	319-84-6	0.0228	2
Hexachlorocyclohexane, beta-	319-85-7	0.0415	6
Isobutyl alcohol	78-83-1	3.13	3
Manganese	7439-96-5	1620	100
Methyl ethyl ketone	78-93-3	69.3	34
Methyl isobutyl ketone (MIBK); methyl-2-pentanone, 4-	108-10-1	15.6	2
Naled	300-76-5	0.840	2
Nitrate	14797-55-8	5020	95
Nitrite	14797-65-0	462	83
N-Nitrosodiphenylamine	86-30-6	65.8	1
Phenol	108-95-2	57.5	34
Pyrene	129-00-0	33.0	5
Silver	7440-22-4	128	84
Trichlorofluoromethane	75-69-4	3.47	5
Trichlorophenoxy) propionic acid, 2-(2,4,5-	93-72-1	0.040	15
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93-76-5	0.0505	29
Trifluralin	1582-09-8	0.155	3
Xylenes (mixture)	1330-20-7	6.63	4

[a] Chemical Abstract Service Registry Number
[b] Dry weight

1.2.2 Properties of Sewage Sludge

In addition to identifying the pollutants in sewage sludge, it was necessary to select representative values for physical properties of the sludge to conduct a modeled exposure and hazard screening assessment. For this screening assessment, EPA assumed that the physical properties of sewage sludge could be adequately characterized by a single set of fixed values. EPA developed values for some of the physical characteristics of sludge (e.g., bulk density [BD], percent solids, and fraction organic carbon [foc]) as part of the Round One risk assessment. For other required physical characteristics (porosity and silt content), if values were not available from EPA for a specific parameter, values for silt soil were used. Table 1-2 lists the sewage sludge characteristics used in this assessment and the sources of these values. The characteristics used in this screening assessment are the same as those used in the risk assessment conducted for the "Exposure Analysis for Dioxins, Dibenzofurans, and Coplanar Polychlorinated Biphenyls in Sewage Sludge," published in support of the NODA (June 12, 2002).

Table 1-2. Physical Characteristics of Sewage Sludge

Characteristic	Parameter Value	Units	Source
Dry bulk density (BD)	1.5	g/cm^3	Technical Support Document for Land Application of Sewage Sludge (U.S. EPA, 1992)
Fraction organic carbon (foc)	0.4	Unitless	Best professional judgment
Percent solid	40 (land appl.) 10 (lagoon)	Volume percent	2001 NSSS (U.S. EPA, 2001)
Porosity	0.4	Unitless	Based on Carsel and Parrish (1988)
Silt content	2.2 to 21 Uniform distribution	Mass percent	Table 13.2.2-1 AP-42 (U.S. EPA, 1995a)

1.3 Source Characterization

This screening assessment evaluated two sewage sludge management practices:

- Land application of sludge to pastureland and cropland
- Surface disposal in sewage sludge lagoons.

1.3.1 Agricultural Land Application Scenario

For this scenario, EPA assumed that sewage sludge is applied to both pastureland and cropland used to raise food commodities for human consumption. The farmer was assumed to apply sewage sludge to pastureland and cropland at the appropriate agronomic rates and conditions, as follows:

- Sewage sludge is applied at a rate of 5 to 10 metric tons per hectare per application (uniform distribution)

- Applications occur once every 2 years for a variable period from one to 40 years (20 applications)

- Cropland is tilled to a depth of 20 cm at application and at two additional times during the year

- Pastureland is not tilled, but the sludge is incorporated to a depth of 2 cm by bioturbidation.

These assumptions reflect agricultural practices common throughout the United States and are the same as those made for the exposure assessment for dioxins in sewage sludge applied to agricultural land (U.S. EPA, 2002b).

In this assessment, the application frequency of sewage sludge was considered constant. Sewage sludge was assumed to be applied to the soil once every other year over a variable period of 1 to 40 years. To model this application process, a triangular distribution of application periods with a minimum of 1, a maximum of 40, and a mode of 20 years was used. The period of sludge application and the rate of application were assumed to be independent. The exposure period for human receptors (i.e., the farm family) was constrained to begin within the period of application of sludge to the agricultural land, but could continue after applications ceased. Application rates for sewage sludge were not varied with location, crop type, or soil characteristics but were assumed to vary independently on a nationwide basis.

A single farmland configuration was assumed in this screening assessment; this configuration defines the area in the immediate vicinity of the farm applying sludge and defines the geographic relationship among the important features of the scenario, such as the cropland, pasture, residence, and waterbodies (see Section 1.4). This configuration was assumed to occur in all environmental settings and was evaluated at each of the 41 climatic regions in the assessment.

1.3.2 Surface Disposal/Sewage Sludge Lagoon Scenario

For this scenario, EPA assumed that sewage sludge was managed in a non-aerated surface disposal lagoon. The lagoon in this exposure and hazard assessment is represented by non-aerated surface impoundments with retention times greater than 2 years. The surface impoundment was assumed to operate for a period of 50 years, after which time it was closed. Only the active life (50 years) of the surface impoundment was modeled. Surface impoundments used in this assessment were selected from a national distribution of non-aerated, nonhazardous surface impoundments based on a representative sample of surface impoundments developed by the EPA Office of Solid Waste (OSW) as part of the Surface Impoundment Study (SIS) (U.S. EPA, 2001b). These surface impoundments were modeled using the data and locations reported in the survey. These data are presented in Appendix A.

1.4 Layout and Setting

Sewage sludge is managed across the United States; therefore, EPA chose a regional approach to capture the variability in site conditions across the United States. This approach combines regional data with data that represent a generic site layout. The approach differs somewhat for the land application and lagoon scenarios because of differences in the pathways evaluated (leading to different site layouts with different data requirements) and differences in the data available.

1.4.1 Agricultural Land Application Scenario

For the agriculture land application scenario, climate and soil data are needed to characterize the environmental setting. These data include the meteorologic data used for air modeling, and the soil and climate data used to estimate fate and transport of the pollutants in the soil, surface waterbody, and groundwater.

The approach for the land application scenario consists of the following elements:

- Regional meteorological, soil, and farm size data for 41 climate regions were selected to capture the variability across the United States

- The site layout data describe a generic setting with one-half of the farm devoted to cropland and one-half of the farm devoted to pasture. Two waterbodies were associated with each farm: (1) a standard index drinking water reservoir receiving runoff with a fixed-size watershed to characterize drinking water risk, and (2) a farm pond receiving runoff to characterize ecological risk and risk from ingestion of home-caught fish.

These elements are discussed in more detail below.

1.4.1.1 Regional Data. The regional data were intended to represent the variability in climate, soil, and farm size attributable to the variety of geographic locations for land application of sewage sludge throughout the United States. This assessment used 41 climate regions, shown in Figure 1-1. The boundaries of these regions were drawn to circumscribe areas that could be represented by a single set of climatic data. The boundaries take into account geographic boundaries, such as mountains, and other parameters that differentiate meteorological conditions (i.e., temperature and windspeed). For each climate region, a representative meteorological data set was selected; the location of this data set is also shown in Figure 1-1. This data set was assumed to be representative of the conditions throughout the entire region and was used for all iterations of the assessment for that climate region. Appendix C provides the details of the meteorologic and climatic data used in the screening assessment. Once the boundaries of the climatic regions were established, soil and field size data (which are also associated with geographic location) were linked to these same regions. Within each of the 41 climatic regions, soil data for areas designated as agricultural land use were used to characterize the soil for that region. This approach captures the variability in soils in a manner that is generally representative of agricultural lands across the United States. A geographic information system (GIS) was used to compile soil texture and other soil data within each climatic region. Appendix D provides a complete description of the soil data used.

Figure 1-1. Map of 41 climatic regions.

Agricultural field size is also associated with location but not directly linked to climate or soil conditions. Farms in the more densely populated eastern part of the United States are much smaller than farms and ranches in the less densely populated western part of the country. The median farm size for each county within the climate region was obtained from the Census of Agriculture.[1] From these data, the farm size modeled for each climate region was determined by taking the average of the median farm size for all counties in the climate region. Appendix B presents the farm sizes used in this assessment.

The regional environmental setting approach maintains the correlation between conditions that are likely to occur together and prevents implausible combinations from being chosen in the probabilistic assessment. Using this approach, a climatic region was randomly selected for each iteration in the assessment, and all data for that iteration (climatic, soil, and field size) were selected to be consistent with that geographic region.

1.4.1.2 Site Layout Data. A generic site configuration including cropland, pastureland, and a waterbody was used to model the land application scenario. Two site configurations were used to represent two different types of waterbodies. In the first site configuration, depicted in Figure 1-2, the waterbody is an "index reservoir." The index reservoir is represented by

[1] The Census of Agriculture (U.S. DOC, 1994) provides periodic and comprehensive statistics about agricultural operations, production, operators, and land use. It is conducted every 5 years for years ending in 2 and 7. Its coverage includes all operators of U.S. farms or ranches (Division A, SIC 01-02) that sold or normally would have sold at least $1,000 worth of agricultural products during the census year. In 1992, approximately 1.9 million operators produced $162 billion in crops and livestock.

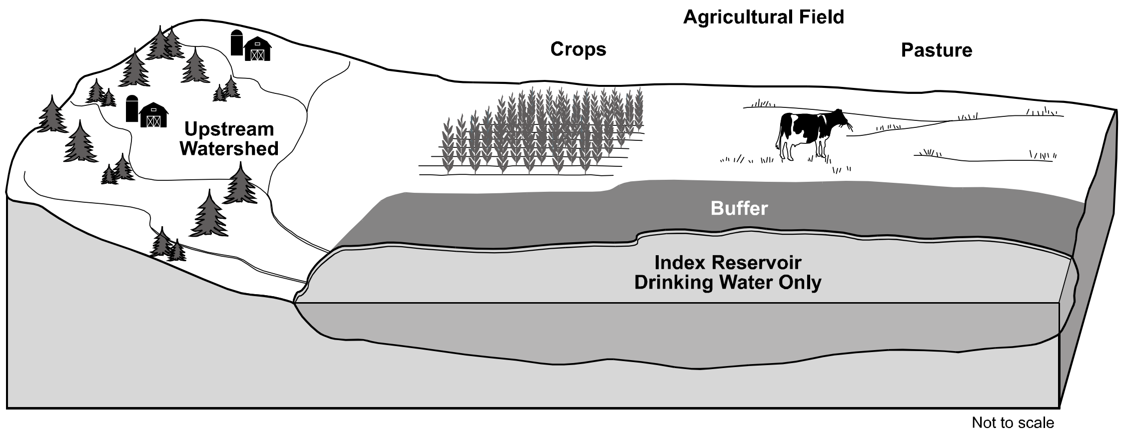

Figure 1-2. Agricultural field index reservoir scenario.

Shipman City Lake in Shipman, Indiana.[2] This reservoir has an area of 13 acres, a depth of 9 ft, and a watershed area of 427 acres. These values remain constant in the assessment, and the same index reservoir is assumed to occur in each of the 41 climate regions. The 427-acre watershed is assumed to contain other farms (in addition to the modeled farm) that also apply sewage sludge. These farms are assumed to occupy 10% to 80% of the 427-acre watershed. Drinking water exposures are assessed using this index reservoir, which receives runoff from agricultural land to which sewage sludge was applied as a fertilizer or soil amendment.

In the second site configuration, depicted in Figure 1-3, the waterbody is a farm pond. The farm pond is used to evaluate ecological exposures as well as human exposures via fish ingestion. The farm is assumed to be the total drainage basin for the farm pond. The area of the farm pond is not constant but is assumed to have a drainage-area-to-capacity ratio of 5. The farm pond depth is assumed to be constant at 9 ft; therefore, the area of the pond is proportional to the farm area. The farm pond is assumed to be located within or immediately adjacent to the farm, with the erosion and runoff from the agricultural land entering directly into the farm pond (no buffer).

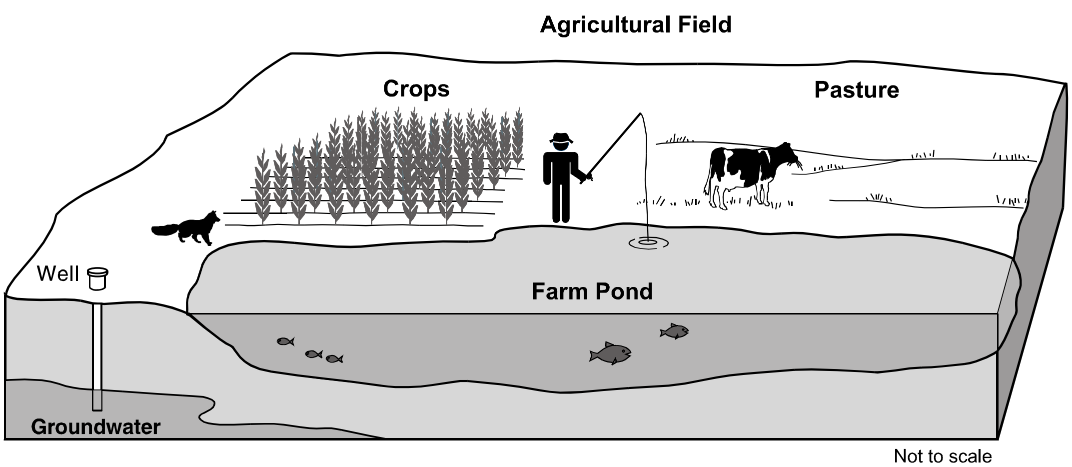

Figure 1-3. Agricultural field farm pond scenario.

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[2] EPA also selected Shipman City Lake as the index reservoir to use in modeling exposures to pesticides from consumption of drinking water from surface water (U.S. EPA, 2001a).

Both site configurations—the index reservoir and the farm pond—are described in *FIRST: A Screening Model to Estimate Pesticide Concentrations in Drinking Water* (U.S. EPA, 2001a), which describes the characteristics of the drainage areas of both waterbodies.

1.4.2 Lagoon Scenario

For the lagoon scenario, only the meteorologic data used for air modeling are needed to characterize the environmental setting.

The approach for the lagoon scenario consists of the following elements:

- Meteorological data were used from the meteorological station nearest to (and most representative of) the actual location of each impoundment from the SIS
- A generic site layout was used to represent the risk to rural residents living at various distances from disposal impoundments.

The meteorologic and climate data used in the assessment are dependent on the impoundment location reported in the SIS. Data from the nearest, most representative meteorological station were used.

Sewage sludge lagoons were assumed to be similar to nonaerated, nonhazardous surface impoundments with long hydraulic residence times. These impoundments are assumed to be located in a rural industrial setting where rural residents may (1) live within a distribution of distances relatively close to the lagoon, (2) be exposed to ambient air contaminated by sludge pollutants, and (3) ingest drinking water from residential groundwater wells. These residents also use their residential wells as a source of tapwater for other household uses, such as showering. Figure 1-4 depicts the lagoon scenario.

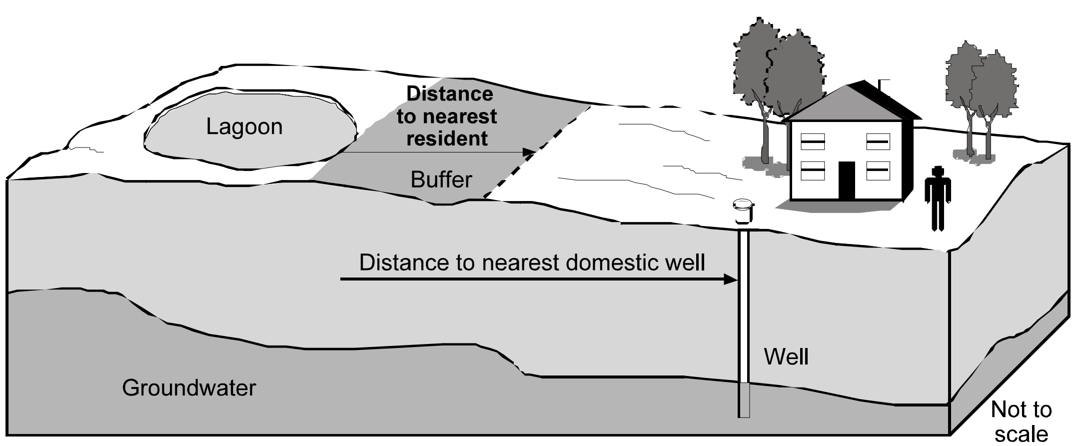

Figure 1-4. Sewage sludge lagoon scenario.

1.5 Conceptual Model

For both the agricultural land application and surface lagoon scenarios, conceptual models were developed to define the sources, releases, exposure pathways, and receptors to be addressed in the screening assessment. Figures 1-5 through 1-7 diagram these conceptual models for the agricultural land application with farm pond, agricultural land application with the index reservoir, and lagoon scenarios, respectively. These diagrams show how the data flow from the source models, which calculate releases to the environment, to the environmental fate and transport models, which calculate concentrations in the soil, sediment, surface water, leachate, and air. These media concentrations are then used to estimate pollutant movement through the food chain and finally exposures to human and ecological receptors.

Members of the human subpopulation defined as subject to reasonable maximum exposure (RME) are farm families assumed to live on a farm and consume farm-raised foods where land-applied sewage sludge is used as fertilizer or a soil amendment and, therefore, are more highly exposed to sewage sludge than the general population. All of the ingestion pathways (ingestion of food and water) were aggregated in the exposure models, where appropriate, to estimate total ingestion hazards to humans in this screening assessment. The ingestion and inhalation pathways were not aggregated. In this hazard screening assessment for sewage sludge, exposure to humans via inhalation for the pollutants that have reference concentration (RfC) values is negligible, as results indicate in the screen. The inhalation HQs for this screening assessment are several orders of magnitude lower than ingestion HQs and, thus, would not add meaningful results if aggregated. For the purposes of this screening assessment, a pathway providing exposure approximately three orders of magnitude lower than the predominant pathway (i.e., ingestion, in particular ingestion of drinking water) need not be aggregated.

The Agency did not assess exposure pathways for wildlife in the sewage sludge lagoon scenario (as a surface disposal unit) or the incineration scenario, but only in the land application scenario. EPA estimates that less than one percent of the sewage sludge produced annually in the United States is disposed of in surface disposal units, and approximately 17 percent is disposed of by combustion in sewage sludge incinerators. Thus, these disposal methods involve a relatively small proportion of total sewage sludge produced compared to land application of sewage sludge. In addition, surface disposal sites generally are areas with poor ecological habitat. Most of the sewage sludge produced in the United States goes to land application to fertilize crops or as a soil amendment. Therefore, the Agency did not assess aquatic and terrestrial wildlife exposure associated with surface disposal or incineration for this screening assessment. The land application scenario, which includes the treated agricultural cropland and pastureland and the farm pond, is more representative of wildlife habitat, and thus, where ecological exposures are most likely to happen. Therefore, EPA believes that assessment of wildlife exposure and hazard under the land application scenario is the most appropriate assessment and is protective of wildlife.

1.6 Exposure Pathways

As shown in Figures 1-5 through 1-7, the human and ecological receptors identified in the conceptual models for each of the sewage sludge management scenarios may be exposed through various pathways. This section describes the exposure pathways addressed for each receptor and scenario combination. More detailed information is provided in Appendices L and N.

1.6.1 Land Application Scenario

For the land application scenario, the farm family is the exposed human population. The ecological receptors for this scenario are terrestrial and aquatic wildlife species that frequent the crop and pasture or that live in or near the farm pond. The exposure pathways for each of these receptors are described in the following sections.

Human Receptors. The exposure pathways considered for the adult and child receptors are presented in Table 1-3. In summary, families living near sewage sludge incinerators and sewage-sludge lagoon, as well as farm families consuming food produced on sewage-sludge-amended soil, were considered the affected populations in this exposure screening assessment.

For the agricultural land application scenario, human members of the subpopulation defined as subject to RME are members of a farm family assumed to live on a farm and consume farm-raised foods where land-applied sewage sludge is used as fertilizer or a soil amendment. These individuals are more highly exposed to sewage sludge than the general population. In addition, EPA assumed that a higher percentage of the farm family's diet consists of food grown on sewage-sludge-amended soil. EPA also assumed that the adults on the farm consume fish caught from a nearby waterbody (a pond) and that the farm family also raises a significant portion of its fruit and vegetable diet on sewage-sludge-amended soils. In addition, the farm family is exposed through drinking water or showering in either untreated surface water from an index reservoir or groundwater from a residential well.

Table 1-3. Human Exposure Pathways for the Agricultural Land Application Scenario

Receptor	Inhalation of Ambient Air	Inhalation of Shower Indoor Air (Groundwater or Surface Water)	Ingestion of Soil	Ingestion of Untreated Drinking Water (Groundwater or Surface Water -Index Reservoir)	Ingestion of Produce	Ingestion of Beef and Dairy Products	Ingestion of Fish (Farm Pond)
Adult farmer	✔	✔	✔	✔	✔	✔	✔
Child farm resident	✔	✔	✔	✔	✔	✔	✔

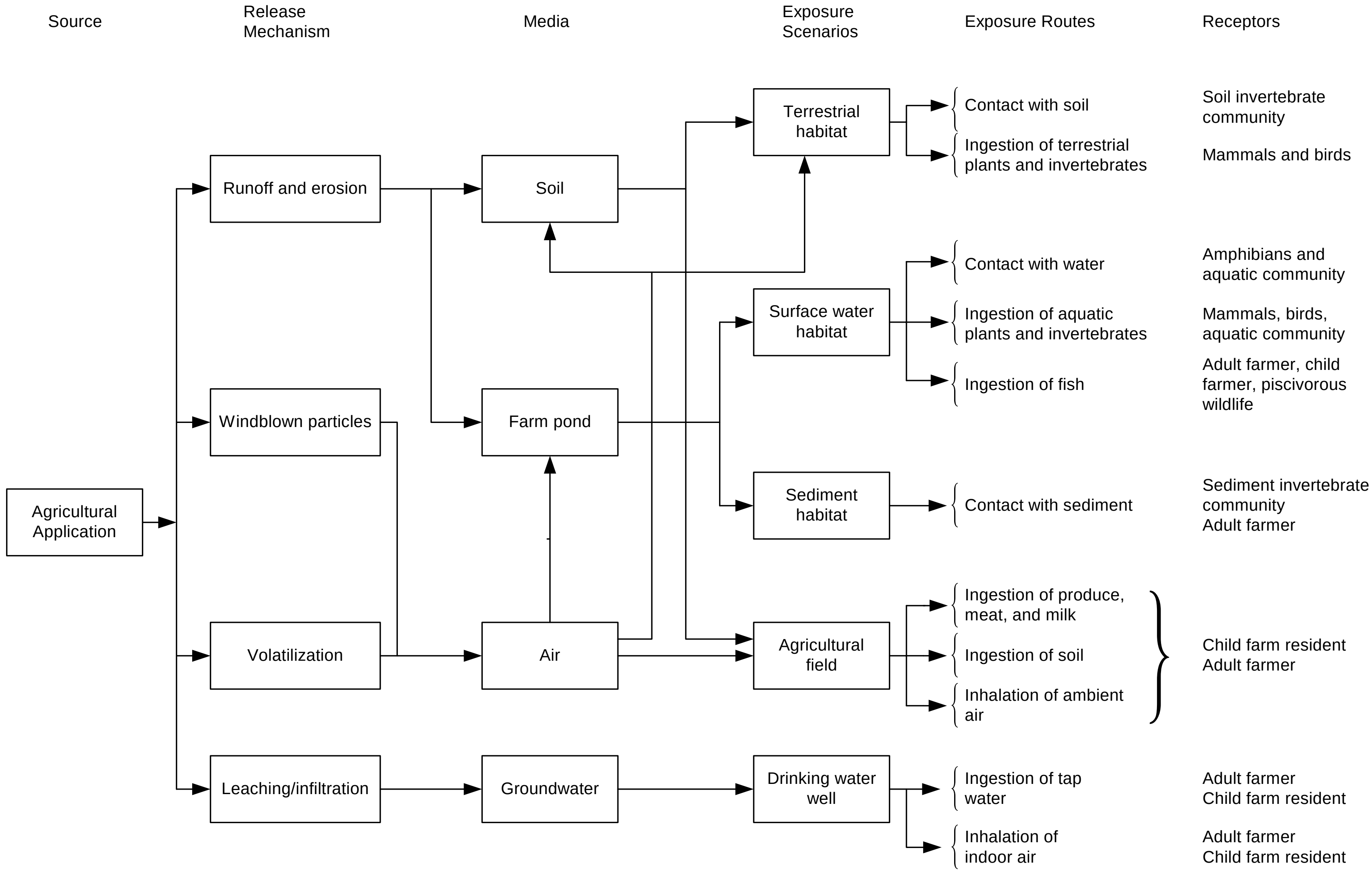

Figure 1-5. Conceptual model for the agricultural land application scenario (with farm pond).

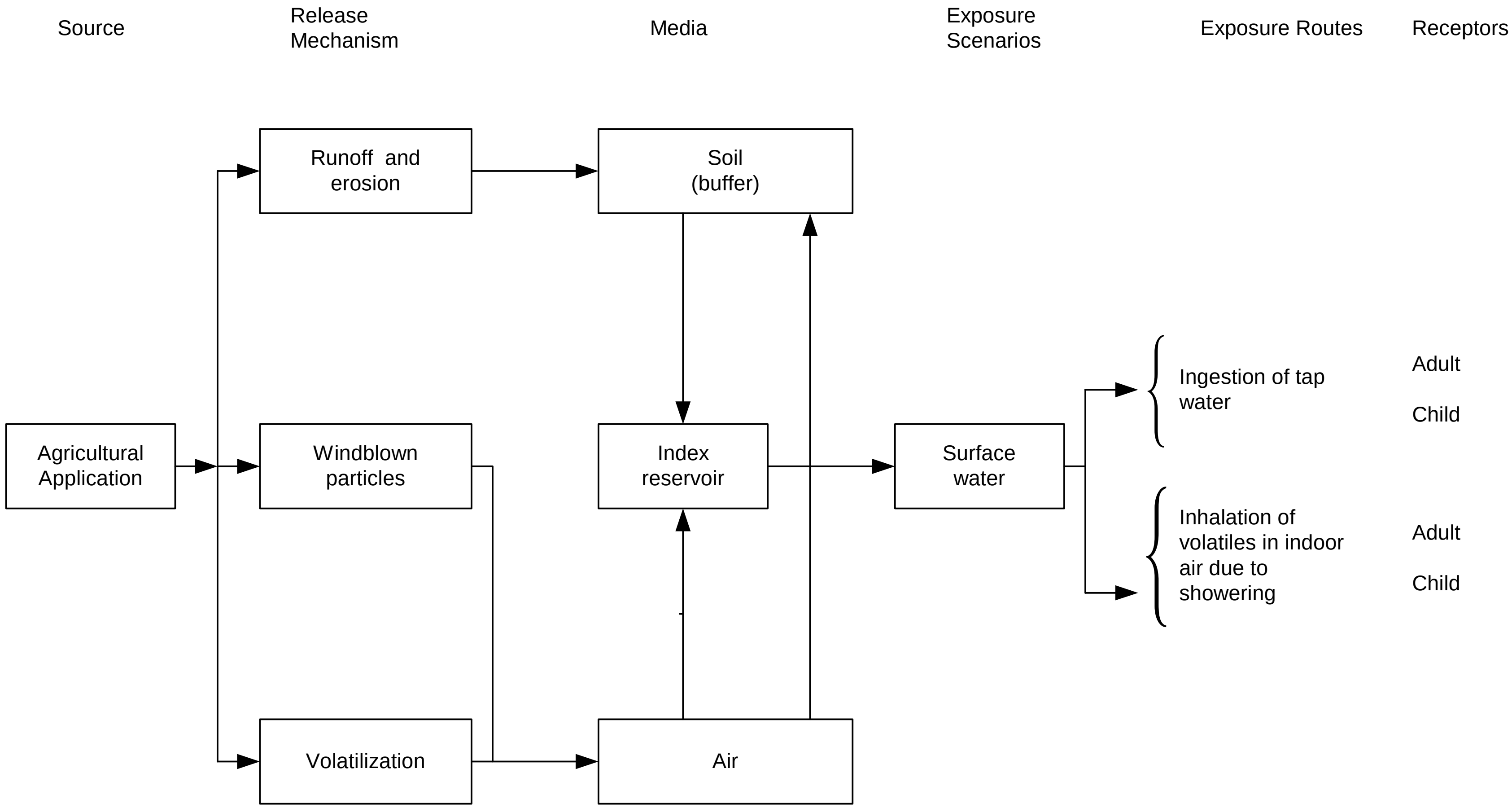

Figure 1-6. Conceptual model for exposure to household tapwater in the agricultural land application scenario (with index reservoir).

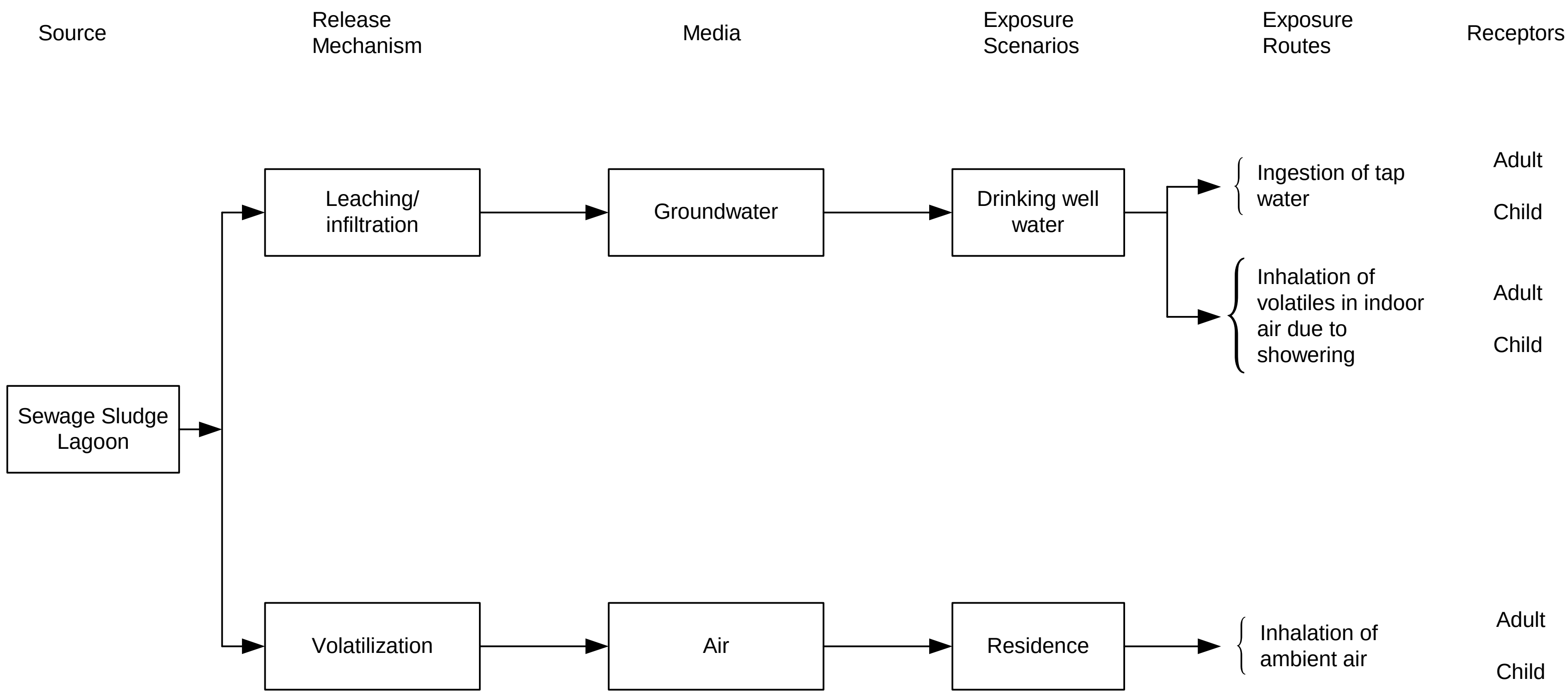

Figure 1-7. Conceptual model for sewage sludge lagoon.

Ecological Receptors. The ecological receptors considered in the land application scenario are assumed to be exposed on the farmland and in the farm pond. The exposure pathways assessed include direct exposure through contact with contaminated media and indirect exposure through ingestion of contaminated food and surface water. The environmental media assessed are soil, sediment, and surface water. Table 1-4 shows the pathways assessed for the different ecological receptors.

Table 1-4. Exposure Pathways for Wildlife Species[a]

Receptor	Direct Contact	Direct Contact Medium	Ingestion
Fish	✔	Surface water (farm pond)	
Aquatic invertebrates	✔	Surface water (farm pond)	
Aquatic plants	✔	Surface water (farm pond)	
Amphibians	✔	Surface water (farm pond)	
Aquatic community	✔	Surface water (farm pond)	
Sediment biota	✔	Sediment (farm pond)	
Soil invertebrates	✔	Soil (agricultural field)	
Mammals			✔
Birds			✔

[a] Sediment biota organisms include sediment invertebrates; aquatic community organisms include fish, aquatic invertebrates, aquatic plants, and amphibians; soil biota organisms include soil invertebrates. Individual mammal and bird species assessed are listed in Table 1-6 and are exposed through ingestion of contaminated terrestrial and aquatic prey and food items.

1.6.2 Lagoon Scenario

The exposed human population for the sewage sludge lagoon scenario is a family living near a facility with a sludge lagoon. This family has a residential drinking water well. The exposure pathways for adults and children in the sewage sludge lagoon scenario are presented in Table 1-5.

Ecological receptors are not considered in this scenario.

Table 1-5. Human Exposure Pathways for the Sewage Sludge Lagoon Scenario

Receptor	Inhalation of Ambient Air	Inhalation of Indoor Shower Air (Groundwater)	Ingestion of Drinking Water (Groundwater)
Adult resident	✔	✔	✔
Child resident	✔	✔	✔

1.7 Receptors

This screening assessment considers both human and ecological receptors in the agricultural application scenario. Only human receptors are considered in the sludge lagoon scenario.

1.7.1 Agricultural Land Application Scenario

In this screening assessment, as stated above in Section 1.6, the receptors considered in the agricultural application scenario include members of the farm family who apply sewage sludge on their farms and ecological receptors who live on or near the farm.

Human Receptors (Adult Farmer and Child Farm Resident). For the agricultural land application scenario, human members of the subpopulation defined as subject to RME are members of a farm family assumed to live on a farm and consume farm-raised foods where land-applied sewage sludge is used as fertilizer or a soil amendment. These individuals are more highly exposed to sewage sludge than the general population. In addition, EPA assumed that a higher percentage of the farm family's diet consists of food grown on sewage-sludge-amended soil. EPA also assumed that the adults on the farm consume fish caught from a nearby waterbody (a pond) and that the farm family also raises a significant portion of its fruit and vegetable diet on sewage-sludge-amended soils. In addition, the farm family is exposed through drinking water or showering (inhalation exposure) in either untreated surface water from an index reservoir or groundwater from a residential well.

Both adult and child members of a farm family are assumed to be exposed to contaminants through the application of sewage sludge to their own farm. The farm family is assumed to be living on the farm during the time that sludge is applied. The adults are assumed to be 20 years old or older when exposure begins, and the children in the farm family are assumed to begin exposure at 1 year of age.

Ecological Receptors. Ecological receptors include invertebrate and vertebrate animals and plants that may be exposed to contaminants through the agricultural application of sewage sludge. Ecological receptors are assumed to be exposed in the cropland and pasture and in the farm pond; therefore, both aquatic and terrestrial receptors were assessed. Two general types of receptors were included: single species, such as the raccoon or the red tail hawk, and assemblages of species, or communities, such as soil invertebrates. Tables 1-6 and 1-7 show the 36 ecological receptors considered in this assessment.

Table 1-6. Ecological Receptors—Mammal and Bird Wildlife Species

Species	Scientific Name	Feeding Guild[a]	Trophic Level[b]
American kestrel	*Falco sparverius*	C	T2
American robin	*Turdus migratorius*	O	T2
American woodcock	*Scolopax minor*	O	T2
Belted kingfisher	*Ceryle alcyon*	O	T2
Black bear	*Ursus americanus*	O	T3
Canada goose	*Branta canadensis*	H	T1
Cooper’s hawk	*Accipiter cooperi*	C	T3
Coyote	*Canis latrans*	O	T3
Deer mouse	*Peromyscus maniculatus*	O	T2
Eastern cottontail rabbit	*Sylvilagus floridanus*	H	T1
Great blue heron	*Ardea herodias*	O	T2
Green heron	*Butorides virescens*	O	T2
Least weasel	*Mustela nivalis*	C	T2
Little brown bat	*Myotis lucifugus*	I	T2
Long-tailed weasel	*Mustela frenata*	C	T2
Mallard	*Anas platyrhynchos*	O	T2
Meadow vole	*Microtus pennsylvanicus*	H	T1
Mink	*Mustela vison*	C	T2
Muskrat	*Ondatra zibethicus*	H	T1
Northern bobwhite	*Colinus virginianus*	O	T2
Prairie vole	*Microtus ochrogaster*	H	T1
Raccoon	*Procyon lotor*	O	T2
Red fox	*Vulpes vulpes*	O	T3
Red-tailed hawk	*Buteo jamaicensis*	C	T3
Short-tailed shrew	*Blarina brevicauda*	O	T2
Short-tailed weasel	*Mustela erminea*	C	T2
Tree swallow	*Tachycineta bicolor*	O	T2
Western meadowlark	*Sturnella neglecta*	O	T2
White-tailed deer	*Odocoileus virginianus*	H	T1

[a] Feeding guild: C = carnivore, H = herbivore, I = insectivore, O = omnivore.
[b] Trophic level: T1 = prey, not a predator; T2 = both a predator and prey; T3 = a top predator, not prey.

Table 1-7. Ecological Receptors—Communities

Receptor	Environmental Medium/Location
Fish	Surface water/farm pond
Aquatic invertebrates	Surface water/farm pond
Aquatic plants	Surface water/farm pond
Amphibians	Surface water/farm pond
Aquatic community	Surface water/farm pond
Sediment invertebrates	Sediment/farm pond
Soil invertebrates	Soil/agricultural fields

Screening assessments often address a few selected receptors known to be highly exposed to the pollutants of interest. For example, the phase 1 screening for dioxins in land-applied sewage sludge assessed risks to four receptors whose diets consist primarily of fish or sediment and soil invertebrates. Dioxin congeners are known to bioaccumulate in these food items, and these receptors were assumed to reflect high exposure levels. However, for this assessment, 40 different pollutants were assessed, including metals, pesticides, and other organics, and exposure pathways of concern included ingestion, as well as direct contact in three different environmental media (soil, sediment, and surface water).

Selecting a small group of receptors known to reflect the highest exposure levels for all pollutants and pathways was not possible because of the wide range in chemical properties. Therefore, the approach adopted was to assess receptors covering all trophic levels (T1 through T3) and feeding guilds (herbivory, omnivory, and carnivory) likely to occur in an agricultural setting and to include both mammals and birds for as many trophic level-feeding guild combinations as possible. Receptor species were selected based on feeding and foraging habitat. Wildlife species are assumed to spend 100 percent of their time on the farm following application of sewage sludge. Thus, 100 percent of their diet comprises contaminated food items. Animals that are expected to derive a significant portion of their diet from a farm scenario were included, as well as those that feed in and around farm ponds. In addition, species with broad distribution across the United States were selected to the extent possible. Feeding guilds were used to indicate diet preference, and trophic levels indicate placement on the food chain.

1.7.2 Lagoon Scenario (Human Only)

For the surface disposal unit scenario, EPA defined RME as exposure to a rural family living near a sewage sludge lagoon. This family is exposed through the ambient air and through the ingestion of drinking water and showering with tapwater from a residential drinking water well. There are no ecological receptors in this scenario.

1.8 Endpoint Selection

The endpoints selected for the screening assessment were chosen based on the most restrictive benchmarks available for each pollutant to be screened for both human receptors and ecological receptors. The selected endpoints are described in the following sections.

1.8.1 Human Health Benchmarks

The human health benchmarks selected for evaluation in the sewage sludge screening assessment include both cancer and noncancer benchmarks. HHBs were considered available for the screening assessment only if the HHB is posted on the IRIS Web site or a reregistration eligibility decision (RED) or interim reregistration eligibility decision (IRED) document is signed and posted on OPP's Web site. These databases are readily available to the public, provide a detailed explanation of the scientific basis of the health assessment, and are likely to be relatively stable (i.e., not subject to change before the next 2-year sewage sludge review cycle).

In the screening assessment, an OPP health assessment of a pesticide registered for food uses took precedence over an IRIS assessment of the same pesticide. For all other pollutants, the IRIS benchmark was used.

HHBs developed by IRIS and OPP used in this screening assessment include chronic reference doses (RfDs), chronic population adjusted doses (PADs), inhalation reference concentrations (RfCs), oral cancer slope factors (CSFs), and inhalation air unit risk factors (AURs). Table 1-8 presents the various HHBs available for the 40 chemicals selected for exposure and hazard screening.

Table 1-8. Human Health Benchmarks for Pollutants Selected for the Sewage Sludge Exposure and Hazard Screening Assessment

Chemical	CASRN	RfD (mg/kg/d)	PAD (mg/kg/d)	CSFo $(mg/kg/d)^{-1}$	RfC (mg/m^3)	AUR $(\mu g/m^3)^{-1}$	Source
Acetone	67-64-1	0.9					IRIS
Acetophenone	98-86-2	0.1					IRIS
Anthracene	120-12-7	0.3					IRIS
Azinphos methyl	86-50-0	0.0015	0.0015		0.0022		OPP
Barium	7440-39-3	0.07					IRIS
Benzoic acid	65-85-0	4.0					IRIS
Beryllium	7440-41-7	0.002			0.00002	0.0024	IRIS
Biphenyl, 1,1-	92-52-4	0.05					IRIS
Butyl benzyl phthalate	85-68-7	0.2					IRIS
Carbon disulfide	75-15-0	0.1			0.7		IRIS
Chloroaniline, 4-	106-47-8	0.004					IRIS
Chlorobenzene; phenyl chloride	108-90-7	0.02					IRIS
Chlorobenzilate	510-15-6	0.02					IRIS

(continued)

Table 1-8. (continued)

Chemical	CASRN	RfD (mg/kg/d)	PAD (mg/kg/d)	CSFo $(mg/kg/d)^{-1}$	RfC (mg/m^3)	AUR $(\mu g/m^3)^{-1}$	Source
Chlorpyrifos	2921-88-2	0.0003	0.00003		0.00005		OPP
Cresol, o- (2-methylphenol)	95-48-7	0.05					IRIS
Diazinon	333-41-5	0.0002	0.0002		0.00006		OPP
Dichloroethene, 1,2-trans-	156-60-5	0.02					IRIS
Dichloromethane	75-09-2	0.06		0.0075		0.00000047	IRIS
Dioxane, 1,4-	123-91-1			0.011			IRIS
Endrin	72-20-8	0.0003					IRIS
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104-64-5	0.00001					IRIS
Fluoranthene	206-44-0	0.04					IRIS
Hexachlorocyclohexane, alpha-	319-84-6			6.3		0.0018	IRIS
Hexachlorocyclohexane, beta-	319-85-7			1.8		0.00053	IRIS
Isobutyl alcohol	78-83-1	0.3					IRIS
Manganese	7439-96-5	0.14 (food);0.047 (water, soil)			0.00005		IRIS
Methyl ethyl ketone	78-93-3	0.6			5		IRIS
Methyl isobutyl ketone (MIBK); Methyl-2-pentanone, 4-	108-10-1				3.0		IRIS
Naled	300-76-5	0.002	0.002		0.0004		OPP
Nitrate	14797-55-8	1.6					IRIS
Nitrite	14797-65-0	0.1					IRIS
N-Nitrosodiphenylamine	86-30-6			0.0049			IRIS
Phenol	108-95-2	0.3					IRIS
Pyrene	129-00-0	0.03					IRIS
Silver	7440-22-4	0.005					IRIS
Trichlorofluoromethane	75-69-4	0.3					IRIS
Trichlorophenoxy) propionic acid, 2-(2,4,5-	93-72-1	0.008					IRIS
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93-76-5	0.01					IRIS
Trifluralin	1582-09-8	0.024		0.0077			OPP
Xylenes (mixture)	1330-20-7	0.2			0.1		IRIS

RfD = reference dose; PAD = population-adjusted dose; CSFo = oral cancer slope factor;
RfC = reference concentration; AUR = air unit risk factor

1.8.2 Ecological Endpoints

For an ecological screening assessment, endpoints are defined as “explicit expressions of the actual environmental value that is to be protected” (U.S. EPA, 1998). The values to be protected for this assessment are viable wildlife populations and ecological communities. However, in many cases, available ecotoxicological data do not directly address population- or community-level effects (e.g., resource availability, age structure, or predator-prey relationships). Particularly for the ingestion pathways, available data provide information on effects on individual organisms, such as reproductive or developmental effects or mortality. Therefore, benchmarks were selected that reflect effects that can be related to population viability.

Effects on reproductive success and growth and development are generally recognized as relevant to population and community viability, and these were the preferred endpoints when selecting ecological benchmarks. On the other hand, effects such as liver damage are not necessarily indicative of population-level effects and were not used to develop ecological benchmarks. Thus, many of the available mammalian toxicological data used for HHBs are not considered useful for ecological benchmarks. This approach assumes that if individuals are protected from adverse reproductive and developmental effects, protection at the population and community levels is inferred.

For many of the chemicals assessed, particularly the pesticides, the only ecotoxicological data identified were for mortality endpoints (e.g., lethal dose 50 [LD_{50}] and lethal concentration 50 [LC_{50}] values reflecting levels at which 50% of the test subjects died). In general, such data are not considered sufficiently protective for a screening-level assessment, but in the absence of other benchmarks, lethality endpoints do provide a basis for assessment. Therefore, benchmarks based on mortality endpoints were included in the ecological screening when more appropriate data could not be identified. Appendix P provides the critical endpoint that served as the basis for each benchmark used in the assessment. Further discussion of methods for selecting benchmark data is presented in Section 2.5.2, Ecological Screening Criteria.

1.9 Analysis Plan

The analysis plan describes how the relationships among the sources, release mechanisms, exposure scenarios, receptors, and benchmarks were considered in the analysis phase of the risk-based screening assessment. The plan includes the rationale behind the relationships that are addressed and the methods, models, data gaps, and uncertainties associated with the data and models. Because this is the first step in a tiered assessment, many of these data gaps and model uncertainties may be addressed in subsequent stages of the analysis.

1.9.1 Probabilistic Approach

EPA adopted a probabilistic approach for this assessment (see Section 2.1) to capture the nationwide variability in human and ecological exposures associated with sewage sludge management. This approach was consistent with EPA's probabilistic risk assessment guidance. The probabilistic approach involves running the modeling system for 3,000 iterations for each scenario and chemical of concern in sewage sludge. By varying model inputs across these iterations, the assessment captures the regional and national variability in site conditions, sludge management operations, exposure factors, receptor locations, and other factors that affect how people and organisms are exposed to pollutants in sewage sludge.

Within this probabilistic framework, each iteration is a predetermined deterministic calculation of the model. The approach is implemented by setting up input files prior to the assessment that include data that are randomly selected based on the regional setting and scenario selected for each iteration. Chemical-specific data are generally constant across all iterations[3] and are not correlated with other input parameters.

The primary constraint for other parameters in the assessment is the source location. For the agricultural land scenario, the location is determined by randomly selecting a climate station for each iteration. The selection of a climate station limits regionally collected data, which include soil data, long-term climate data, daily meteorological data, and farm size data.

For the lagoon scenario, a surface impoundment is randomly selected from the SIS survey database[4], and the SIS survey database is used to provide site-specific data (e.g., meterological data and surface impoundment dimensions) for that impoundment.

The probabilistic assessment cycles through the types of receptors addressed in the assessment, including adult and child receptors and ecological receptors. Receptor type determines the exposure factors used in the assessment. Receptor type and exposure factors are not specific to location and, for the human health assessment, are varied nationally. Exposure factors are randomly chosen for each iteration and are not correlated with each other or with geographic locations. Ecological receptors' exposure factors are set at median values and are not varied.

All parameters are selected prior to the assessment and, except for the chemical-specific inputs, the same 3,000-record input data set is used for each chemical addressed in the assessment. This will allow additive risk across chemicals to be considered in subsequent analyses.

1.9.2 Source Modeling

The source modeling simulates the release of pollutants as a result of the management of sewage sludge in lagoons or by application to agricultural land. The source models consider releases of pollutants to the environment through volatilization, and leaching to groundwater from lagoons. In the case of application of sludge to agricultural land, erosion from the agricultural land to nearby land and waterbodies is also modeled. The source modeling considers the environmental setting for each sludge management location modeled. Both source models used in this assessment were developed for EPA OSW to estimate releases from waste management units (WMUs) for the identification of hazardous wastes. These models have been peer reviewed and verified for accuracy. More details on each of the models can be found in Section 2.2 and in Appendices G and H.

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[3] Metal partition coefficients are varied using empirical distributions and are the only variable chemical-specific inputs.

[4] Surface impoundments were selected from the subset of nonaerated SIS surface impoundments with waste residence times of 2 years or more.

1.9.3 Fate and Transport Modeling

The fate and transport modeling addresses the movement of pollutants through the environment once they are released from the agriculture field or lagoon. The air model used in this assessment is the Industrial Source Complex Short-Term Model, Version 3 (ISCST3). ISCST3 is a steady-state Gaussian plume model used for modeling concentration, dry deposition, and wet deposition from point, area, volume, and open-pit sources; it was designed primarily to support EPA's regulatory modeling programs.

The agricultural land application source model also estimates erosion of soil runoff of pollutants from the agricultural land directly to the farm pond or through the buffer to the nearby index reservoir. The index reservoir drains a larger watershed area that also contains other agricultural land amended with sewage sludge. The additional contribution of pollutant to the index reservoir from these other areas of agricultural land application is estimated by extending the pollutant concentrations estimated from modeling of the primary farm to the entire watershed. The agricultural land application source model also estimates leachate concentrations at a depth of 1 m under the agricultural land. This leachate concentration is used as the concentration in the residential well that may be used as a drinking water source and as a source for tapwater used for showering. The ISCST3 air modeling was performed for these specific farm areas and locations as a part of the exposure assessment conducted for dioxins in sewage sludge applied to agricultural land, and the dispersion and deposition factors developed for that assessment were used.

The surface impoundment source model used to simulate sewage sludge lagoons estimates emissions of pollutants in vapor form to air and leaching of pollutants to groundwater. The modeling of vapors emitted from surface impoundments in specific locations was performed in support of Industrial Waste Air (IWAIR) model development. As with the sludge-amended land, the concentration of pollutants in the leachate under the surface impoundment is adjusted to represent dilution by ambient groundwater by using a protective dilution-attenuation factor (DAF). The residential well is assumed to be used as a source of drinking water and as a source for other household uses, such as showering.

1.9.4 Human Exposure Modeling

The outputs from the fate and transport model are used to estimate the amount of each pollutant to which the farm family or residents are exposed. In the agricultural scenario, farm family members are assumed to consume homegrown produce and animal products as a substantial portion (up to 49 percent) of their diet. After the fate and transport models have predicted concentrations of pollutants in the air, soil, water, and sediment, pollutant concentrations are calculated in food chain items.

Pollutants in air may be deposited on plants growing in the agricultural field. Simultaneously, these plants may take up pollutants from the soil. Plants thus accumulate pollutants from both routes (from air and soil) into the fruits and vegetables consumed by the farm family. In addition, beef and dairy cattle may consume forage and silage that are grown on a sludge-amended farm. Subsequently, the farm family may consume home-produced beef and dairy products from these animals. In addition, pollutants applied to the farm may erode and run off into the farm pond and accumulate in fish. The fish in the farm pond may be caught and consumed by members of the farm family. Family members are also assumed to incidentally ingest soil from the crop area close to their house and to drink and shower with water from either the index reservoir or an onsite residential well. In addition, the farm family breathes the ambient air on the farm.

The residents who live near the sewage sludge lagoon are assumed to drink and shower with water from an onsite residential well and to breathe the ambient air at their residential location. Section 2.4.1 describes the human exposure modeling conducted for this assessment.

1.9.5 Ecological Exposure Modeling

Ecological receptors occur only in the agricultural application scenario. For the screening assessment, it is assumed that 100 percent of receptors' diets comes from the farm pond and farm fields where sludge is applied. The aquatic receptors (aquatic community, aquatic plants, aquatic and benthic invertebrates, amphibians, and fish) are exposed in the farm pond. The terrestrial receptors (mammals, birds, and soil invertebrates) feed and forage on the crop field and pasture. In addition, some of the mammals and birds eat fish, benthic organisms (e.g., mussels and insect larvae), and aquatic plants from the farm pond. The concentrations in the soil, water, and vegetation to which the ecological receptors are exposed are the same as those calculated for the human health modeling. In addition, the surface water model generates sediment concentrations for the ecological exposure modeling. There are no ecological receptors associated with the index reservoir or the sewage sludge lagoon. The farm pond is considered to be a representative and protective scenario for evaluating exposures to ecological receptors (see discussion in Section 1.5). Section 2.4.2 describes the ecological exposure modeling conducted for this assessment.

1.9.6 Screening Criteria Development

The screening criteria for this assessment are based on both cancer and noncancer effects for human receptors and on effects relevant to population sustainability and community structure and function for ecological receptors. Criteria were developed for several key exposure pathways, including ingestion, inhalation (human health only), and direct contact (ecological risk only). These screening criteria are intended for use in the risk estimation by comparing each receptor-specific criterion (in units of dose or concentration) to the dose or concentration, as appropriate, predicted by the model.

The screening criteria used in this assessment are critical doses (CDs) or critical concentrations (CCs). The CCs are used as an air pathway criterion. For air exposures to pollutants with noncancer endpoints, the CC is the RfC as reported in IRIS. For air exposures to pollutants with cancer endpoints, the CC is associated with a risk of 1E-5, based on the AUR. If a pollutant has both a cancer and a noncancer inhalation benchmark, the lower CC calculated by these methods is the CC used as the screening criterion.

The screening criterion used for the ingestion pathways is the CD. For ingestion exposures to pollutants with noncancer endpoints, the CD is the RfD reported in IRIS or the RfD or the PAD reported in the RED and IRED documents issued by OPP. For ingestion exposures to pollutants with cancer endpoints, the CD is calculated as the dose that yields a cancer risk level of 1E-5 (1 in 100,000) over a lifetime (this dose is calculated as 1E-5/$CSF_{\_oral}$).

For ecological receptors, CDs were used for ingestion pathways (i.e., for mammals and birds), whereas CCs were used for direct contact exposures (e.g., fish and aquatic invertebrates). Additional detail on the development of screening criteria for this screening assessment can be found in Section 2.5.

2.0 Analysis Phase

The problem formulation phase presented in Section 1 provides the blueprint for the analysis phase of the screening assessment. As discussed in Section 1, EPA adopted a probabilistic approach for this assessment to capture the national variability in human and ecological exposures associated with sewage sludge managed through application to agricultural lands and disposal in sewage sludge lagoons. Section 2.1 describes the framework for the probabilistic assessment of chemicals of concern in sewage sludge, a simulation consisting of 3,000 iterations that varies data on region, waste management characteristics, exposure factors, receptor locations, and other variable input parameters to the model. Sections 2.2 through 2.5 describe the technical approach, assumptions, and data for the major modeling components (i.e., source; fate and transport; and exposure) and the development of screening criteria.

2.1 Probabilistic Modeling Framework

For each scenario and chemical evaluated, the screening analysis used 3,000 iterations of the probabilistic analysis. The analysis was implemented using a looping structure developed and applied for the agricultural land and lagoon scenarios as shown in Figures 2-1 and 2-2, respectively.

In this analysis, all chemical-specific parameters were assumed constant, with the exception of partition coefficients (K_d values) for metals, which were randomly sampled from empirical distributions during construction of the input files. Chemical inputs were not assumed to be correlated with other parameters.

For the agricultural land scenario, the location was determined by randomly selecting a climate station for each of the 3,000 iterations. For the lagoon scenario, a surface impoundment was randomly selected from the SIS survey database[1], and the location of that surface impoundment was used to determine the climate station for that iteration.

[1] Surface impoundments were selected from the subset of nonaerated SIS surface impoundments with waste residence times of 2 years or greater.

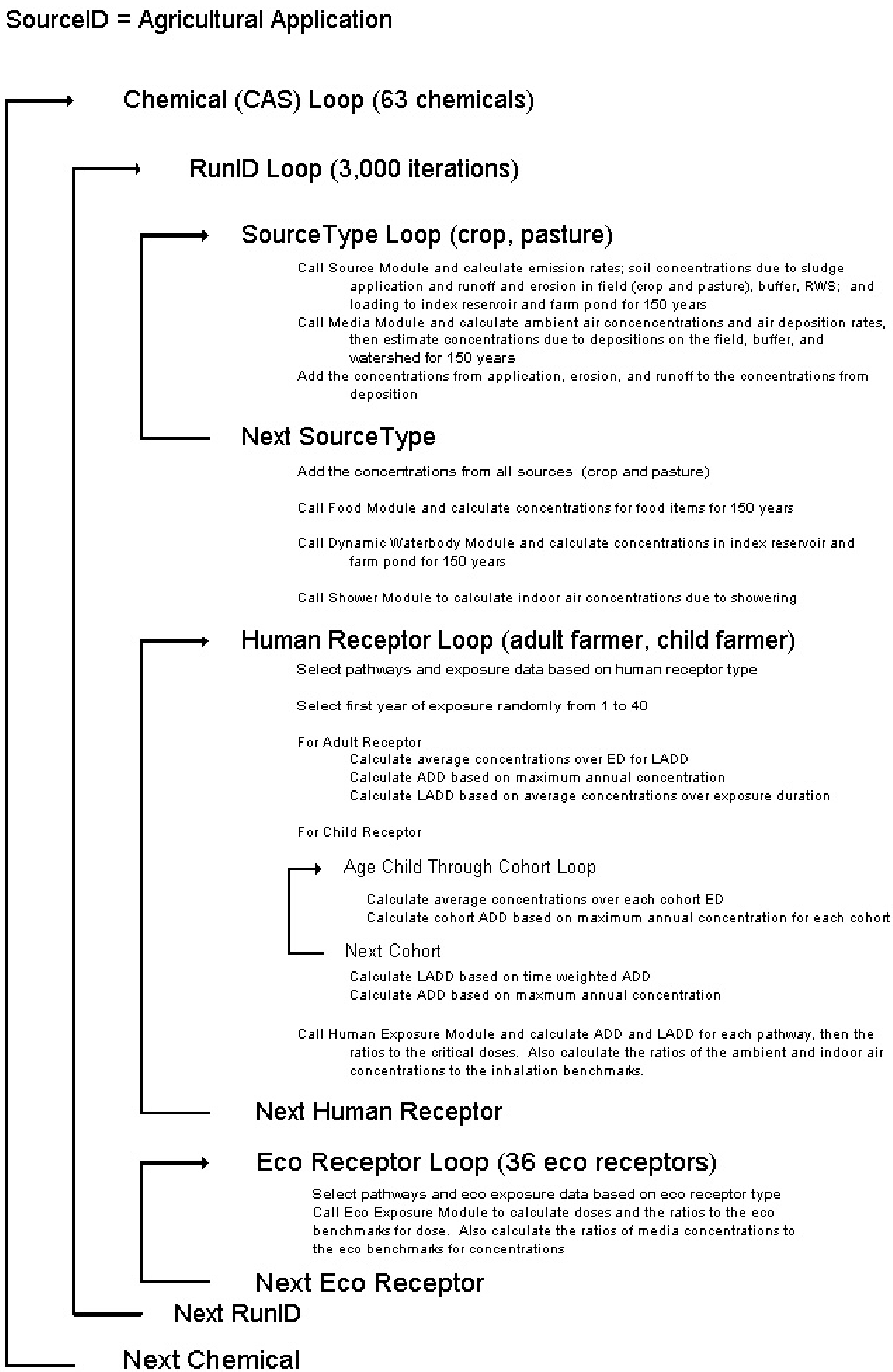

Figure 2-1. Looping structure for agricultural land application modeling.

SourceID = Sludge Disposal Lagoon

- Chemical (CAS) Loop (63 chemicals)
  - RunID Loop (3,000 iterations)

    Select a surface impoundment ID and associated site from SIS

    Call Source Module and calculate time series annual leachate concentrations and emissions for 50 years

    Calculate groundwater concentrations using DAF = 2

    Call Shower Module and calculate indoor air concentrations due to showering

    Select distance to air modeling receptor, select maximum unitized air concentration for distance, calculate time series annual ambient air concentration.

    Determine maximum years of groundwater, indoor air, and ambient air concentrations

    - Receptor Loop (adult resident, child resident)

      Select pathways and exposure data based on human receptor type

      Select the first and last year of exposure around the year with the maximum groundwater concentration and the maximum ambient air concentration.

      Calculate average ambient air and indoor air concentrations around the max year using ED

      For Adult Receptor
      - Calculate average groundwater concentrations over ED for LADD
      - Calculate ADD based on maximum annual groundwater concentration
      - Calculate LADD based on average groundwater concentrations over exposure duration

      For Child Receptor
      - Age Child Through Cohort Loop
        - Calculate average groundwater concentrations over each cohort ED
        - Calculate cohort ADD based on maximum annual concentration for each cohort
        - Calculate LADD based on time weighted ADD
      - Next Cohort

      Call Human Exposure Module and calculate the ratios of ADD and LADD to the critical doses. Also calculate the ratios of ambient air concentrations and indoor air concentrations to the inhalation benchmarks.

    - Next Receptor
  - Next RunID
- Next Chemical

Figure 2-2. Looping structure for sewage sludge lagoons.

The selection of a climate station limits regionally collected data (e.g., soil data, meteorological data, farm size) to conditions prevalent in the selected climate region. For soils, the probability of selecting a particular soil type was dependent on the prevalence of that soil type within the climate region. The remainder of the regional data were held constant for all iterations for a climate region. These data are the long-term climate data, the daily meteorological data, source area (farm area and surface impoundment area), and air modeling data (dispersion and deposition results that depend on the meteorological data and the source area).

The next loop in the probabilistic analysis cycled through the types of receptors addressed in the analysis. The model considered both adult and child receptors. The receptor type determined the exposure factors used in the analysis. Receptor type and exposure factors were not specific to location[2]; as a result, any receptor could be present at any location with any applicable exposure parameter values. This assumption applies to ecological receptors and to humans. Although some of the ecological receptors are not distributed throughout the United States (e.g., eastern cottontail rabbit), the species included were selected to provide as broad a distribution as possible. They are considered representative of receptors that would be exposed throughout the United States. Receptor-specific exposure factors include exposure duration, the year that exposure starts (for the agricultural scenario), dietary consumption rates, ingestion and inhalation rates, individual body weight, and showering parameters (e.g., shower duration). A set of adult and child exposure parameters was chosen for each iteration. Exposure parameters were not correlated with each other or with geographic locations. Ecological exposure factors were set at median values and were not varied.

All parameters were selected prior to the analysis and all 3,000 sets of selected parameters were placed in a database according to run number. For each chemical, the model stepped through the run numbers, using the selected parameters to calculate results for each of 3,000 iterations. In this way, the same non-chemical-specific parameters were used for each iteration of the analysis for every chemical. Thus, if it is appropriate to add the effects of different chemicals together (e.g., for carcinogens or chemicals with noncancer effects on the same target organ), the results can be summed on an iteration-by-iteration basis.

2.2 Source Modeling

Modeling the release of pollutants from the agricultural land and the sewage sludge lagoon requires models that are specific to these management practices. This section describes how the source models were applied in the screening analysis.

2.2.1 Modeling Agricultural Fields

Chemical releases from agricultural fields to surrounding media were simulated using a modified version of the land application unit (LAU) model initially developed as part of the Multimedia, Multipathway, Multireceptor Risk Assessment (3MRA) modeling system (U.S.

[2] Human exposure factors are selected from national distributions developed from data in EPA's *Exposure Factors Handbook* (U.S. EPA, 1997a,b,c). Ecological exposure factors are taken from EPA's *Wildlife Exposure Factors Handbook* (U.S. EPA, 1996), as well as several other sources, as described in Appendix N.

EPA, 2002b). An overview of the LAU model is presented in the following sections. Appendix H describes the important assumptions inherent in the LAU modeling approach, the fundamental fate and transport algorithms (the Generic Soil Column Model [GSCM]), its hydrology and soil erosion methodologies, the methods for estimating particulate emissions to the atmosphere, and modifications required to execute the LAU model for purposes of this analysis.

The inputs to the LAU model include

- Physical and chemical properties of the pollutant
- Size of the agricultural field
- Characteristics of the sludge (e.g., percent solids, bulk density, foc)
- Soil and climate conditions at the farm site
- Daily meteorologic data at the farm site
- Agricultural practices (e.g., application rate, tilling frequency)
- Site geometry (e.g., location of waterbody with respect to agricultural land).

The LAU model uses these inputs to estimate the vertical movement of the pollutants within the agricultural land (releases through leaching to groundwater), volatile and particle releases to the air, and horizontal movement of pollutants (runoff and erosion from the agricultural land across any buffer area to a nearby waterbody). These estimates are made using the GSCM as the computational engine. The particle emissions from the agricultural land as a result of tilling operations and wind erosion are estimated using equations based on empirical relationships developed by EPA in 1986 (updated, U.S. EPA, 1995a) and by Cowherd et al. (1985), and summarized in U.S. EPA (1995b). The model considers losses from the agricultural land due to hydrolysis and biodegradation, as well as leaching and volatilization.

The outputs of the agricultural application source model are:

- Annual vertical profile of the concentration of the pollutant in the soil of the agricultural land and buffer due to application of sewage sludge before the air deposition of pollutants

- Annual emission of volatile pollutants from the surface of the agricultural land

- Annual emission of pollutants sorbed to particles from the surface of the agricultural land due to tilling and wind erosion

- Daily concentrations and mass of soil eroded from the agricultural land (used in calculating the load to the farm pond or to the buffer)

- Daily concentrations and mass of soil eroded from the buffer area (used in calculating the load to the farm pond)

- Daily concentrations and volume of runoff from the agricultural land (used in calculating the load to the farm pond or to the buffer)

- Daily concentrations and volume of runoff from the buffer area (used in calculating the load to the farm pond)

- Annual infiltration rate of water from the agricultural land

- Annual leachate flux of pollutant from the agricultural land.

2.2.2 Modeling Sewage Sludge Lagoons

A lagoon of the type used to manage sewage sludge can be represented as a surface impoundment for modeling purposes. This screening assessment used a surface impoundment model initially developed for the 3MRA modeling system (U.S. EPA, 2002b) to estimate releases to the environment through the emission of volatile pollutants to the air and through the leaching of soluble pollutants to the groundwater. Appendix G provides a detailed description of the background and application of the surface impoundment model.

The surface impoundment model predicts emissions under normal operating conditions; the model does not estimate emissions due to overflows or structural failures of the impoundment. Emissions are assumed to occur only while the surface impoundment is operational; thus, pollutant releases are calculated for 50 years, which is the assumed operational life of sewage sludge lagoons. The surface impoundment model uses the following types of inputs to estimate environmental releases:

- Physical and chemical properties of the pollutant
- Characteristics of the sludge (e.g., percent solids, bulk density, foc)
- Size and characteristics of the lagoon
- Soil and climate conditions at the site of the lagoon.

The specific inputs and the data used in the surface impoundment source model are found in Appendix G. The surface impoundment model uses these data and considers losses in the impoundment due to hydrolysis, biodegradation, and the partitioning to and settling of suspended solids. The model takes into consideration the effects of environmental and waste temperatures on the fate of chemicals in the impoundment.

The outputs from the surface impoundment model include the following:

- Emission rates for volatile constituents from the surface of the lagoon
- Infiltration rate of liquid from the lagoon
- Leachate flux of pollutant from the lagoon.

The leachate flux and the infiltration rate are used to calculate the concentration of the pollutant in the leachate released from the bottom of the lagoon.

2.3 Fate and Transport Modeling

This section describes the methodology and the models used to predict the fate and transport of pollutants in the environment after release from the agricultural land or lagoon.

Once pollutants are released, they move through the environment by the natural processes depicted in Figure 2-3. The purpose of the fate and transport modeling is to estimate the concentrations of pollutants in environmental media (i.e., air, soil, and food items) at the point of exposure. To predict a pollutant's movement through these different media, several media-specific fate and transport models are employed. Fate and transport models are a series of either computer-based algorithms or sets of equations that predict chemical movement due to natural forces. These fate and transport models integrate information on a site's geology, hydrology, and meteorology with chemical, physical, and biological processes that take place in the environment. The result is a simulation of chemical movement in the environment and a prediction of the concentration of a chemical at specific locations called the "exposure points."

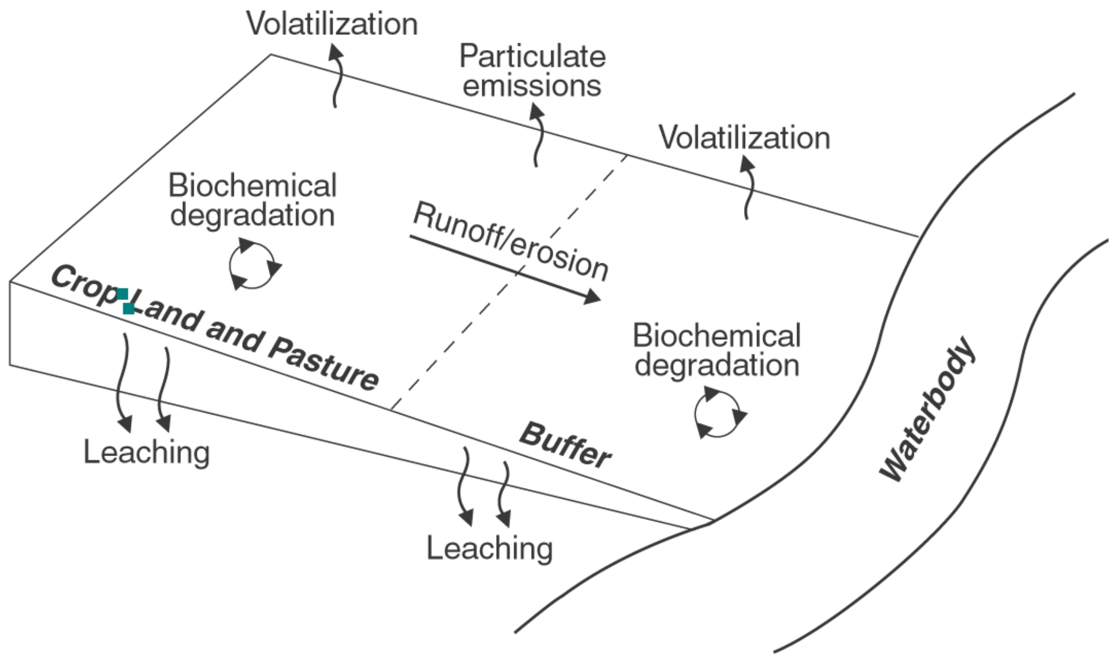

Figure 2-3. Emissions mechanisms in the local watershed.

The following fate and transport models were used for this analysis:

- Air dispersion and deposition model (ISCST3)
- Watershed and waterbody models
- Dilution-attenuation factor for groundwater transport
- Food chain model.

These models and the general framework for performing the fate and transport modeling are described in the following sections. Section 2.3.1 discusses the air dispersion and deposition modeling. Section 2.3.2 describes the watershed and waterbody model used to determine watershed soil, farm pond, and index reservoir pollutant concentrations, along with the approach used to estimate groundwater concentrations. Detailed descriptions of the models and a comprehensive list of the input values used in them can be found in Appendices I, J, and K. The calculations of the food chain model are based on these media concentrations and are presented in Section 2.3.3. Section 2.3.4 describes the aquatic food web calculation used in the ecological assessment.

2.3.1 Air Dispersion and Deposition Modeling (ISCST3)

Dispersion modeling uses a computer-based set of calculations to estimate ambient ground-level constituent concentrations associated with constituent releases from sewage sludge management practices. The dispersion model uses information on meteorology (e.g., windspeed, wind direction, temperature) to estimate the movement of pollutants through the atmosphere. Movement downwind is largely determined by windspeed and wind direction. Dispersion around the centerline of the plume is estimated using empirically derived dispersion coefficients that account for movement of pollutants in the horizontal and vertical directions. In addition, pollutant movement from the atmosphere to the ground is also modeled to account for deposition processes driven by gravitational settling and removal by precipitation.

The inputs to the air dispersion and deposition model include

- Surface area of the agriculture field or lagoon
- Meteorologic data for the site of the farm or lagoon
- Locations of potential receptors.

The input data and the resulting unitized air concentrations used in this analysis for the air dispersion modeling (for the sewage sludge lagoons) are provided in Appendix I.

The air dispersion and deposition modeling conducted for this analysis produced output data that were used to calculate environmental media concentrations and food chain concentrations. The dispersion model outputs included air concentration of vapors and particles, wet deposition of vapors and particles, and dry deposition of particles. Dry deposition of vapors was also calculated, but outside the dispersion model. For the sewage sludge lagoon scenario, only air dispersion modeling of vapors was performed because the only air emissions from lagoons are vapors, and therefore, the only exposure point concentration required is the air concentrations of vapors at the exposure point.

For the agricultural application scenario, the ISCST3 modeling included all potential outputs over a grid of receptor points. These outputs were processed in a GIS to produce the following outputs:

- Air concentration of vapors and particles
- Wet deposition of vapors and particles
- Dry deposition of particles.

These outputs were produced for each of the following locations:

- Agricultural land (crop and pasture)
- Buffer area (residential exposure)
- Watershed area
- Waterbodies (index reservoir and farm pond).

For the screening analysis, the maximum grid point value for each output was used to represent the air modeling results for each location with the exception of the watershed, where the average of the grid point values was used.

2.3.2 Estimation of Soil, Water, and Sediment Concentrations

This section describes how total soil concentration was estimated for each of the locations in the conceptual site (cropland, pasture, buffer, and watershed). These concentrations are common to both the human health and ecological screening analysis. It also describes the components that make up the two waterbodies modeled in this analysis. The first waterbody is EPA's index reservoir for evaluating drinking water exposures to pesticides (Shipman Lake), a 13-acre lake that has a 427-acre watershed and is separated from the sludge-amended agricultural land by a 10-ft buffer. This waterbody was used as a drinking water source in this analysis. The second waterbody is a farm pond that is located immediately adjacent to the sludge-amended land and receives runoff and erosion directly from the sludge-amended land (no buffer). The farm pond is the site of all ecological receptor exposures and is used for recreational fishing by the farm family. Finally, this section describes the dilution-attenuation factor used to estimate the groundwater concentrations used for drinking water and showering.

2.3.2.1 Soil Concentrations. Soil concentrations were calculated considering pollutant loads from the direct agricultural application of sewage sludge to agricultural fields (which are assumed to be half cropland and half pasture) and aerial deposition of pollutants onto cropland, pasture, the buffer area, and the regional watershed. For the agricultural land where sewage sludge is applied, pollutant concentrations in soil change with each year of sludge application. During the application period, the pollutant concentrations in soils resulting from aerial deposition also change.

In each case, the concentration of a contaminant in the soil is determined by the flux of chemical (from application or deposition) and loss mechanisms of that chemical from the soil. Soil losses accounted for in this analysis include erosion, biodegradation, volatilization, leaching, and dissolved loss in surface runoff. For a particular site and model iteration, these loss processes were assumed to be the same in all locations across the site and surrounding watershed.

Temporal changes in soil concentration were accounted for through annual average soil concentrations produced by the land application model and annual estimates of deposition from the air model. For a particular iteration, the model used an average value over the exposure duration. In addition, the concentrations due to air deposition were added to the concentrations in the soil due to application of sludge (cropland to pasture and pasture to cropland[3]) and upslope erosion (agricultural field to buffer).

The areas modeled for soil concentrations differ for the two land application scenarios.

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[3] Sludge applications to the adjacent cropland and pastureland are modeled simultaneously for a given iteration. The cropland receives depositional loads from the pasture, and the pasture receives depositional loads from the cropland.

- For the farm pond scenario, the source model calculated soil concentrations for the cropland and pasture only, which comprise the entire watershed for the pond.

- For the drinking water (index) reservoir scenario, soil concentrations were calculated for cropland, pasture, a buffer area between the farm and the waterbody (the local watershed), and a regional watershed that feeds the drinking water reservoir.

The regional watershed area was assumed to be agricultural land, some of which (10 percent to 80 percent) is also amended with sewage sludge. To account for this additional load of pollutants in the watershed area, the soil concentrations in the agricultural field were scaled to the area of amended agricultural land in the regional watershed. In addition, the regional watershed soil receives a chemical load via averaged air deposition rates from the modeled agricultural field. These soil chemical loads (application and deposition) were totaled to estimate soil concentrations in the regional watershed, which, in turn, were used to estimate chemical loads to the index reservoir from soil erosion and overland transport (see Appendix J for methods).

2.3.2.2 Predicting Surface Water Concentrations. The waterbodies in this analysis include the index reservoir, which is a source of drinking water, and a farm pond, where ecological receptors live and feed and from which the farm family catches fish. Pollutants enter the waterbody by any of four pathways:

1. Constituents in the air above the waterbody can be deposited directly onto the waterbody's surface. This occurs for airborne particles via dry and wet deposition due to gravitational settling and scavenging by precipitation, respectively.

2. Vapors can also deposit directly onto the waterbody's surface via scavenging by precipitation (i.e., wet deposition).

3. Constituents on the soils can enter the waterbody through runoff and erosion. This occurs directly from the sludge-amended agricultural field to the farm pond and from the sludge-amended agricultural field to the buffer to the index reservoir.

4. Pollutants deposited onto soils in the upstream watershed also enter the index reservoir through runoff and erosion.

Thus, the total pollutant load to each of the waterbodies is the sum of all of the loads to that waterbody from these pathways. The methods used to develop this load are presented in Appendix J.

The index reservoir also requires a base flow. Base flow represents the component of streamflow that is not direct surface runoff. The watershed model provides a base flow to the index reservoir. The waterbody models take the inputs from these sources (daily loads due to erosion, runoff, and deposition) and use these loads in addition to other inputs for the waterbody (area, depth, and baseflow) to estimate concentrations in the various components of the waterbody over varying time periods. The concentration was estimated for pollutants in the dissolved phase in the water column, in the suspended solids, and in the benthic sediment. These estimates consider losses due to hydrolysis and/or biodegradation. The mechanism used to calculate the concentrations in each component of the each of the two waterbodies is presented in Appendix J.

2.3.2.3 Predicting Groundwater Concentrations. The concentration of the pollutant in leachate may be diluted in the groundwater system before reaching a nearby residential well. This dilution is estimated in this screening analysis by the application of a dilution-attenuation factor (DAF). No chemical-specific groundwater modeling was performed for the screening analysis. The DAF used in this screening analysis was the 10^{th} percentile DAF estimated by performing chemical-specific modeling for a variety of chemicals in a distribution of surface impoundments. This modeling was conducted for the Industrial Waste Management Evaluation Model (IWEM). IWEM considered chemicals with a range of chemical and physical properties in a representative nationwide sample of surface impoundments. EPA placed residential wells at a fixed distance of 150 m from the edge of the impoundments from the SI to calculate DAFs for IWEM. This screening analysis, used a DAF of 2 (10^{th} percentile DAF from the Tier 1 IWEM analysis) to estimate the concentration of each pollutant in the nearby residential well from the SI leachate concentration. For the constituents that exceed the critical dose for groundwater ingestion in the lagoon scenario and remain in the analysis, pollutant- and site-specific groundwater modeling will be conducted during the full-scale modeling.

Groundwater concentrations in the agricultural application scenario are assumed to be the leachate concentration at a depth of 1 m below the surface. No DAF is applied to this concentration.

2.3.3 Calculation of Food Chain Concentrations

Food chain exposures were evaluated for the agricultural application scenario. After the fate and transport models have predicted concentrations of pollutants in the air, soil, water, and sediment, pollutant concentrations are calculated in food items. Pollutants pass from contaminated soil, water, sediment, and air through the food chain to the farm family and ecological receptors. For example, pollutants in air may be deposited on plants growing in the agricultural field. Simultaneously, these plants may take up pollutants from the soil and accumulate pollutants from both routes in the fruits and vegetables consumed by the farm family and ecological receptors. In addition, beef and dairy cattle, as well as wildlife receptors, may consume forage and silage that are grown in sludge-amended pasture soil. Subsequently, the farm family may consume home-produced beef and dairy products from these animals. Similarly, pollutants applied to the agricultural land may erode and run off into a farm pond and accumulate in fish and other aquatic biota. The fish in the farm pond may be caught and consumed by members of the farm family, and aquatic biota may be consumed by wildlife receptors.

This section presents the methodology used to calculate pollutant concentrations for each of the diet items in the food chain pathways considered.

2.3.3.1 Terrestrial Food Chain. The terrestrial food chain is designed to predict the accumulation of a pollutant in the edible parts of food crops eaten by the farm family and in plants and prey items consumed by wildlife receptors. Edible crops include exposed and protected fruits, exposed and protected vegetables, and root vegetables. The term "exposed" refers to the fact that the edible portion of the produce is exposed to the atmosphere. The term "protected" refers to the fact that the edible portion of the produce is shielded from the atmosphere. Examples of the categories include tomatoes (exposed vegetable), corn (protected vegetable), apples (exposed fruit), oranges (protected fruit), and potatoes (root vegetables). In addition, the farm family is assumed to raise beef and dairy cattle that forage on the pasture, consume silage raised on the cropland, and consume associated soil. Figure 2-4 shows the data flow into and out of the farm food chain model. The equations used to calculate the food chain concentrations of pollutants are presented in Appendix K. Bio-uptake factors are provided in Appendix F.

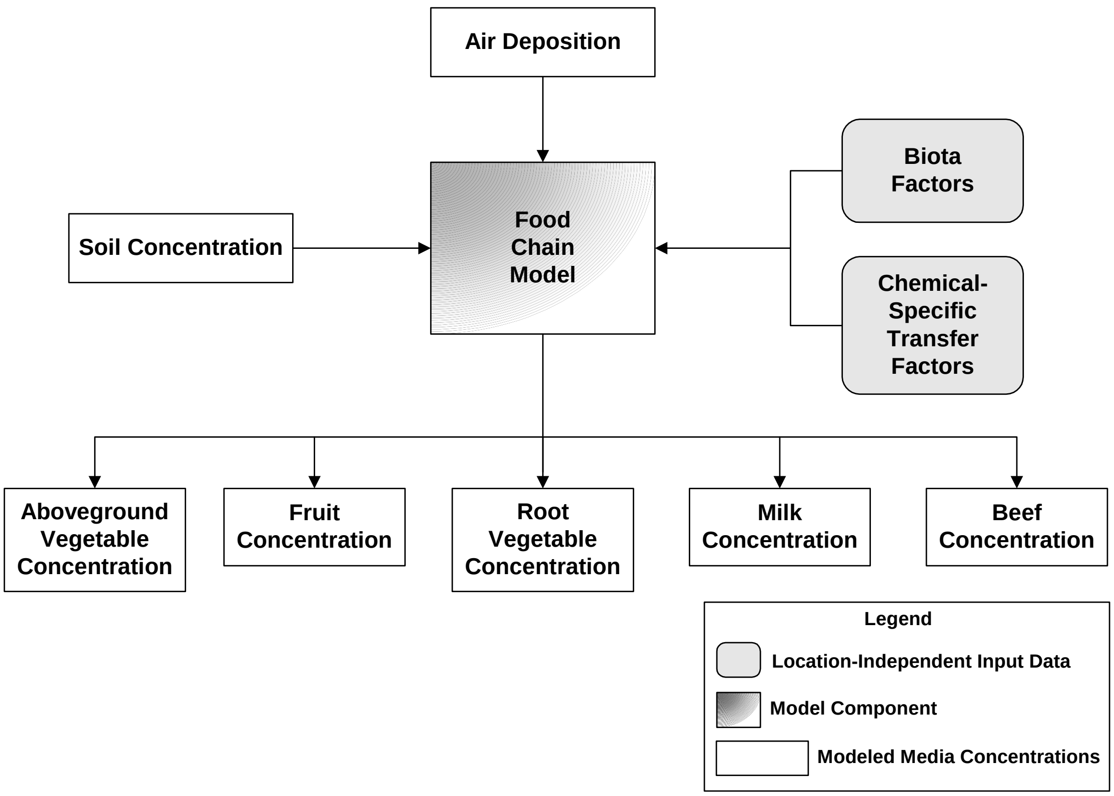

Figure 2-4. Farm food chain model.

Ecological receptors also are exposed to contaminants through ingestion of terrestrial food items. The terrestrial food chain for ecological receptors also includes vegetation and prey items in the diet. Figure 2-5 illustrates the terrestrial food chain modeled for ecological exposure. The screening analysis conservatively assumes that receptors take all of the vegetation in their diets from the farm field where sewage sludge is applied. Herbivorous receptors, such as the white-tailed deer, and omnivorous receptors, such as the raccoon and the red fox, eat similar types of vegetation as do the human receptors (e.g., exposed vegetables) and the beef and dairy cattle (e.g., forage grass) raised by the farm family. The concentrations in vegetation in the ecological receptors' diets were predicted using the same modeling approach as that used to predict concentrations in the human diet.

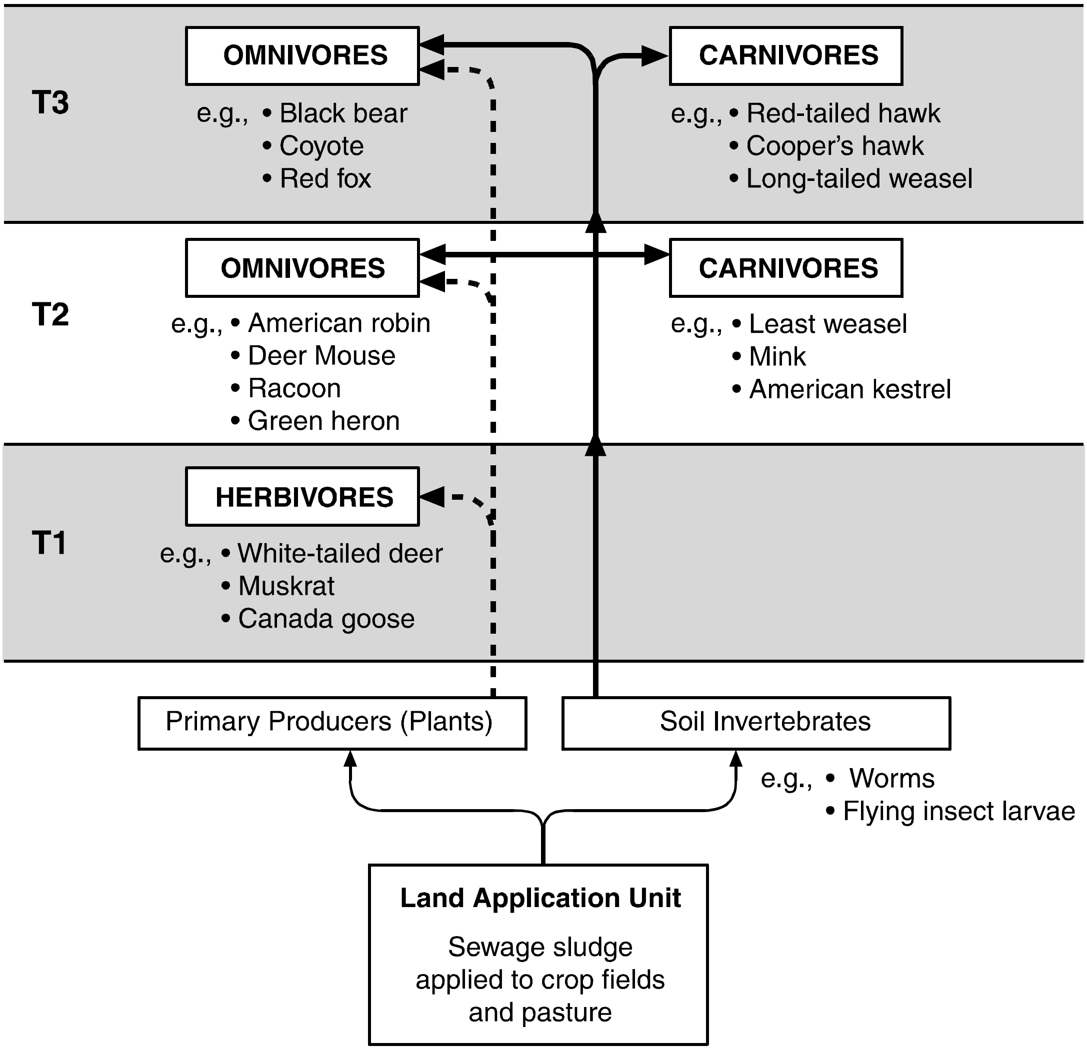

Figure 2-5. Terrestrial food web, including example receptors.

Omnivorous and carnivorous receptors eat a variety of terrestrial vertebrates, such as small mammals and birds, and soil invertebrates. Again, it was conservatively assumed that all terrestrial prey come from the agricultural field where sewage sludge is applied. Concentrations in terrestrial prey items were calculated by applying chemical-specific bioaccumulation factors (BAFs) to the soil concentrations. However, BAFs for organic chemicals in this analysis were generally lacking for terrestrial prey types, and a default value of 1 was used for all organics for terrestrial prey. For metal contaminants, BAFs derived from empirical data were identified in the literature for worms and for small mammals. In the absence of BAFs for other prey types (e.g., small birds, lizards and reptiles, and larger mammals), the small mammal BAFs were used for all terrestrial vertebrate prey, and the worm BAFs were used for all terrestrial invertebrate prey. The BAFs used to calculate food item concentrations are shown in Appendix M.

2.3.4 Calculation of Aquatic Food Web Concentrations

Some of the ecological receptors are exposed to contaminants through the ingestion of aquatic food items, including fish, sediment invertebrates (e.g., mussels), and aquatic plants in the farm pond. For example, wading birds, such as the great blue heron, eat fish and sediment invertebrates; the muskrat eats aquatic vegetation; and the raccoon eats a variety of fish, amphibians, and sediment invertebrates, in addition to a wide variety of terrestrial items. Figure 2-6 illustrates the aquatic food web modeled in the screening analysis. The screening analysis assumed that all aquatic items in the receptors' diets come from the farm pond. The concentrations in the fish and aquatic plants are calculated by applying chemical-specific bioconcentration factors (BCFs) to the water concentration, and the concentrations in the sediment invertebrates are calculated by applying BCFs to the sediment concentrations. BCF values for the aquatic food chain were the same as those used in the human exposure modeling to calculate concentrations in fish tissue. These values are shown in Appendix E.

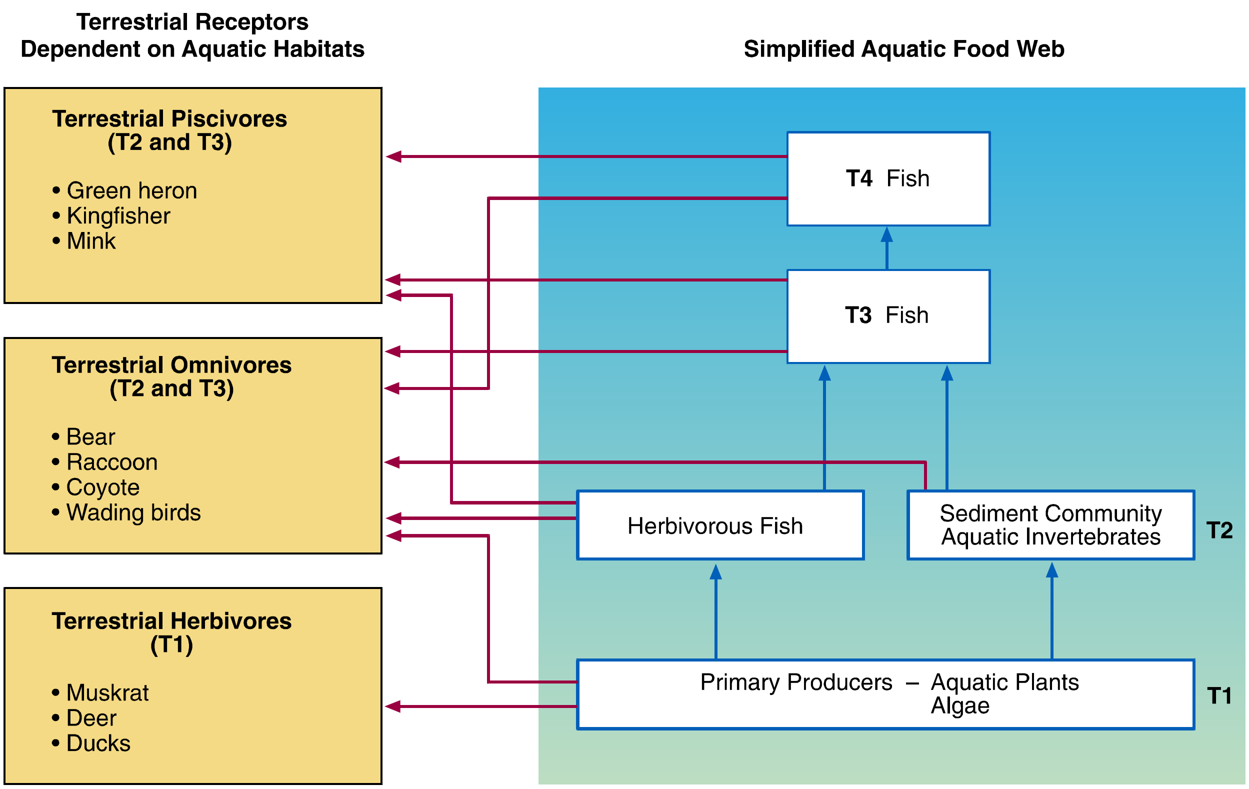

Figure 2-6. Aquatic food web, including example receptors.

2.4 Exposure Modeling

The pollutant concentrations in the food chain items identified in the previous section are used to estimate human and ecological exposures. This section describes the human and ecological exposure modeling.

2.4.1 Human Exposure Modeling

Human exposures occur as a result of disposal of sewage sludge in a lagoon or application of sewage sludge to agricultural land. The human exposures assumed for the sewage sludge lagoon scenario are presented in Table 2-1. A resident family was assumed to live near a facility with a sewage sludge lagoon and breathe the air at that location. In addition, the family was assumed to have a residential well that supplies tapwater to the household for use as drinking water and for showering for the family. The air exposures (ambient and indoor) were calculated by estimating the average daily air concentration of vapors to which an individual may be exposed. The exposure through the drinking water route was estimated by multiplying the maximum annual concentration of the pollutant in the groundwater by the consumption rate of the individual. This is the average daily dose (ADD) for an individual. To estimate a lifetime average daily dose (LADD) needed to screen for constituents with cancer endpoints, the ADD for each year of the exposure duration was summed and divided by the lifetime (70 years) for the adult and child resident who drink water from the residential well (exposure frequency is assumed to be 350 days per year, and the period of exposure was assumed to coincide with the highest annual exposure concentrations).

Table 2-1. Human Exposure Pathways for the Sewage Sludge Lagoon Scenario

Receptor	Ingestion of Drinking Water (Groundwater)	Inhalation of Indoor Air[a]	Inhalation of Ambient Air
Adult resident	✓	✓	✓
Child resident	✓	✓	✓

[a] Indoor air contaminated from showering.

For the purposes of this hazard analysis, ADD was defined as

$$ADD = C \times IR \qquad (2\text{-}1)$$

where

ADD = average daily dose (mass constituent/body weight mass/day)
C = concentration (mass/volume or mass/mass)
IR = intake rate (mass/body weight mass/time or volume/body weight mass/day).

The LADD, used for assessing risks for carcinogenic effects, was defined as

$$LADD = \frac{C \times IR \times ED \times EF}{AT \times 365} \qquad (2\text{-}2)$$

where

LADD = lifetime average daily dose (mass constituent/body weight mass/day)
C = average concentration (mass/mass or mass/volume)
IR = intake rate (mass/body weight mass/time or volume/body weight mass/day)
ED = exposure duration (yr)

EF = exposure frequency (d/yr)
AT = averaging time (yr, 70-year lifetime)
365 = unit conversion factor (d/yr).

The exposure pathways considered for the farm family are presented in Table 2-2. The same general approach used to estimate exposures for the lagoon scenario was used to estimate exposures for the agricultural application scenario. In the agricultural application scenario, however, more exposure routes are considered in the analysis. The air exposures were estimated using the same method as was used for the lagoon scenario. The air exposures (ambient and shower) were calculated by estimating the average daily air concentration of vapors and particles (ambient only) to which an individual may be exposed.

All ingestion pathways for the agricultural application scenario (drinking water, soil, produce, beef, milk, and fish) were estimated using the same method. An annual ADD or LADD was estimated for each exposure pathway individually, and the doses for all pathways were then summed to yield a total ADD or LADD for the farmer and child across all pathways. The exposure factors used in this analysis are described in detail in Appendix L.

Table 2-2. Human Exposure Pathways for the Agricultural Land Application Scenario

Receptor	Inhalation of Ambient Air	Ingestion of Drinking Water (Ground Water or Index Reservoir)	Ingestion of Soil	Ingestion of Above- and Belowground Produce	Ingestion of Beef and Dairy Products	Ingestion of Fish (Farm Pond)
Adult farmer	✔	✔	✔	✔	✔	✔
Child farm resident	✔	✔	✔	✔	✔	✔

2.4.2 Ecological Exposure Modeling

The ecological screening analysis is based on (1) predicted chemical concentrations in environmental media (e.g., soil, sediment), and (2) predicted exposure doses for birds and mammals. The predicted chemical concentrations were compared to either an environmental quality criterion (e.g., Ambient Water Quality Criterion) or a concentration-based benchmark for certain receptors (e.g., early life-stage lethality to amphibians in direct contact with contaminated water). The predicted doses were compared to dose-based benchmarks (in mg/kg-day) to screen for potential ecological hazard to these receptor species.

For exposures assessed on the basis of medium concentration (or direct contact) shown in Table 2-3, maximum annual average chemical concentrations were used for soil and sediment, and multiple averaging times were used for chemical concentrations in surface water. For example, if the benchmark for fish was derived from a 96-hour study, the 4-day maximum concentration was selected as the exposure concentration. Appendix P provides the exposure duration assumed for each receptor and constituent.

Table 2-3. Receptors Assessed Using Media Concentrations

Receptor	Exposure Concentration
Fish	Surface water concentration (farm pond)
Aquatic invertebrates	Surface water concentration (farm pond)
Aquatic plants	Surface water concentration (farm pond)
Amphibians	Surface water concentration (farm pond)
Aquatic community	Surface water concentration (farm pond)
Sediment invertebrates	Sediment concentration (farm pond)
Soil invertebrates	Soil concentration (agricultural field)

For the ingestion pathway, exposure dose was calculated as a function of the concentrations in each receptor's diet, and receptor-specific ingestion rates and body weight. Dietary composition was based on species-specific data on foraging and feeding behavior and reflected a year-round adult diet. Diet items were grouped in 17 categories, including different types of vegetation (e.g., fruits, forage, grain, roots) and several categories of prey (e.g., small birds, small mammals, invertebrates, fish). For example, the American robin's dietary composition is as follows (Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996):

Diet Item	Dietary Percentage Range
Soil invertebrates (other than earthworms)	8 to 93
Fruits	7 to 92
Earthworms	15 to 27
Forage	0 to 24

Each receptor's diet was constructed using the average of the minimum and maximum percentages for each diet item, beginning with the item with highest value and proceeding through the diet items until a full diet (100 percent) was accumulated. Thus, the robin's diet would consist of 50.5 percent soil invertebrates and 49.5 percent fruits, based on the following average dietary percentages:

Diet Item	Average
Soil invertebrates	50.5
Fruits	49.5
Worms	21
Forage	12

The dietary composition used for each receptor species is presented in Appendix N.

Each receptor's exposure dose was calculated as a function of its respective ingestion rate, body weight, and the concentrations in the various diet items. In addition to prey and plant items, soil, sediment, and drinking water ingestion were also accounted for. Soil and sediment ingestion are expressed as a fraction of total diet. Ingestion dose was calculated as

$$Dose_A = \frac{\Sigma(IR_{diet} \times C_{diet\ Aj} \times DietFrac_j) + (C_{soil/sed\ A} \times IR_{diet} \times S_{frac}) + (C_{sw\ A} \times IR_{water})}{BW} \quad (2\text{-}3)$$

where

$Dose_A$	=	Exposure dose for chemical *A* (mg/kg-d)
IR_{diet}	=	Species-specific dietary ingestion rate (kg WW/d)
$C_{diet\ Aj}$	=	Concentration of chemical *A* in diet item *j* (mg/kg WW)
$DietFrac_j$	=	Fraction of diet consisting of item *j* (unitless)
$C_{soil/sed\ A}$	=	Concentration of chemical *A* in soil or sediment (mg/kg)
S_{frac}	=	Fraction of soil or sediment in the diet (unitless)
$C_{sw\ A}$	=	Concentration of chemical *A* in surface water (mg/L)
IR_{water}	=	Species-specific water ingestion rate (L/d)
BW	=	Species-specific average adult body weight (kg).

The species-specific exposure factors (ingestion rates and body weights) were taken from EPA's *Wildlife Exposure Factors Handbook* (U.S. EPA, 1993) and are presented in Appendix N.

2.5 Screening Criteria Development

2.5.1 Human Health Screening Criteria

The human health benchmarks used in this assessment are critical doses (CDs) or critical concentrations (CCs). The CCs were used as air pathway criteria. For air exposures to pollutants with noncancer endpoints, the CC is the RfC as reported in IRIS. For air exposures to pollutants with cancer endpoints, the CC is associated with a cancer risk of 1E-5, based on the AUR. If a pollutant had both a cancer and noncancer inhalation benchmark, the lower CC calculated by these methods was the CC used as the screening criterion.

The human health benchmarks used for the ingestion pathways is the CD, which was compared to the ADD (for noncarcinogens) or LADD (for carcinogens). For ingestion exposures to pollutants with noncancer endpoints, the CD was the RfD reported in IRIS or the RfD or the PAD reported in the RED or IRED documents issued by EPA OPP. For ingestion exposures to pollutants with cancer endpoints, the CD was calculated as the dose that yields a cancer risk level of 1E-5 (1 in 100,000) over a lifetime (that dose was calculated as 1E-5/ $CSF_{\_oral}$).

The screening criteria used in this analysis are presented in Table 2-4.

Table 2-4. Human Health Screening Criteria for Pollutants

Chemical	CASRN	Oral Critical Dose (mg/kg/d)	Inhalation Critical Concentration (mg/m^3)
Acetone	67-64-1	0.9	
Acetophenone	98-86-2	0.1	
Anthracene	120-12-7	0.3	
Azinphos methyl	86-50-0	0.0015	0.0022
Barium	7440-39-3	0.07	
Benzoic acid	65-85-0	4.0	
Beryllium	7440-41-7	0.002	0.000004
Biphenyl, 1,1-	92-52-4	0.05	
Butyl benzyl phthalate	85-68-7	0.2	
Carbon disulfide	75-15-0	0.1	0.7
Chloroaniline, 4-	106-47-8	0.004	
Chlorobenzene; Phenyl chloride	108-90-7	0.02	
Chlorobenzilate	510-15-6	0.02	
Chlorpyrifos	2921-88-2	0.00003	0.00005
Cresol, o- (2-methylphenol)	95-48-7	0.05	
Diazinon	333-41-5	0.0002	0.00006
Dichloroethene, 1,2-trans-	156-60-5	0.02	
Dichloromethane	75-09-2	0.0013	0.02
Dioxane, 1,4-	123-91-1	0.000909	
Endrin	72-20-8	0.0003	
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104-64-5	0.00001	
Fluoranthene	206-44-0	0.04	
Hexachlorocyclohexane, alpha-	319-84-6	0.0000016	0.000006
Hexachlorocyclohexane, beta-	319-85-7	0.0000056	0.00002
Isobutyl alcohol	78-83-1	0.3	
Manganese	7439-96-5	0.14[a]	0.00005
Methyl ethyl ketone	78-93-3	0.6	5.0
Methyl isobutyl ketone (MIBK); Methyl-2-pentanone, 4-	108-10-1		3.0
Naled	300-76-5	0.002	0.0004
Nitrate	14797-55-8	1.6	
Nitrite	14797-65-0	0.1	
N-Nitrosodiphenylamine	86-30-6	0.002	

(continued)

Table 2-4. (continued)

Chemical	CASRN	Oral Critical Dose (mg/kg/d)	Inhalation Critical Concentration (mg/m^3)
Phenol	108-95-2	0.3	
Pyrene	129-00-0	0.03	
Silver	7440-22-4	0.005	
Trichlorofluoromethane	75-69-4	0.3	
Trichlorophenoxy) propionic acid, 2-(2,4,5-	93-72-1	0.008	
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93-76-5	0.01	
Trifluralin	1582-09-8	0.0013	
Xylenes (mixture)	1330-20-7	0.2	0.1

For human receptors, the air concentration at the receptor location is compared to the screening criterion (CC). For all the ingestion pathways, the total ADD or LADD calculated for a receptor is compared to the CD. If any of these ratios is greater than one, the pollutant fails the screening criterion and is retained in the analysis for additional study.
[a] The oral critical dose for manganese from drinking water and soil is 0.047 mg/kg/day.

2.5.2 Ecological Screening Criteria

The screening criteria for ecological receptors are benchmarks expressed in terms of media concentration (e.g., mg/L for surface water or mg/kg for soil) or in terms of dose (mg/kg^{-d}). Because there is no single repository for approved ecological benchmarks analogous to IRIS, benchmarks were derived from various EPA and other government reports and from toxicological studies in the open literature.

Several factors were considered in selecting toxicological data for use in developing benchmarks. These factors include, for example, the effect level, exposure duration, measurement endpoint, and completeness of reported information. The objectives of the selection process were to:

- Use data from reliable, preferably peer-reviewed sources
- Use data that are relevant to the assessment endpoints (population/community viability)
- Select the lowest (most protective) value that is relevant and appropriate.

The decision framework process used for selecting benchmark data is illustrated in Table 2-5. The preferred characteristics, shown in the second column, are the target objectives for data selection. If data meeting the preferred condition were not available for a pollutant-receptor combination, then other data were considered. For example,

- Reproductive and growth effects and mortality data would be selected for consideration, while data on liver damage would not be considered because it is not necessarily relevant to population viability

- For mammal or bird data, studies in which the dose is administered in feed would be considered, while dermal injection studies would not be considered because they do not necessarily reflect ingestion exposure

- For aquatic studies, data from flow through tests would be selected over equivalent data from static tests

- Because the screening assessment addresses long term chronic exposure, studies based on longer durations (generally longer than 96 hours) were preferred

- Endpoints measuring lethality (e.g., LC_{50}) were considered only in cases where non-lethal endpoints (e.g., chronic NOECs and LOECs) are not available. Risk results based on benchmarks derived from lethality data must be interpreted differently than results based on non-lethal effects (e.g., reduced growth or hatching success). See Section 3.3.1 for further discussion of interpreting lethality-based results

- Measured values were preferred over predicted (e.g., values generated based on structure activity relationships [SARs])

- All else being equal, the lowest acceptable value was selected.

Different references were consulted for different receptors and environmental media. Table 2-6 shows the references consulted for benchmarks. Numbers preceding each reference indicate the data quality hierarchy. The ecological benchmarks used in the screening analysis and their respective sources are provided in Appendix P.

Ecological hazard was expressed in terms of hazard quotients (HQs). For the direct exposure pathway, HQs were calculated as the ratio of the exposure concentration to the relevant benchmark. For example, the HQ for fish was calculated as the ratio of the surface water concentration to the fish benchmark. For the ingestion pathway, the HQs were the ratio of the exposure dose to the relevant benchmark. An HQ greater than or equal to one is an indication that further analysis may be warranted.

Table 2-5. Criteria for Selecting Toxicological Data

Component	Preferred	Not preferred	Not allowed
Assessment Endpoint (Effect)	Effects related to population or community viability: reproduction, growth	Mortality	Effects **not** related to population or community viability
Mammal and Bird Studies: Type	Ingestion (dietary and other)studies		Injection studies
Mammal and Bird Studies: Reported data	Test species, test duration, and body weight reported	Test species, test duration, or body weight **not** reported	
Aquatic Studies: study design	Flow through	Static	
Study Duration	Chronic, longest	Shorter, acute	
Measurement endpoint	NOEL - LOEL, MATL, other threshold effects levels	LC_{50}, LD_{50}, EC_{50}	
Measured vs. Predicted Values	Measured	Predicted	
Value	Lowest (most toxic) value	Higher values	

Table 2-6. Sources for Ecological Benchmarks

	Organic Contaminants	Metal Contaminants
Water	1. U.S. EPA, 2002a (NAWQC) 2. Suter and Tsao, 1996 3. Canadian Council of Ministers of the Environment, 2002 4. U.S. EPA, 2003a (EFED Database) 5. California EPA, 2003 6. U.S. EPA, 2003b (ECOTOX database)	1. U.S. EPA, 2002a (NAWQC) 2. Suter and Tsao, 1996 3. Canadian Council of Ministers of the Environment, 2002 4. U.S. EPA, 2003a (EFED Database) 5. California EPA, 2003 6. U.S. EPA, 2003b (ECOTOX database)
Soil	1. Effroymson et al., 1997 2. Canadian Council of Ministers of the Environment, 2002 3. U.S. EPA, 2003b (ECOTOX database)	1. Effroymson et al., 1997 2. Canadian Council of Ministers of the Environment, 2002 3. U.S. EPA, 2003b (ECOTOX database)
Sediment	1. Jones et al., 1997 2. Canadian Council of Ministers of the Environment, 2002 3. U.S. EPA, 2003b (ECOTOX database)	1. Jones et al., 1997 2. Canadian Council of Ministers of the Environment, 2002 3. U.S. EPA, 2003b (ECOTOX database)
Mammals and Birds	1. Sample et al., 1996 2. U.S. EPA, 2003a (EFED Database) 3. U.S. EPA, 2003b (ECOTOX database)	1. Sample et al., 1996 2. U.S. EPA, 2003a (EFED Database) 3. U.S. EPA, 2003b (ECOTOX database)

3.0 Screening Results

For chemicals with human health benchmark (HHB) values for ingestion, the results of the screening analysis are a ratio of the estimated average daily dose (ADD) or lifetime average daily dose (LADD) to a critical dose (CD) for each pollutant. For chemicals with an HHB for inhalation, the average daily air concentration is compared with the critical concentration (CC) for these pollutants. If either of these ratios exceeds one at the 95^{th} percentile of the hazard quotient (HQ) distribution, the pollutant fails the screen. A similar comparison is performed for ecological benchmark values. If the HQ based on a wildlife toxicity endpoint equals or exceeds one for any pollutant, that pollutant is considered to fail the screening assessment for that representative ecological receptor.

3.1 Human Health Screening Results

The human health screening assessment was performed using CDs and CCs based on both cancer and noncancer endpoints. The CDs based on noncancer endpoints were compared with the ADD for both the adult and child receptors. The CDs based on cancer endpoints were compared with the LADD. Similar comparisons were made for the inhalation endpoints. The CCs based on noncancer and noncancer endpoints were compared with the average daily concentration to which humans were assumed to be exposed.

In both the agricultural land application scenario and the sewage sludge lagoon scenario, no pollutants with cancer endpoints had HQs greater than one. No pollutant with either a cancer or noncancer endpoint had HQs greater than one on the basis of an inhalation exposure.

Nitrite had HQs greater than one in both scenarios, based on the ingestion of drinking water from groundwater in the sewage sludge lagoon scenario, and based on the ingestion of drinking water from surface water and total ingestion in the agricultural land application scenario. Silver had HQs greater than one for the agricultural land application scenario only. Barium, manganese, nitrate, and 4-chloroaniline had HQs greater than one for the lagoon scenario only. Table 3-1 presents the results for the pollutants that had HQs greater than one for the agricultural land application scenario, and Table 3-2 presents the results for the pollutants that had HQs greater than one for the sewage sludge lagoon scenario.

Table 3-1. Human Hazard Quotient Values Greater Than One at the 95th Percentile of the HQ Distribution by Pathway for the Agricultural Land Application Scenario

CASRN	Chemical	Pathway	Receptor	HQ
14797-65-0	Nitrite	Ingestion of Surface Water	Child	1.1
		Total Ingestion	Child	1.3
7440-22-4	Silver	Ingestion of Milk	Adult	3.8
			Child	12.0
		Total Ingestion	Adult	4.0
			Child	12.3

Table 3-2. Human Hazard Quotient Values Greater Than One at the 95th Percentile of the HQ Distribution by Pathway for the Sewage Sludge Lagoon Scenario

CASRN	Chemical	Pathway	Receptor	HQ
7440-39-3	Barium	Drinking Water from Groundwater	Adult	1.5
			Child	3.5
106-47-8	4-Chloroaniline	Drinking Water from Groundwater	Adult	2.7
			Child	6.4
7439-96-5	Manganese	Drinking Water from Groundwater	Adult	32.3
			Child	76.3
14797-65-0	Nitrite	Drinking Water from Groundwater	Adult	13.6
			Child	33.8
14797-55-8	Nitrate	Drinking Water from Groundwater	Adult	9.2
			Child	23

3.2 Ecological Screening Results

The ecological screening assessment addressed risks from direct contact with contaminated media and from ingestion of contaminated food and feed. The ecological screening was performed by comparing environmental concentrations to comparable benchmark values for the agricultural land application scenario. Hazards are expressed as HQs calculated as the ratio of the exposure dose, or concentration, to the relevant benchmark.

Table 3-3 shows the pollutants that had ecological HQs greater than one at the 95^{th} percentile of the HQ distribution for the direct contact pathway. There was no ingestion hazard for any aquatic or terrestrial wildlife species from any of the chemicals. Complete results are presented in Appendix R.

Table 3-3. Hazard Quotient Values Equal to or Greater Than One at the 95^{th} Percentile of the HQ Distribution for Aquatic and Terrestrial Wildlife Via Direct Contact Pathways

CASRN	Chemical	Receptor[a]	HQ
67-64-1	Acetone	Sediment Biota	356.2
120-12-7	Anthracene	Sediment Biota	2.9
7440-39-3	Barium	Aquatic Community	235.7
7440-41-7	Beryllium	Aquatic Community	7.8
75-15-0	Carbon disulfide	Sediment Biota	1.9
106-47-8	4-Chloroaniline	Aquatic Invertebrates	1.3
333-41-5	Diazinon	Sediment Biota	1.1
206-44-0	Fluoranthene	Aquatic Community Sediment Biota	10.7 4.2
7439-96-5	Manganese	Aquatic Community	13.9
78-93-3	Methyl Ethyl Ketone	Sediment Biota	5.8
108-95-2	Phenol	Sediment Biota	102.4
129-00-0	Pyrene	Aquatic Community Sediment Biota Soil Biota	41.9 21.1 4.5
7440-22-4	Silver	Aquatic Community Aquatic Invertebrates Fish	246.6 28.2 4.8

[a] Sediment biota organisms include sediment invertebrates; aquatic community organisms include fish, aquatic invertebrates, aquatic plants, and amphibians; soil biota organisms include soil invertebrates.

3.2.1 Direct Contact Pathway

The direct contact pathway analysis assesses risks to ecological receptors exposed through direct contact with contaminated media—surface water, sediment, and soil.

Thirteen pollutants had HQs that were greater than one. The ecological benchmark values for different receptors and pollutants are based on different measurement endpoints and therefore reflect varying levels of protection. In most cases, the benchmarks are based on chronic effects data for reproductive and developmental endpoints, such as lowest observed adverse effects levels (LOAELs) or effects range-low values (ERLs). As such, an HQ below one indicates that adverse effects at the population or community level are not expected from that particular pollutant for that particular receptor. However, for some of the chemicals assessed, the only aquatic ecotoxicological data identified were for mortality endpoints (e.g., LC_{50} values reflecting levels at which 50 percent of the test subjects died). The implications of risk results that are based on lethality benchmarks are not equivalent to those that are based on chronic effects endpoints. An HQ below one that is based on a lethality endpoint may still imply impacts to the receptor. For example, an HQ of 0.1 that is based on an LC_{50} value may result in lethality to a significant percentage of the population (e.g., 10 percent). This result may be of much greater ecological significance than an HQ of 1.0 that is based, for example, on a LOAEL for reproductive fitness, which may only affect a small percentage of the population.

3.2.2 Ingestion Pathway

The ingestion pathway analysis assesses risks to ecological receptors exposed through ingestion of plants, prey, and drinking water, and through incidental ingestion of soil and sediment. Diet items include terrestrial plants and prey taken from the agricultural fields and aquatic plants and prey taken from the farm pond. No pollutant had HQ values greater than one for aquatic or terrestrial receptor species. Results are presented in Appendix R.

3.3 Analysis of Variability and Uncertainty

This is a screening assessment and therefore, where uncertainty and variability were identified, the choice was made to err on the side of being more protective.

> **Variability** arises from true heterogeneity in characteristics, such as body weight differences within a population or differences in contaminant levels in the environment.
>
> **Uncertainty** represents lack of knowledge about factors, such as the nature of adverse effects from exposure to constituents, that may be reduced with additional research.

Variability and uncertainty are fundamentally different. Variability represents true heterogeneity in characteristics, such as body weight differences within a population or differences in pollutant levels in the environment. It accounts for the distribution of risk within the exposed population. Uncertainty, on the other hand, represents lack of knowledge about factors, such as adverse effects from pollutant exposure, that may be reduced with additional research to improve data or models.

This discussion describes the treatment of variability and uncertainty in reference to some parameters used to describe human and ecological exposures and risk. Treatment of variability using a Monte Carlo simulation forms the basis for the exposure distributions. Previous sections of this document describe how distributions were generated and values were estimated for input parameters. They also describe how these values were used in the models and in calculations to produce a national-level distribution of exposure concentrations and doses. Uncertainty necessitated the use of assumptions and default values in this screening assessment. This discussion focuses on how this treatment of variability and uncertainty affects the results.

3.3.1 Parameter Variability

Variability is often used interchangeably with the term uncertainty, but the two are not synonymous. Variability is tied to variations in physical, chemical, and biological processes and cannot be reduced with additional research or information. Although variability may be known with great certainty (e.g., age distribution of a population may be known and represented by the mean age and its standard deviation), it cannot be eliminated and needs to be treated explicitly in the assessment. Spatial and temporal variability in parameter values used to model exposure account for the distribution in the exposed population.

For example, the meteorological parameters used in dispersion modeling, such as windspeed and wind direction, are measured hourly by the National Weather Service at many locations throughout the United States, and statistics about these parameters are well documented. Although the distributions of these parameters may be well known, their actual values vary spatially and temporally and cannot be predicted exactly. Thus, the concentration calculated by a dispersion model for a particular receptor for a particular time period will provide information on average conditions that may over- or underpredict actual concentrations. Much of the temporal variation is accounted for by using models such as ISCST3 that calculate concentrations hourly and sum these hourly values to provide annual concentration estimates. Additionally, using meteorological data from multiple monitoring stations located throughout the United States can account for some, but not all, spatial variability.

In planning this assessment, it was important to specifically address as much of the variability as possible, either directly in the Monte Carlo analysis or through disaggregation of the data into discrete elements of the analysis. For example, use of a refined receptor grid accounts for spatial variability in concentrations on and around the agricultural field where sewage sludge is applied. Variability in agricultural practices is accounted for by using distributions that represent the range of possible agricultural practices.

Because sewage sludge is generated nationwide, its application to agricultural fields may occur anywhere in the United States. Thus, this assessment characterized environmental conditions that influence the fate and transport of constituents in the environment using regional data based on climatic conditions. Spatial variability in environmental setting was accounted for by using 41 different climatic regions throughout the contiguous 48 states.

The risk assessment components discussed include the following:

- Source characterization and emissions modeling
- Fate and transport modeling
- Exposure modeling.

3.3.1.1 Source Characterization and Emissions Model Variables. The specific agricultural fields where sludge was applied were not known; however, EPA assumed that sewage sludge could be applied to any agricultural land. For this assessment, agricultural field areas were varied according to climatic regions. The median farm size for each climatic region was used to represent the regional variability of farm size. However, uncertainty about farm size within a climatic region remained. Distributions were used to capture nationwide variability in agricultural practices. The variation in median farm size based on regions and the nationwide distribution of agricultural practice parameters was used in the probabilistic assessment to characterize the national variation in farm areas and operating characteristics.

Source partition modeling was performed for 41 different climatic regions, which allowed variation in location-dependent parameters (e.g., soil, temperature, precipitation) to be considered explicitly in the modeling. Variation in these parameters influenced variation in predicted air emissions rates and leachate concentrations. Meteorological data sets were combined with the surface area of the agricultural field to provide unit air concentrations (UACs), which were used with emissions data to estimate air concentrations for cropland and pastures. Soil data sets were combined with the meteorologic locations to provide distribution of soil types and characteristics.

In the Monte Carlo analysis, the agricultural field characteristics, environmental conditions from 41 climatic regions, and parameter values for sludge characteristics were combined to produce the 3,000 iterations of the source partition model calculations. The source model calculations generated the distribution of environmental releases used in the fate and transport modeling.

3.3.1.2 Fate and Transport Model Variables. The parameter values required to model contaminant fate and transport were obtained from regional databases. The treatment of regional variation in location-dependent parameters used in fate and transport modeling is discussed in the following sections.

<u>Dispersion Model Variables</u>. To capture geographic variation, dispersion modeling was conducted using meteorological data sets from 41 different meteorological stations throughout the contiguous 48 states. This provided regional representation of the variability in meteorological data. The 41 meteorological stations do not represent every site-specific condition that could exist in the continental United States. However, in selecting the climatic regions, consideration was given to represent different Bailey's ecological regions and to not exclude from the assessment those areas with unique dispersion characteristics (e.g., coastal areas). Thus, it is believed that these 41 climatic regions are a reasonable representation of the variability in meteorological conditions for the United States.

<u>Soil and Water Model Variables</u>. Soil characteristics were based on the location of the 41 climatic regions used in the modeling. Soil characteristics for all nonurban soil within the climatic region were used to determine the soil characteristics for watershed modeling. This approach captured the national distribution of soil types and accounted for regional variation in soil characteristics.

Waterbody characteristics for the index reservoir and its associated watershed size were not varied in the fate and transport modeling. However, in addition to variation in soil type and precipitation, watershed modeling also took into account regional variation in agricultural field size, which can affect constituent loading to the waterbody via runoff and erosion. The farm pond varied in size on a regional basis in relation with regional variation in farm size.

Terrestrial and Aquatic Food Chain Variables. No regional variations were explicitly considered for the aquatic food chain modeling. However, agricultural field size and variation in regional watershed characteristics affect runoff and erosion loadings to the waterbodies modeled in this assessment, which indirectly affects the food chain modeling.

Exposure Modeling Variables. Individual physical characteristics, activities, and behavior are quite different. As such, the exposure factors that influence the exposure of an individual, including inhalation rate, ingestion rate, body weight, and exposure duration, are quite variable. To include this variability explicitly in the assessment, statistical distributions for these variables were used for each receptor in the assessment: adult, child, and infant in the farm family and a recreational fisher. For adults, a single exposure factor distribution was used for males and females. For child exposures, one age (age 1) was used to represent the age at the start of exposure, because this age group is considered to be most sensitive for most health effects. Exposure parameter data from the *Exposure Factors Handbook* (EFH; U.S. EPA, 1997a,b,c) were used to establish statistical distributions of values for each exposure parameter for each receptor.

Summary of Variability Considerations. In summary, a distribution of exposures was developed that includes specific consideration of the variability in

- Agricultural field size
- Agricultural practices
- Regional-specific environmental conditions
- Exposure factors for each receptor.

Taken together, these form the basis for national exposure concentration distributions for use in the screening assessment.

3.4 Uncertainty

Uncertainty is a description of the imperfection in knowledge of the true value of a particular parameter. In contrast to variability, uncertainty is reducible by additional information-gathering or analysis activities (e.g., better data, better models). EPA typically classifies the major areas of uncertainty in risk assessments as scenario uncertainty, model uncertainty, and parameter uncertainty. Scenario uncertainty refers to missing or incomplete information needed to fully define exposure and dose. Model uncertainty is a measure of how well the model simulates reality. Parameter uncertainty is the lack of knowledge regarding the true value of a parameter used in the assessment.

Although some aspects of uncertainty were directly addressed in this assessment, much of the uncertainty associated with this assessment could only be addressed qualitatively. Significant sources of uncertainty are presented in this section. If the assessment directly addressed uncertainty, the approach used is described. If the assessment did not directly address uncertainty, a qualitative discussion of its importance is provided.

3.4.1 Scenario Uncertainty

Sources of scenario uncertainty include the assumptions and modeling decisions that are made to represent an exposure scenario. The hypothetical farm scenario is a major source of uncertainty in this assessment. The assessment is based on a single conceptual site model that assumes that sewage sludge is applied to a farm that is half cropland and half pasture and that the farm family lives adjacent to those areas. There are no data about the specific farms where this is done. However, it is known that sewage sludge is applied to both cropland and pastures nationwide. Therefore, a hypothetical farm was developed to allow the estimation of exposure from the application of sewage sludge to farms producing all types of agricultural products anywhere in the nation. These are reasonable assumptions; however, much uncertainty is associated with the scenario. The lack of information to define and model actual exposure conditions introduced uncertainty into this assessment, but the assessment is reasonable and protective in the light of the associated scenario uncertainty.

The hypothetical sewage sludge lagoon scenario is also a major source of uncertainty in this assessment. There are no data specifically about lagoons where sewage sludge is managed. Therefore, human exposures to pollutants released from sewage sludge lagoons are calculated using a national distribution of nonaerated surface impoundments. Families are assumed to live near the impoundment, breathe the ambient air, and use groundwater. This is a reasonable and protective scenario, but there is much uncertainty associated with it.

3.4.1.1 Receptor Populations Evaluated. The human receptors evaluated for the agricultural application scenario are the farm family, which includes an adult farmer and a child. Exposure estimates presented in this document address hypothetical chronic exposures for these receptors and are designed to provide a realistic range of potential scenarios. Although it is possible for any type of individual to be present on a farm where sewage sludge is applied, to ensure that all potential receptors and exposure pathways are evaluated, it is assumed that at least an adult farmer and child live on each farm modeled. This simplifying assumption allows the evaluation of all receptors and pathways in all locations. Although these assumptions include scenario uncertainty, they are reasonable and protective.

3.4.1.2 Characteristics and Location of Waterbodies. One aspect of the site configuration of particular relevance to the drinking of surface water and the aquatic food chain modeling is the location and characteristics of the waterbodies. The size of the waterbodies affects pollutant concentration predicted for that waterbody. The location of the waterbody was assumed to be at the edge of the agricultural field. Because there are no site-specific locations for the farms and nearby waterbodies, there is uncertainty associated with the placement and dimensions of the nearest surface water source for drinking water and the associated watershed. Therefore, a single index reservoir and associated watershed were used. Although this assumption has much uncertainty associated with it, this is a protective assumption.

The assumptions made for this risk assessment also allow the evaluation of the fish ingestion pathway based on reasonable and protective assumptions. The uncertainty associated with this portion of the scenario must also be considered in the qualitative evaluation of uncertainty. The assumptions about the location and size of the stream may bias the risk results for the fish ingestion pathway, resulting in higher risk estimates.

3.4.2 Model Uncertainty

Model uncertainty is associated with all models used in all phases of a risk assessment because models and their mathematical expressions are simplifications of reality that are used to approximate real-world conditions and processes and their relationships. Computer models are simplifications of reality, requiring exclusion of some variables that influence predictions but that cannot be included in models either because of their complexity or because data are lacking on a particular parameter. Models do not include all parameters or equations necessary to express reality because of the inherent complexity of the natural environment and the lack of sufficient data to describe the natural environment. Because this is a probabilistic assessment that predicts what may occur with the management of sludge under assumed scenarios, it is not possible to compare the results of these models to any specific situation that may exist (sometimes referred to as model validation).

The risk assessor needs to consider the importance of excluded variables on a case-by-case basis because a given variable may be important in some instances and not important in others. A similar problem can occur when a model that is applicable under one set of conditions is used for a different set of conditions. In addition, in some instances, choosing the correct model form is difficult when conflicting theories seem to explain a phenomenon equally well. In other instances, EPA does not have established model forms from which to choose to address certain phenomena, such as facilitated groundwater transport.

Models used in this screening assessment were selected based on science, policy, and professional judgment. These models were selected because they provide the information needed for this assessment and because they are generally considered to be state of the science. Even though the models used in the risk analyses are used widely and have been accepted for numerous applications, they each retain significant sources of uncertainty. Evaluated as a whole, the sources of model uncertainty in this assessment could result in either an overestimation or an underestimation of risk.

3.4.2.1 Air Dispersion Modeling. The ISCST3 model was used to calculate the dispersion of particle and vapor emissions from a waste management unit. This model has many capabilities needed for this assessment, such as the ability to model area sources. For dispersion modeling of this type, ISCST3 is considered a fairly accurate model with error within about a factor of 2. It does not include photochemical reactions or degradation of a chemical in the air, which results in additional model uncertainty. Deposition and associated plume depletion are important for particulates and vapors and were explicitly incorporated into this assessment. Currently, algorithms specifically designed to model the dry deposition of gases have not been verified for the specific compounds in question (primarily volatile organics). In place of algorithms, a transfer coefficient was used to model the dry deposition of gases. A concern with this approach is that the deposition is calculated outside of the model. As a result, the mass is deposited on the ground from the plume and is not subtracted from the air concentrations estimated by ISCST3. This results in a slight nonconservation of mass in the system.

Other uncertainties introduced into the assessment in dispersion modeling are related to agricultural field shape. The shape (square and rectangular) of the agricultural field modeled in this assessment introduces some uncertainty because its actual orientation to the wind direction is not known.

3.4.3 Parameter Uncertainty

Parameter uncertainty occurs when (1) there is a lack of data about the values used in the equations, (2) the data that are available are not representative of the particular instance being modeled, or (3) parameter values cannot be measured precisely or accurately because of limitations in measurement technology. Random, or sample, errors are a common source of parameter uncertainty that is especially critical for small sample sizes. More difficult to recognize are nonrandom or systematic errors that result from bias in sampling, experimental design, or choice of assumptions.

3.4.3.1 Pollutant Concentrations. Another source of uncertainty in this assessment is the concentration of the pollutants in sewage sludge. The concentration data used in the screening assessment are the 95^{th} percentile concentrations measured in the 1988–1989 NSSS.

3.4.3.2 Agricultural Field Parameters. Source characterization required making assumptions about agricultural practices on farms where sludge may be applied. There is much uncertainty associated with the actual practices used on farms where sludge is applied. It is not known what area is amended with sludge, what crops or animals are raised on the amended land, or what specific practices are used. The parameters used in this assessment represent the data available on potential agricultural practices. For this reason, substantial uncertainty remains concerning the variable values for agricultural practices.

3.4.3.3 Watershed Universal Soil Loss Equation (USLE) Parameters. A combination of region-specific and national default parameters was used along with the USLE to model soil erosion losses from watersheds to waterbodies. The USLE calculations are particularly sensitive to site-specific values; thus, uncertainty is associated with using regional and national parameter values. Many of the USLE parameters were based on the regional meteorological and regional soil data used in other parts of the assessment. These include soil erodibility factor (K), rainfall erosivity, and slope. Other parameters were based on national default values (e.g., cover and management factors) or default relationships with other factors (e.g., length was determined as a function of slope).

3.4.3.4 Sludge Characteristics. Few data were available on the physical and chemical characteristics of sewage sludge. To address this lack, assumptions on specific sludge characteristics were based on general knowledge of sludge. In this assessment, except for constituent concentration (which was measured), general sludge characteristics were used, including default assumptions for bulk density, moisture, and porosity.

3.4.3.5 Exposure Uncertainty. Exposure modeling relies heavily on default assumptions concerning population activity patterns, mobility, dietary habits, body weights, and other factors. As described earlier in the variability section, the probabilistic assessment for the adult and child exposure scenario addressed the possible variability in the exposure modeling by using distributions of values for exposure factors. There are some uncertainties, however, in the data that were used. Although it is possible to study various populations to determine various exposure parameters (e.g., age-specific soil ingestion rates or intake rates for food) or to assess past exposures (epidemiological studies) or current exposures, risk assessment is about prediction. Therefore, long-term exposure monitoring in this context is infeasible.

The EFH (U.S. EPA, 1997a,b,c) provides the current state of the science concerning exposure assumptions, and it was used throughout this assessment. To the extent that actual exposure scenarios vary from the assumptions in this risk assessment, risks could be under- or overestimated. For example, there could be farmers and children who have higher exposures than those predicted; however, it is more likely that actual exposures for most of these individuals would fall within the predicted range and, moreover, would be similar to what was modeled.

3.4.3.6 Ecological Exposure Uncertainty. For the ingestion pathway, it is assumed that 100 percent of the receptors' food and water comes from the farm field where sewage sludge is applied and from the associated farm pond. The actual proportion of wildlife receptors' diets that would be contaminated depends on a number of factors such as the species' foraging range, quality of food source, season, intra- and interspecies competition, to name just a few. Considerable uncertainty is associated with estimating what proportion of the diet would be contaminated. For purposes of the screening assessment, it is conservatively assumed that all food and drinking water come from the farm where sludge is applied.

Exposure dose is calculated using BCFs and BAFs to estimate the transfer of pollutants from environmental media into food items. Uncertainty is associated with models used to estimate BCFs for aquatic biota. Furthermore, because bioaccumulation factors specifically for sediment biota were not available, the aquatic BCFs were used to estimate transfer of constituents from sediment to sediment biota. The aquatic BCFs were developed based on surface water concentrations and concentrations in aquatic biota, thus uncertainty is introduced by applying these values to sediment biotransfer. In addition, as noted in Section 2.3.3.1, soil-based BAFs for organic chemicals are unavailable, and a default value of 1 was used to estimate concentrations in terrestrial prey for all organics. While this approach introduces uncertainty, the chemicals addressed in the assessment are not known to be significant bioaccumulators, and the default value of 1 is considered reasonably conservative.

Finally, the BAFs identified in the literature for worms are applied for all soil invertebrates, and the BAFs for small mammals are applied for all terrestrial vertebrate prey (small mammals, birds, and herpetofauna). The worm BAFs and small mammal BAFs were developed based on measured concentrations in worms and small mammals, respectively. Applying these values to derive concentrations in prey of widely varying faunal classes introduces uncertainty in the exposure dose calculations.

3.4.3.7 Human Health Values. The Agency routinely accounts for uncertainty in its development of RfDs and other HHBs. For example, if certain toxicological data are missing from the overall toxicological database (e.g., reproductive data), the Agency will account for this by applying an uncertainty factor.

3.4.3.8 Exposure Factors. For most exposure factors addressed, data analyses involved fitting distributions of data summaries from the EFH (U.S. EPA, 1997a,b,c), in most cases by fitting distributions to selected percentiles. It is assumed that little information is lost by fitting to percentiles versus fitting to raw data. However, some believe that such analyses should always be based on raw data, synthesizing all credible sources.

Three standard two-parameter probability statistical distributions (gamma, lognormal, and Weibull) were used for this assessment. These distributions are special cases of a three-parameter distribution (generalized gamma) that allows for a likelihood ratio test of the fit of the two-parameter models. Other statistical distributions are possible (e.g., U.S. EPA, 2000), but the technique used in this assessment offered considerable improvement over using a lognormal model in all cases, and it was appropriate for this assessment. In support of this conclusion, a comparison of results showed that the three-parameter generalized gamma distribution did not significantly improve on goodness of fit over the two-parameter distributional forms in 58 of 59 cases at the 5 percent level of significance.

Although they offer significant improvement in objectivity over visual estimation, goodness-of-fit tests used to determine which statistical distribution to use for a particular parameter are themselves subject to some uncertainty that should be considered in their application to exposure factors. One area of concern is uncertainty about how the survey statistics in the EFH (U.S. EPA, 1997a,b,c) were calculated. All of the statistics that have been used to assess goodness of fit assume a random sample, which may or may not be a valid assumption for EFH data. Specifically, many of the EFH data sources are surveys that, in many cases, do not involve purely random samples. Rather, they use clustering and stratification, primarily for economic reasons.

3.4.4 Sensitivity Analysis

EPA conducted a statistically based sensitivity analysis to rank the variable parameters in the risk screening assessment according to their contribution to the variability of the resulting HQ calculated for each receptor and constituent combination. This methodology is referred to as a “response surface regression approach” because it uses models similar to those used in a response surface experiment. A response surface methodology uses a statistical approach to designing experiments and an associated model estimation methodology. The terminology “response surface” derives from the fact that a regression model involving a number of continuous independent variables can be viewed as providing an estimated surface of the results in space. Often, a goal of response surface experimentation is to ascertain the combination(s) of input variable values that will yield a minimum or a maximum response. The complexity of the model (e.g., whether it contains only first- and second-order terms or terms of higher degree) determines the general shape of the contours and the degree to which the “true” surface can be approximated.

In this analysis, a regression analysis was applied to a linear equation to estimate the relative change in the output of a probabilistic simulation relative to the changes in the input variable values. This methodology is one of the recommended methods for conducting a sensitivity analysis based on the results of a Monte Carlo analysis described in Appendix B of *RAGS 3A - Process For Conducting Probabilistic Risk Assessment - Draft* (U.S. EPA, 1999b).

Sensitivity analyses historically were conducted by evaluating how much change in risk occurred as a result of varying an individual input variable from a median or mean value to a 90th percentile (high end) value or a 10th percentile (low end) value, depending upon which extreme value produced the higher risk value. However, when the risk depends on the aggregate impact of a number of input variables, such an approach may not necessarily identify the most important inputs. This may occur for several reasons:

- The ranges chosen for the various input variables may not be defined consistently

- Various input variables may interact with one another (i.e., the effect of input X_1 on an outcome Y depends on the level of other inputs X_2, X_3, etc., so that the observed effect of X_1 depends on what values were chosen for the other variables as well)

- Nonlinear effects may obscure the effect of the input variable (e.g., if only low and high values of an input variable are examined, but the relationship between the risk and the input variable is of a quadratic nature, then the importance of the input variable may be overlooked).

To address such issues, statistical regression methods were used to perform the sensitivity analysis. Although regression methods have distinct advantages over previous approaches, certain limitations remain. Regression methods are not capable of determining the sensitivity of model results to input variables that are not varied in the analysis (e.g., assumptions) or are not otherwise included within the scope of the analysis (e.g., model-derived variables). If for some reason the most important variables are not varied or their variability is improperly characterized, the sensitivity analysis may not identify them as being important.

This sensitivity analysis was conducted on a data set generated during modeling of each pathway. This data set included a set of input variables (X_1, X_2, ..., X_p) that were used in the modeling simulation. In this case, the *X*s are parameters associated with management practices, site, environmental conditions, and exposure parameters. The result of interest is the HQ calculated for each pollutant/receptor/management practice combination.

The regression approach uses the various combinations of *X* values that were used during the simulation and the resulting HQ values as input data to a regression model. Functions of the results variables (denoted as *Y*s) were treated as dependent variables; for example, *Y* denoted the logarithm of the HQ. Functions of the *X*s were treated as independent variables. The goals of the approach were to

- Determine a fairly simple polynomial approximation to the simulation results that expressed the *Y*s as functions of the *X*s

- Optimize this “response surface” and assess the importance of the various *X*s by performing statistical tests on the model parameters

- Rank the *X*s based on their relative contribution (in terms of HQ) to the final response surface regression model.

These goals were realized using a second-order regression model. Such a model takes the following form:
where the βs are the least squares regression estimates of the model parameters.

The statistical significance of the parameters associated with the first-order, squared, and cross-product terms were tested and all nonsignificant terms were removed from the model. The parameters in this reduced model were then re-estimated and the testing was repeated. This was

$$\hat{Y} = \hat{\beta}_0 + \sum_{k=1}^{p} \hat{\beta}_k x_k + \sum_{k=1}^{p} \hat{\beta}_{kk} x_k^2 + \sum_{k=1}^{p-1} \sum_{j=k+1}^{p} \hat{\beta}_{kj} x_k x_j \qquad (3\text{-}1)$$

done to capture the most important independent variables (*X*s) that influence the dependent variables (*Y*s).

Once the final regression model was developed, the input parameters (*X*s) were ranked based on the percent of the HQ accounted for by that parameter. The percent HQ was calculated using the following equation:

$$Percent\ HQ = \frac{[FMSS - RMSS]}{[FMSS + ERSS]} \qquad (3\text{-}2)$$

where

FMSS = model sum of squares for the final model

RMSS = model sum of squares for a model in which all terms involving x_u are removed (i.e., a reduced model)

ERSS = model error sum of squares.

The major steps in the sensitivity analysis are identified below, along with details on the reasons for these steps.

1. **Perform any necessary manipulations on the data set.** To perform the sensitivity analysis, the data set must contain only one record for each Monte Carlo iteration, and all variables in the data set must be numeric.

2. **Remove any variables that are constants.** Any variable that was constant across all Monte Carlo iterations does not have any effect on the resulting HQ and was removed from the data set prior to the start of the regression analysis.

3. **Perform transformations (e.g., log, square root) to the continuous input variables, if necessary, so that all input variables will have approximately symmetric distributions.** Transforming the input variables so that each one has an approximately symmetric distribution is necessary to make the standardization of the variables meaningful (i.e., so the mean is near the midpoint of the extremes, and the mean and standard deviation are not highly related).

4. **Check the correlations of the transformed input variables and remove any input variables that are highly correlated with other input variables in the data set.** Regression analysis measures the linear relationship between the terms in the model and the response variable. If two or more input variables are highly correlated with one another, then there is a strong linear relationship between those input variables. Keeping all highly correlated variables in the model will reduce the significance of each of the correlated input variables because each one is essentially explaining the same linear relationship with the response variable (i.e., the effect of one such variable may mask the effect of another).

5. **Standardize the transformed variables.** Standardizing the input variables (i.e., subtracting the mean and dividing by the standard deviation) allows the regression results to be independent of the magnitude of the value of the input variables. The larger value input variables could cause the regression results to seriously underestimate the effects of the smaller value input variables on the changes in environmental concentration and HQ. The combination of transforming and standardizing the input variables creates more optimal conditions for regression analysis.

6. **Use response surface regression methods to test for the main effects, squared terms, and cross products that have the greatest effect on the log(HQ) and develop a model for log(HQ) based on the results of the regression analysis.** After the response surface regression results are obtained, the significance of each term on environmental concentration is evaluated. First, any second-order terms that are determined not to have a significant effect on the environmental concentration are dropped from the model. Any first-order term that is part of a significant second-order term remains in the model, regardless of the level of significance of that first-order term. For example, if the second-order term $X_1 \times X_2$ has a significant effect on the environmental concentration and remains in the model, then both of the first-order terms X_1 and X_2 also remain in the model. Any first-order terms that are determined not to be significant and not to have any significant second-order terms are dropped from the model. The regression analysis is then conducted again on the reduced model. This process is repeated until all of the second-order terms in the model have significant effects on the environmental concentration and no more terms can be removed. The iterative process of dropping insignificant terms and re-evaluating the model allows only the input variables with the greatest effect on the environmental concentration to remain in the model.

7. **Test for the effect of each variable on log(HQ) and use the *p*-values to rank the variables by the amount of effect each variable has on log(HQ).** Because the final model will most likely contain first- and second-order terms involving the same input variables, *F*-tests must be performed to evaluate the effect of each input variable in the final model on the log(HQ). The *F*-tests of each variable will be of the form

$$F = \frac{[FMSS - RMSS] \ / \ [FMDF - RMDF]}{FRSS \ / \ FRDF} \tag{3-3}$$

where

FMSS	=	model sum of squares for full model
RMSS	=	model sum of squares for reduced model
RMDF	=	model degrees of freedom for reduced model
FMDF	=	model degrees of freedom for full model
FRSS	=	residual sum of squares for full model
FRDF	=	residual degrees of freedom for full model.

The full model refers to the model containing all significant terms in the final log(HQ) model. The reduced model refers to the full model minus all terms containing the input variable *X* whose significance is being tested. The *F*-tests evaluate the effect of variable *X* on the HQ by evaluating the differences when variable *X* is in the regression model (full model) and when all model terms containing variable *X* are removed (reduced model). If a substantial increase in the residuals results from ignoring terms involving the variable *X*, then *F* will be "large," implying that these factors can be considered important, in the sense that they require different regression coefficients for the *X*s. The ordering of the *p*-values from such tests can then be used to rank the importance of the various factors on the HQ. The parameters responsible for most of the HQ variability as identified by the sensitivity analysis are presented in the accompanying tables. Detailed results of the sensitivity analysis are presented in Attachment A to this memorandum.

3.4.4.1 Results for Sewage Sludge Lagoons. The screening assessment for sewage sludge managed in lagoons identified six constituents that had human health HQs greater than one for one or more receptors: barium, 4-chloroaniline, manganese, nitrate, and nitrite. A sensitivity analysis was performed for each receptor that had an HQ greater than one for these constituents.

Tables 3-4 to 3-7 show the results for metals. The sensitivity analysis results for the metals indicate that the most important variable is the metal Kd. The one metal for which we had sludge-specific Kd values was silver, and that metal did not result in an HQ greater than one for the sewage sludge lagoon scenario. The exposure factors are important variables for metals in this analysis. Exposure factors most likely will not be refined in a detailed risk assessment.

The results for metals are presented below; only receptors with an HQ greater than one are shown. Note that in all result tables, SS stands for sum of squares and DF for degrees of freedom.

Table 3-4. Sensitivity Analysis Results for Barium in Sewage Sludge Managed in Sewage Sludge Lagoons (Adult)

Variable Name	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Kd	1505.62	32	22411.66	38	20906.04	93
Adult drinking water consumption rate	21605.46	37	22411.66	38	806.20	4

98 percent of variation is accounted for by this method.

Table 3-5. Sensitivity Analysis Results for Barium in Sewage Sludge Managed in Sewage Sludge Lagoons (Child)

Variable Name	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Kd	1863.173	35	22760.94	39	20897.77	92
Child drinking water consumption rate	21583.06	38	22760.94	39	1177.883	5

98 percent of variation is accounted for by this method.

Table 3-6. Sensitivity Analysis Results for Manganese in Sewage Sludge Managed in Sewage Sludge Lagoons (Adult)

Variable Name	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Kd	828.43	28	2844.38	31	2015.95	70.9
Adult drinking water consumption rate	2135.12	30	2844.38	31	709.26	24.9
Adult body weight	2750.71	30	2844.38	31	93.67	3.3

100 percent of variation is accounted for by this method.

Table 3-7. Sensitivity Analysis Results for Manganese in Sewage Sludge Managed in Sewage Sludge Lagoons (Child)

Variable Name	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Kd	1320.07	28	3334.88	31	2014.82	60
Child drinking water consumption rate	2163.38	30	3334.88	31	1171.51	35
Child body weight	3282.85	30	3334.88	31	52.03	2

99 percent of variation is accounted for by this method.

Table 3-8 shows the results for an organic chemical (4-chloroanaline). The results of the sensitivity analysis performed for organic constituents are not as straightforward as the results for metals. The only organic constituent that had an HQ value greater than one was 4-chloroaniline. The constituent 4-chloroaniline failed on the basis of the ingestion of drinking water in the sewage sludge lagoon scenario. For this constituent, three parameters accounted for most of the variability in the HQ values: site latitude, site longitude, and drinking water consumption rate. Other parameters that appeared on the list were body weight, surface impoundment descriptors, and soil parameters.

Table 3-8. Sensitivity Analysis Results for 4-Chloroaniline in Sewage Sludge Managed in Sewage Sludge Lagoons (Adult and Child)

Parameter	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Site latitude	2066.16	46	2890.25	55	824.09	29
Consumption of drinking water	2084.55	54	2890.25	55	805.70	28
Site longitude	2356.09	45	2890.25	55	534.16	18

88 percent of variation is accounted for by this method.

Tables 3-9 and 3-10 show the results for inorganics. The inorganic, nonmetal constituents, nitrate and nitrite, are assumed to have a Kd of one and to move unimpeded through the subsurface. For these constituents, only exposure parameters (drinking water consumption rates and body weights) were identified as responsible for the variability in the HQ values.

Table 3-9. Sensitivity Analysis Results for Nitrate in Sewage Sludge Managed in Sewage Sludge Lagoons (Adult and Child)

Variable Name	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Drinking water consumption rate	126.58	24	945.25	25	818.68	87
Body weight	847.00	24	945.25	25	98.26	10

97 percent of variation is accounted for by this method.

Table 3-10. Sensitivity Analysis Results for Nitrite in Sewage Sludge Managed in Sewage Sludge Lagoons (Adult and Child)

Variable Name	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Drinking water consumption rate	126.58	24	945.26	25	818.68	87
Body weight	847.00	24	945.26	25	98.26	10

97 percent of variation is accounted for by this method.

3.4.4.2 Results for Agricultural Land Application of Sewage Sludge. The screening assessment for sewage sludge managed by agricultural land application identified two constituents that had human health HQs greater than one. The screening assessment does not include groundwater modeling, but uses the leachate concentration of the constituent estimated at a depth of 1 meter immediately under the agricultural land as the drinking water concentration for exposure to groundwater that is used for drinking and showering. This is an extremely protective assumption; in a detailed assessment, groundwater modeling can be included to evaluate this pathway more realistically. The highest ranking variables for all constituents in the sensitivity analysis for human health pathways are as follows:

- Drinking water consumption rates and body weights,
- Total amount of sludge applied to the land (rate of sludge application and the number of years sludge is applied),
- Time period during and after sludge application when adults and children live on the farm,
- Air modeling data (air concentrations of particles and vapors and wet and dry deposition of particles) in various areas within the conceptual site,
- Factors that affect runoff from the farm (length-slope factor, erosivity factor, erodibility factor, silt content of soils, and curve number applied to the farm), and
- Kd's for metals.

The distribution of values used in this assessment is from the *Exposure Factors Handbook* (EFH) and represents true variability in this parameter that most likely will remain in the detailed assessment. The air modeling variables were set to maximum values for each geographic area for the screening assessment. These distributions can be refined in the detailed assessment. The factor that is specific to metals is the Kd (soil-water partitioning coefficient). The only metal with sludge-specific values for this parameter is silver. The values for the other metals can be refined to be more appropriate for the sewage sludge matrix in the detailed assessment.

The constituents that had HQ values greater than one for one or more human receptors are as follows:

- Nitrite
- Silver.

The sensitivity analysis results for these chemicals are shown in Tables 3-11 to 3-13.

Table 3-11. Sensitivity Analysis Results for Nitrite in Sewage Sludge Managed by Agricultural Land Application (Child)

Variable Name	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Child (1-5 years) drinking water consumption rate	2859.77	83	3730.73	84	870.96	23
Last year sludge is applied	3498.32	80	3730.73	84	232.41	6
Year child moves to the farm	3582.54	79	3730.73	84	148.19	4
Residence period child lives on the farm	3593.41	83	3730.73	84	137.32	4

64 percent of variation is accounted for by this method.

Table 3-12. Sensitivity Analysis Results for Silver in Sewage Sludge Managed by Agricultural Land Application (Adult)

Variable Name	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Adult drinking water consumption rate	3345.80	71	4107.59	72	761.79	19
Last year of sludge application	3532.30	69	4107.59	72	575.30	14
Residence period adult farmer lives on the farm	3563.25	71	4107.59	72	544.35	13
Year adult moves to the farm	3827.35	67	4107.59	72	280.24	7
Rainfall factor	3982.22	69	4107.59	72	125.37	3

70 percent of variation is accounted for by this method.

Table 3-13. Sensitivity Analysis Results for Silver in Sewage Sludge Managed by Agricultural Land Application (Child)

Variable Name	Reduced Model SS	Reduced Model DF	Full Model SS	Full Model DF	Variable SS	Percent Variation
Child (1-5 years) drinking water consumption rate	2305.33	97	3144.67	98	839.33	27
Last year of sludge application	2735.15	94	3144.67	98	409.52	13
Year child moves to the farm	2965.26	92	3144.67	98	179.40	6
Residence period child lives on the farm	3025.46	97	3144.67	98	119.21	4
Rate of application of sludge	3040.12	96	3144.67	98	104.55	3

73 percent of variation is accounted for by this method.

4.0 References

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Appendix A

Characterization of Surface Impoundments

Appendix A

Characterization of Surface Impoundments

The surface impoundments modeled in the sewage sludge screening analysis were selected from the population of surface impoundments that manage industrial nonhazardous wastewaters identified in the Surface Impoundment Study (SIS) survey conducted by EPA's Office of Solid Waste (*Industrial Surface Impoundments in the United States*, March 2001, EPA 530-R-01-005). Because sewage sludge disposal lagoons are generally nonaerated and tend to hold sewage sludge for a long time, only the nonaerated SIS survey impoundments with residence times greater than 2 years were used to represent sewage sludge lagoons in the screening analysis.[1] In addition, all of the impoundments modeled are assumed to be unlined. The dimensions and locations of these surface impoundments are included as Attachment A to this appendix.

A1.0 Location of Surface Impoundments

The surface impoundments modeled in this analysis were modeled at the locations reported for them in the SIS survey. These nonhazardous surface impoundments are located throughout the United States in a wide array of settings. Some facilities are located in rural areas adjacent to agricultural land use, whereas other facilities are in heavily populated residential areas or are part of a concentration of industrial activity. Generally, surface impoundments are located in areas with fairly significant precipitation levels and availability of water.

A2.0 Surface Impoundment Size

As evidenced in Attachment A to this appendix, impoundments vary considerably in surface area and depth. Impoundment size is an important factor in assessing the potential for human exposure to chemicals managed at these facilities. For the air pathway, volatilization potential can increase at larger impoundments as a result of the increase in surface area exposed to the atmosphere at these impoundments. Increasing impoundment size also increases impacts through the groundwater pathway from the unlined impoundments considered in the sewage sludge lagoon analysis.

[1] The hydraulic residence time was calculated using the volumetric flow rate for the surface impoundment. For those impoundments for which the survey did not identified a flow rate, the residence time was randomly selected out of a uniform distribution of values between 2 and 50 years.

A3.0 Proximity of Humans to Surface Impoundments

The proximity of human receptors to surface impoundments has a great impact on the potential for exposure through air and groundwater pathways. For air, EPA has generally observed a significant decline in the concentration of airborne chemicals in a plume as the distance from the source increases. Because of this sensitivity and the uncertainties in the location of human receptors around any particular sewage sludge lagoons, a national distribution was used to vary receptor distance when assessing human exposure to sewage sludge pollutants through the air pathway. For each iteration of the probabilistic analysis, the closest human receptors were assumed to reside at a randomly selected distances of 75, 150, 250, or 500 meters from the lagoon. Because sewage sludge lagoons are located in both urban and rural settings, EPA believes that this is a reasonable distribution of distances to represent maximumly exposed receptors in a screening analysis.

The movement of a contaminant plume in groundwater to human receptors is influenced by a host of factors ranging from soil and aquifer conditions to the distance to a drinking water well. Attenuation through the groundwater pathway between the lagoon and a downgradient was represented very simply in this analysis as a dilution attenuation factor (DAF), which is the contaminant concentration in the leachate leaving the lagoon divided by the concentration at the receptor well. For all model runs, a DAF of 2 was applied to the leachate concentrations immediately below the impoundment to estimate the concentration at a downgradient drinking water well (i.e., the well concentration was set at half the leachate concentration). This factor is the 10^{th} percentile DAF determined in the SIS for all chemicals managed in all surface impoundments, and EPA believes it is a reasonably protective DAF to use in this screening analysis.

A4.0 References

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Appendix A

Attachment A:
Surface Impoundment Descriptive Data

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
2701-1	03822 (Savannah)	1040	0.50	Taken from a uniform distribution of values between 2-50 yrs
4378-1	03822 (Savannah)	26710	5.34	Taken from a uniform distribution of values between 2-50 yrs
4378-2	03822 (Savannah)	30350	4.42	Taken from a uniform distribution of values between 2-50 yrs
4378-2	03822 (Savannah)	30350	8.82	Taken from a uniform distribution of values between 2-50 yrs
9063-9	03822 (Savannah)	81030	3.24	Taken from a uniform distribution of values between 2-50 yrs
9063-9	03822 (Savannah)	81030	4.77	Taken from a uniform distribution of values between 2-50 yrs
9063-9	03822 (Savannah)	81030	5.61	Taken from a uniform distribution of values between 2-50 yrs
6790-6	03937 (Lake Charles)	1244	2.32	Taken from a uniform distribution of values between 2-50 yrs
6790-6	03937 (Lake Charles)	1244	3.68	Taken from a uniform distribution of values between 2-50 yrs
6790-6	03937 (Lake Charles)	1244	8.58	Taken from a uniform distribution of values between 2-50 yrs
6790-7	03937 (Lake Charles)	743.2	5.72	Taken from a uniform distribution of values between 2-50 yrs
7146-1	03947 (Kansas City)	1030	7.32	Taken from a uniform distribution of values between 2-50 yrs
1269-1	03947 (Kansas City)	1684	7.02	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
7765-3	03947 (Kansas City)	1698	1.78	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	4.27	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	4.53	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	5.62	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	6.10	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	6.15	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	7.01	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	7.11	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	7.47	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	7.48	Taken from a uniform distribution of values between 2-50 yrs
7146-2	03947 (Kansas City)	724.4	7.64	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.63	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.73	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
1361-1	13737 (Norfolk)	2935	0.78	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.84	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.86	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.90	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.91	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.93	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.97	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.98	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	0.99	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.00	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.01	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.04	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.07	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
1361-1	13737 (Norfolk)	2935	1.17	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.20	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.26	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.30	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.31	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.35	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.39	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.40	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.41	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.43	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.44	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.50	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.51	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
1361-1	13737 (Norfolk)	2935	1.58	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.67	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.69	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.75	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.84	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.93	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.94	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.96	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.98	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	1.99	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.00	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.07	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.19	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
1361-1	13737 (Norfolk)	2935	2.22	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.23	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.28	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.31	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.43	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.75	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.82	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	2.87	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	3.02	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	3.25	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	3.35	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	3.37	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	3.38	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
1361-1	13737 (Norfolk)	2935	3.72	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	3.73	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	3.79	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	3.89	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	3.94	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	4.34	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	4.41	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	5.25	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	5.92	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	5.96	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	6.16	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	6.32	Taken from a uniform distribution of values between 2-50 yrs
1361-1	13737 (Norfolk)	2935	6.55	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
1361-1	13737 (Norfolk)	2935	6.89	Taken from a uniform distribution of values between 2-50 yrs
3268-1	13739 (Philadelphia)	2090	1.53	Taken from a uniform distribution of values between 2-50 yrs
8984-7	13739 (Philadelphia)	3579	3.60	12.85
2232-2	13739 (Philadelphia)	486.5	0.68	Taken from a uniform distribution of values between 2-50 yrs
4595-9	13873 (Athens)	44870	1.22	2.50
8848-1	13874 (Atlanta)	173.9	1.22	15.35
6782-3	13874 (Atlanta)	92.9	6.67	Taken from a uniform distribution of values between 2-50 yrs
2748-11	13880 (Charleston)	1619	1.74	Taken from a uniform distribution of values between 2-50 yrs
2748-12	13880 (Charleston)	1619	2.44	Taken from a uniform distribution of values between 2-50 yrs
2748-8	13880 (Charleston)	18210	3.21	Taken from a uniform distribution of values between 2-50 yrs
2748-10	13880 (Charleston)	4856	5.80	Taken from a uniform distribution of values between 2-50 yrs
2748-9	13880 (Charleston)	4856	4.15	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
2748-7	13880 (Charleston)	9308	2.14	Taken from a uniform distribution of values between 2-50 yrs
2748-3	13880 (Charleston)	9680	7.78	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	2.33	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	2.36	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	2.38	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	2.51	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	2.57	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	2.78	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	3.49	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	3.50	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	3.80	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	3.88	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	3.90	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
7848-3	13897 (Nashville)	1856	4.13	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	4.44	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	4.55	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	4.68	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	4.89	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	4.96	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	7.43	Taken from a uniform distribution of values between 2-50 yrs
7848-3	13897 (Nashville)	1856	9.85	Taken from a uniform distribution of values between 2-50 yrs
8689-2	13897 (Nashville)	6961	5.18	12.69
1579-1	13957 (Shreveport)	766	2.29	Taken from a uniform distribution of values between 2-50 yrs
3864-1	13957 (Shreveport)	809400	3.05	Taken from a uniform distribution of values between 2-50 yrs
3578-7	13963 (Little Rock)	11870	1.45	8.30
4126-6	13963 (Little Rock)	214500	3.66	5.68

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
3578-9	13963 (Little Rock)	4608	1.53	5.10
3770-3	13967 (Oklahoma City)	1986	1.25	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	2.25	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	2.47	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	2.68	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	3.41	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	4.00	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	4.57	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	5.43	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	5.67	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	6.03	Taken from a uniform distribution of values between 2-50 yrs
3770-3	13967 (Oklahoma City)	1986	6.09	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	1.27	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
3770-4	13967 (Oklahoma City)	2277	1.42	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	1.48	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	1.71	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	1.76	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	1.82	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	1.92	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	2.16	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	2.48	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	2.49	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	3.31	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	3.69	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	4.50	Taken from a uniform distribution of values between 2-50 yrs
3770-4	13967 (Oklahoma City)	2277	4.54	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
3770-4	13967 (Oklahoma City)	2277	6.06	Taken from a uniform distribution of values between 2-50 yrs
9487-1	13968 (Tulsa)	1524	2.02	Taken from a uniform distribution of values between 2-50 yrs
9487-1	13968 (Tulsa)	1524	2.17	Taken from a uniform distribution of values between 2-50 yrs
9487-1	13968 (Tulsa)	1524	3.55	Taken from a uniform distribution of values between 2-50 yrs
9487-1	13968 (Tulsa)	1524	8.47	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.64	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.65	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.66	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.67	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.69	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.70	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.71	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.72	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
5980-2	13968 (Tulsa)	26	0.74	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.79	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.80	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.82	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.83	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.85	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.87	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.88	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.89	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.92	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.94	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	0.96	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.02	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
5980-2	13968 (Tulsa)	26	1.03	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.05	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.08	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.09	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.10	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.12	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.13	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.15	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.18	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.19	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.21	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.23	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.24	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
5980-2	13968 (Tulsa)	26	1.28	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.33	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.37	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.46	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.47	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.49	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.52	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.54	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.56	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.57	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.60	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.61	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.73	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
5980-2	13968 (Tulsa)	26	1.80	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.86	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.88	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.89	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	1.97	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.01	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.10	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.15	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.18	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.20	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.26	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.37	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.41	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
5980-2	13968 (Tulsa)	26	2.45	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.54	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.56	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.69	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.81	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.84	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.86	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.89	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.90	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.91	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.93	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.94	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.96	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
5980-2	13968 (Tulsa)	26	2.98	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	2.99	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.00	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.06	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.17	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.19	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.20	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.27	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.29	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.32	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.40	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.42	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.51	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
5980-2	13968 (Tulsa)	26	3.58	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.60	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.61	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.64	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.66	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.84	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.85	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.93	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.95	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	3.96	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	4.19	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	4.25	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	4.36	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
5980-2	13968 (Tulsa)	26	4.58	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	4.65	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	4.83	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	4.84	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	4.85	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	5.09	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	5.20	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	5.32	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	5.35	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	5.39	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	6.46	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	6.58	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	6.65	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
5980-2	13968 (Tulsa)	26	6.66	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	7.05	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	8.78	Taken from a uniform distribution of values between 2-50 yrs
5980-2	13968 (Tulsa)	26	9.38	Taken from a uniform distribution of values between 2-50 yrs
1663-1	13968 (Tulsa)	580.6	1.83	Taken from a uniform distribution of values between 2-50 yrs
2058-6	13994 (St Louis)	480000	4.80	Taken from a uniform distribution of values between 2-50 yrs
3647-1	14740 (Hartford)	913.8	0.75	Taken from a uniform distribution of values between 2-50 yrs
3647-1	14740 (Hartford)	913.8	2.30	Taken from a uniform distribution of values between 2-50 yrs
3647-1	14740 (Hartford)	913.8	2.55	Taken from a uniform distribution of values between 2-50 yrs
3647-1	14740 (Hartford)	913.8	2.58	Taken from a uniform distribution of values between 2-50 yrs
3647-1	14740 (Hartford)	913.8	2.83	Taken from a uniform distribution of values between 2-50 yrs
3647-1	14740 (Hartford)	913.8	4.97	Taken from a uniform distribution of values between 2-50 yrs
3647-1	14740 (Hartford)	913.8	5.14	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
3647-1	14740 (Hartford)	913.8	9.40	Taken from a uniform distribution of values between 2-50 yrs
3647-1	14740 (Hartford)	913.8	9.79	Taken from a uniform distribution of values between 2-50 yrs
6177-6	14764 (Portland)	45790	3.36	3.37
6177-7	14764 (Portland)	6070	1.77	Taken from a uniform distribution of values between 2-50 yrs
6177-7	14764 (Portland)	6070	3.23	Taken from a uniform distribution of values between 2-50 yrs
6177-7	14764 (Portland)	6070	4.03	Taken from a uniform distribution of values between 2-50 yrs
6177-7	14764 (Portland)	6070	4.38	Taken from a uniform distribution of values between 2-50 yrs
6177-7	14764 (Portland)	6070	4.51	Taken from a uniform distribution of values between 2-50 yrs
6177-7	14764 (Portland)	6070	5.87	Taken from a uniform distribution of values between 2-50 yrs
6177-7	14764 (Portland)	6070	6.72	Taken from a uniform distribution of values between 2-50 yrs
2837-1	14840 (Muskegon)	8763	3.05	3.33
2837-2	14840 (Muskegon)	8877	4.27	9.45

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
1137-4	23174 (Los Angeles)	29260	5.68	4.17
1137-1	23174 (Los Angeles)	9394	1.22	Taken from a uniform distribution of values between 2-50 yrs
7695-5	23232 (Sacramento)	1619	2.06	Taken from a uniform distribution of values between 2-50 yrs
7695-5	23232 (Sacramento)	1619	2.27	Taken from a uniform distribution of values between 2-50 yrs
7695-5	23232 (Sacramento)	1619	2.46	Taken from a uniform distribution of values between 2-50 yrs
7695-5	23232 (Sacramento)	1619	3.11	Taken from a uniform distribution of values between 2-50 yrs
7695-5	23232 (Sacramento)	1619	6.54	Taken from a uniform distribution of values between 2-50 yrs
7695-6	23232 (Sacramento)	1619	1.65	Taken from a uniform distribution of values between 2-50 yrs
7695-6	23232 (Sacramento)	1619	1.85	Taken from a uniform distribution of values between 2-50 yrs
7695-6	23232 (Sacramento)	1619	3.22	Taken from a uniform distribution of values between 2-50 yrs
7695-6	23232 (Sacramento)	1619	3.33	Taken from a uniform distribution of values between 2-50 yrs
7695-6	23232 (Sacramento)	1619	3.56	Taken from a uniform distribution of values between 2-50 yrs
7695-6	23232 (Sacramento)	1619	4.86	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
7695-6	23232 (Sacramento)	1619	5.74	Taken from a uniform distribution of values between 2-50 yrs
7695-6	23232 (Sacramento)	1619	6.07	Taken from a uniform distribution of values between 2-50 yrs
7695-6	23232 (Sacramento)	1619	7.08	Taken from a uniform distribution of values between 2-50 yrs
7695-7	23232 (Sacramento)	161900	2.42	Taken from a uniform distribution of values between 2-50 yrs
7695-7	23232 (Sacramento)	161900	2.88	Taken from a uniform distribution of values between 2-50 yrs
7695-7	23232 (Sacramento)	161900	2.97	Taken from a uniform distribution of values between 2-50 yrs
8458-1	23232 (Sacramento)	29140	3.25	2.27
8458-1	23232 (Sacramento)	29140	3.74	2.62
8458-1	23232 (Sacramento)	29140	4.58	3.20
8458-1	23232 (Sacramento)	29140	4.86	3.40
8458-1	23232 (Sacramento)	29140	4.92	3.44
8458-1	23232 (Sacramento)	29140	5.01	3.50
8458-1	23232 (Sacramento)	29140	8.04	5.62

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
8458-1	23232 (Sacramento)	29140	8.67	6.06
8458-2	23232 (Sacramento)	29140	3.05	2.13
4972-4	23234 (San Francisco)	2420	2.05	Taken from a uniform distribution of values between 2-50 yrs
4972-1	23234 (San Francisco)	6475	1.11	Taken from a uniform distribution of values between 2-50 yrs
6728-1	24018 (Cheyenne)	1001	2.60	Taken from a uniform distribution of values between 2-50 yrs
6728-1	24018 (Cheyenne)	1001	3.45	Taken from a uniform distribution of values between 2-50 yrs
6728-1	24018 (Cheyenne)	1001	4.47	Taken from a uniform distribution of values between 2-50 yrs
6728-1	24018 (Cheyenne)	1001	4.66	Taken from a uniform distribution of values between 2-50 yrs
6728-6	24018 (Cheyenne)	116600	3.36	2.46
6728-2	24018 (Cheyenne)	1281	4.32	Taken from a uniform distribution of values between 2-50 yrs
6728-2	24018 (Cheyenne)	1281	5.76	Taken from a uniform distribution of values between 2-50 yrs
6728-2	24018 (Cheyenne)	1281	8.28	Taken from a uniform distribution of values between 2-50 yrs
6728-5	24018 (Cheyenne)	3518	1.87	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
6728-5	24018 (Cheyenne)	3518	2.08	Taken from a uniform distribution of values between 2-50 yrs
6728-5	24018 (Cheyenne)	3518	4.90	Taken from a uniform distribution of values between 2-50 yrs
6728-5	24018 (Cheyenne)	3518	7.28	Taken from a uniform distribution of values between 2-50 yrs
6728-5	24018 (Cheyenne)	3518	9.02	Taken from a uniform distribution of values between 2-50 yrs
2710-1	24033 (Billings)	1486	1.53	4.84
9793-2	24033 (Billings)	1810	0.62	6.14
9793-2	24033 (Billings)	1810	0.62	6.13
9793-2	24033 (Billings)	1810	0.62	6.15
9793-2	24033 (Billings)	1810	0.63	6.31
9793-2	24033 (Billings)	1810	0.63	6.22
9793-2	24033 (Billings)	1810	0.65	6.47
9793-2	24033 (Billings)	1810	0.65	6.45
9793-2	24033 (Billings)	1810	0.65	6.46

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	0.65	6.44
9793-2	24033 (Billings)	1810	0.67	6.68
9793-2	24033 (Billings)	1810	0.67	6.64
9793-2	24033 (Billings)	1810	0.68	6.80
9793-2	24033 (Billings)	1810	0.68	6.76
9793-2	24033 (Billings)	1810	0.69	6.84
9793-2	24033 (Billings)	1810	0.71	7.07
9793-2	24033 (Billings)	1810	0.71	7.06
9793-2	24033 (Billings)	1810	0.71	7.02
9793-2	24033 (Billings)	1810	0.71	7.09
9793-2	24033 (Billings)	1810	0.72	7.13
9793-2	24033 (Billings)	1810	0.72	7.12
9793-2	24033 (Billings)	1810	0.72	7.14

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	0.72	7.17
9793-2	24033 (Billings)	1810	0.72	7.16
9793-2	24033 (Billings)	1810	0.73	7.30
9793-2	24033 (Billings)	1810	0.74	7.38
9793-2	24033 (Billings)	1810	0.75	7.42
9793-2	24033 (Billings)	1810	0.76	7.53
9793-2	24033 (Billings)	1810	0.77	7.62
9793-2	24033 (Billings)	1810	0.77	7.69
9793-2	24033 (Billings)	1810	0.79	7.83
9793-2	24033 (Billings)	1810	0.79	7.84
9793-2	24033 (Billings)	1810	0.81	8.11
9793-2	24033 (Billings)	1810	0.82	8.12
9793-2	24033 (Billings)	1810	0.84	8.36

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	0.85	8.46
9793-2	24033 (Billings)	1810	0.85	8.50
9793-2	24033 (Billings)	1810	0.86	8.60
9793-2	24033 (Billings)	1810	0.86	8.54
9793-2	24033 (Billings)	1810	0.86	8.53
9793-2	24033 (Billings)	1810	0.88	8.78
9793-2	24033 (Billings)	1810	0.89	8.83
9793-2	24033 (Billings)	1810	0.89	8.87
9793-2	24033 (Billings)	1810	0.90	8.95
9793-2	24033 (Billings)	1810	0.90	8.92
9793-2	24033 (Billings)	1810	0.92	9.15
9793-2	24033 (Billings)	1810	0.93	9.28
9793-2	24033 (Billings)	1810	0.94	9.36

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	0.94	9.39
9793-2	24033 (Billings)	1810	0.95	9.46
9793-2	24033 (Billings)	1810	0.95	9.50
9793-2	24033 (Billings)	1810	0.96	9.53
9793-2	24033 (Billings)	1810	0.97	9.68
9793-2	24033 (Billings)	1810	0.97	9.64
9793-2	24033 (Billings)	1810	0.98	9.76
9793-2	24033 (Billings)	1810	0.98	9.71
9793-2	24033 (Billings)	1810	0.98	9.72
9793-2	24033 (Billings)	1810	0.98	9.78
9793-2	24033 (Billings)	1810	1.00	9.99
9793-2	24033 (Billings)	1810	1.02	10.19
9793-2	24033 (Billings)	1810	1.04	10.36

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	1.06	10.57
9793-2	24033 (Billings)	1810	1.07	10.60
9793-2	24033 (Billings)	1810	1.08	10.77
9793-2	24033 (Billings)	1810	1.08	10.79
9793-2	24033 (Billings)	1810	1.08	10.72
9793-2	24033 (Billings)	1810	1.08	10.70
9793-2	24033 (Billings)	1810	1.09	10.82
9793-2	24033 (Billings)	1810	1.10	10.96
9793-2	24033 (Billings)	1810	1.10	10.98
9793-2	24033 (Billings)	1810	1.11	11.04
9793-2	24033 (Billings)	1810	1.11	11.00
9793-2	24033 (Billings)	1810	1.13	11.24
9793-2	24033 (Billings)	1810	1.15	11.46

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	1.15	11.43
9793-2	24033 (Billings)	1810	1.15	11.40
9793-2	24033 (Billings)	1810	1.17	11.63
9793-2	24033 (Billings)	1810	1.18	11.78
9793-2	24033 (Billings)	1810	1.19	11.89
9793-2	24033 (Billings)	1810	1.19	11.87
9793-2	24033 (Billings)	1810	1.20	11.94
9793-2	24033 (Billings)	1810	1.20	11.92
9793-2	24033 (Billings)	1810	1.21	12.07
9793-2	24033 (Billings)	1810	1.22	12.10
9793-2	24033 (Billings)	1810	1.23	12.23
9793-2	24033 (Billings)	1810	1.24	12.34
9793-2	24033 (Billings)	1810	1.24	12.32

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	1.24	12.30
9793-2	24033 (Billings)	1810	1.24	12.33
9793-2	24033 (Billings)	1810	1.25	12.40
9793-2	24033 (Billings)	1810	1.25	12.42
9793-2	24033 (Billings)	1810	1.25	12.39
9793-2	24033 (Billings)	1810	1.26	12.53
9793-2	24033 (Billings)	1810	1.27	12.59
9793-2	24033 (Billings)	1810	1.27	12.67
9793-2	24033 (Billings)	1810	1.27	12.68
9793-2	24033 (Billings)	1810	1.29	12.86
9793-2	24033 (Billings)	1810	1.29	12.79
9793-2	24033 (Billings)	1810	1.29	12.87
9793-2	24033 (Billings)	1810	1.29	12.81

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	1.34	13.31
9793-2	24033 (Billings)	1810	1.35	13.44
9793-2	24033 (Billings)	1810	1.35	13.41
9793-2	24033 (Billings)	1810	1.41	14.07
9793-2	24033 (Billings)	1810	1.42	14.18
9793-2	24033 (Billings)	1810	1.44	14.32
9793-2	24033 (Billings)	1810	1.44	14.34
9793-2	24033 (Billings)	1810	1.46	14.57
9793-2	24033 (Billings)	1810	1.47	14.60
9793-2	24033 (Billings)	1810	1.47	14.66
9793-2	24033 (Billings)	1810	1.49	14.80
9793-2	24033 (Billings)	1810	1.49	14.79
9793-2	24033 (Billings)	1810	1.51	15.03

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	1.51	15.05
9793-2	24033 (Billings)	1810	1.52	15.09
9793-2	24033 (Billings)	1810	1.53	15.24
9793-2	24033 (Billings)	1810	1.53	15.19
9793-2	24033 (Billings)	1810	1.54	15.28
9793-2	24033 (Billings)	1810	1.54	15.35
9793-2	24033 (Billings)	1810	1.55	15.40
9793-2	24033 (Billings)	1810	1.55	15.39
9793-2	24033 (Billings)	1810	1.55	15.47
9793-2	24033 (Billings)	1810	1.56	15.48
9793-2	24033 (Billings)	1810	1.58	15.75
9793-2	24033 (Billings)	1810	1.60	15.90
9793-2	24033 (Billings)	1810	1.60	15.93

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	1.60	15.89
9793-2	24033 (Billings)	1810	1.61	15.99
9793-2	24033 (Billings)	1810	1.63	16.21
9793-2	24033 (Billings)	1810	1.63	16.27
9793-2	24033 (Billings)	1810	1.64	16.34
9793-2	24033 (Billings)	1810	1.65	16.39
9793-2	24033 (Billings)	1810	1.66	16.52
9793-2	24033 (Billings)	1810	1.68	16.70
9793-2	24033 (Billings)	1810	1.69	16.81
9793-2	24033 (Billings)	1810	1.69	16.80
9793-2	24033 (Billings)	1810	1.70	16.96
9793-2	24033 (Billings)	1810	1.72	17.09
9793-2	24033 (Billings)	1810	1.76	17.48

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	1.83	18.23
9793-2	24033 (Billings)	1810	1.86	18.50
9793-2	24033 (Billings)	1810	1.86	18.51
9793-2	24033 (Billings)	1810	1.92	19.13
9793-2	24033 (Billings)	1810	1.92	19.10
9793-2	24033 (Billings)	1810	1.95	19.37
9793-2	24033 (Billings)	1810	1.95	19.44
9793-2	24033 (Billings)	1810	2.04	20.28
9793-2	24033 (Billings)	1810	2.07	20.65
9793-2	24033 (Billings)	1810	2.07	20.63
9793-2	24033 (Billings)	1810	2.07	20.59
9793-2	24033 (Billings)	1810	2.09	20.83
9793-2	24033 (Billings)	1810	2.10	20.92

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	2.12	21.13
9793-2	24033 (Billings)	1810	2.13	21.18
9793-2	24033 (Billings)	1810	2.17	21.55
9793-2	24033 (Billings)	1810	2.18	21.66
9793-2	24033 (Billings)	1810	2.19	21.80
9793-2	24033 (Billings)	1810	2.19	21.83
9793-2	24033 (Billings)	1810	2.20	21.92
9793-2	24033 (Billings)	1810	2.21	22.03
9793-2	24033 (Billings)	1810	2.21	22.02
9793-2	24033 (Billings)	1810	2.22	22.05
9793-2	24033 (Billings)	1810	2.23	22.23
9793-2	24033 (Billings)	1810	2.23	22.21
9793-2	24033 (Billings)	1810	2.25	22.35

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	2.26	22.54
9793-2	24033 (Billings)	1810	2.27	22.57
9793-2	24033 (Billings)	1810	2.27	22.56
9793-2	24033 (Billings)	1810	2.30	22.87
9793-2	24033 (Billings)	1810	2.36	23.47
9793-2	24033 (Billings)	1810	2.39	23.81
9793-2	24033 (Billings)	1810	2.40	23.92
9793-2	24033 (Billings)	1810	2.41	23.99
9793-2	24033 (Billings)	1810	2.41	23.96
9793-2	24033 (Billings)	1810	2.43	24.22
9793-2	24033 (Billings)	1810	2.44	24.30
9793-2	24033 (Billings)	1810	2.44	24.29
9793-2	24033 (Billings)	1810	2.45	24.35

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	2.46	24.53
9793-2	24033 (Billings)	1810	2.47	24.54
9793-2	24033 (Billings)	1810	2.54	25.29
9793-2	24033 (Billings)	1810	2.55	25.35
9793-2	24033 (Billings)	1810	2.57	25.58
9793-2	24033 (Billings)	1810	2.68	26.64
9793-2	24033 (Billings)	1810	2.70	26.90
9793-2	24033 (Billings)	1810	2.74	27.30
9793-2	24033 (Billings)	1810	2.75	27.34
9793-2	24033 (Billings)	1810	2.76	27.52
9793-2	24033 (Billings)	1810	2.81	28.01
9793-2	24033 (Billings)	1810	2.88	28.63
9793-2	24033 (Billings)	1810	2.88	28.68

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	2.91	28.97
9793-2	24033 (Billings)	1810	2.92	29.08
9793-2	24033 (Billings)	1810	2.96	29.48
9793-2	24033 (Billings)	1810	2.97	29.55
9793-2	24033 (Billings)	1810	3.03	30.12
9793-2	24033 (Billings)	1810	3.04	30.29
9793-2	24033 (Billings)	1810	3.06	30.45
9793-2	24033 (Billings)	1810	3.13	31.20
9793-2	24033 (Billings)	1810	3.16	31.48
9793-2	24033 (Billings)	1810	3.21	31.94
9793-2	24033 (Billings)	1810	3.25	32.39
9793-2	24033 (Billings)	1810	3.27	32.53
9793-2	24033 (Billings)	1810	3.29	32.79

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	3.36	33.41
9793-2	24033 (Billings)	1810	3.42	34.05
9793-2	24033 (Billings)	1810	3.46	34.42
9793-2	24033 (Billings)	1810	3.47	34.58
9793-2	24033 (Billings)	1810	3.60	35.81
9793-2	24033 (Billings)	1810	3.62	36.06
9793-2	24033 (Billings)	1810	3.64	36.19
9793-2	24033 (Billings)	1810	3.72	37.01
9793-2	24033 (Billings)	1810	3.73	37.16
9793-2	24033 (Billings)	1810	3.79	37.75
9793-2	24033 (Billings)	1810	3.79	37.71
9793-2	24033 (Billings)	1810	3.80	37.81
9793-2	24033 (Billings)	1810	3.83	38.17

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	3.91	38.87
9793-2	24033 (Billings)	1810	3.92	39.05
9793-2	24033 (Billings)	1810	3.95	39.31
9793-2	24033 (Billings)	1810	4.01	39.96
9793-2	24033 (Billings)	1810	4.02	39.99
9793-2	24033 (Billings)	1810	4.07	40.48
9793-2	24033 (Billings)	1810	4.09	40.68
9793-2	24033 (Billings)	1810	4.10	40.83
9793-2	24033 (Billings)	1810	4.28	42.61
9793-2	24033 (Billings)	1810	4.35	43.30
9793-2	24033 (Billings)	1810	4.37	43.48
9793-2	24033 (Billings)	1810	4.38	43.63
9793-2	24033 (Billings)	1810	4.40	43.84

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
9793-2	24033 (Billings)	1810	4.52	45.00
9793-2	24033 (Billings)	1810	4.53	45.13
9793-2	24033 (Billings)	1810	4.55	45.30
9793-2	24033 (Billings)	1810	4.60	45.79
9793-2	24033 (Billings)	1810	4.70	46.82
9793-2	24033 (Billings)	1810	4.71	46.88
9793-2	24033 (Billings)	1810	4.78	47.57
9793-2	24033 (Billings)	1810	4.88	48.59
9793-2	24033 (Billings)	1810	4.89	48.63
9793-2	24033 (Billings)	1810	5.01	49.90
2710-4	24033 (Billings)	27.9	0.61	Taken from a uniform distribution of values between 2-50 yrs
4115-2	24033 (Billings)	3333	1.68	Taken from a uniform distribution of values between 2-50 yrs
4115-2	24033 (Billings)	3333	5.13	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
4115-2	24033 (Billings)	3333	6.01	Taken from a uniform distribution of values between 2-50 yrs
4115-1	24033 (Billings)	5549	2.40	Taken from a uniform distribution of values between 2-50 yrs
4115-1	24033 (Billings)	5549	3.10	Taken from a uniform distribution of values between 2-50 yrs
4115-1	24033 (Billings)	5549	3.36	Taken from a uniform distribution of values between 2-50 yrs
4115-1	24033 (Billings)	5549	4.05	Taken from a uniform distribution of values between 2-50 yrs
6055-3	93819 (Indianapolis)	20230	2.08	2.11
6055-3	93819 (Indianapolis)	20230	2.14	2.17
6055-3	93819 (Indianapolis)	20230	2.59	2.64
6055-3	93819 (Indianapolis)	20230	3.00	3.04
6055-3	93819 (Indianapolis)	20230	3.22	3.27
6055-3	93819 (Indianapolis)	20230	3.65	3.70
6055-3	93819 (Indianapolis)	20230	3.69	3.75
6055-3	93819 (Indianapolis)	20230	4.06	4.12

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
6055-3	93819 (Indianapolis)	20230	4.63	4.71
6055-3	93819 (Indianapolis)	20230	5.29	5.38
6055-3	93819 (Indianapolis)	20230	5.49	5.58
6055-3	93819 (Indianapolis)	20230	5.80	5.89
6055-3	93819 (Indianapolis)	20230	6.26	6.36
8589-1	94018 (Boulder)	1299	1.29	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	1.32	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	1.34	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	1.45	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	1.70	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	1.81	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	1.91	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	1.95	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
8589-1	94018 (Boulder)	1299	2.04	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	2.09	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	2.13	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	2.52	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	2.64	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	2.66	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	2.67	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	3.07	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	3.16	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	3.18	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	3.43	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	3.44	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	3.54	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
8589-1	94018 (Boulder)	1299	3.74	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	3.75	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	3.97	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.02	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.06	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.07	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.10	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.11	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.26	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.29	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.35	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.46	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.52	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
8589-1	94018 (Boulder)	1299	4.88	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	4.95	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	5.00	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	5.12	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	5.27	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	5.31	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	5.40	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	5.48	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	5.55	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	5.97	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	6.02	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	6.05	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	6.37	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
8589-1	94018 (Boulder)	1299	6.50	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	6.51	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	6.64	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	6.83	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	7.94	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	8.07	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	8.50	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	8.63	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	9.05	Taken from a uniform distribution of values between 2-50 yrs
8589-1	94018 (Boulder)	1299	9.88	Taken from a uniform distribution of values between 2-50 yrs
8672-2	94823 (Pittsburgh)	1301	1.79	Taken from a uniform distribution of values between 2-50 yrs
8672-2	94823 (Pittsburgh)	1301	2.92	Taken from a uniform distribution of values between 2-50 yrs
8672-2	94823 (Pittsburgh)	1301	7.31	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
1471-1	94846 (Chicago)	540	0.62	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	0.76	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	0.77	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	0.81	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	0.95	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	1.06	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	1.36	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	1.38	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	1.55	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	1.59	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	1.63	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	1.66	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	1.90	Taken from a uniform distribution of values between 2-50 yrs

Table A-A-1. Surface Impoundment Descriptive Data

Surface Impoundment	Location	Surface Area (m2)	Depth of Impoundment (m)	Hydraulic Residence Time (yrs)
1471-1	94846 (Chicago)	540	2.24	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	2.95	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	3.01	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	3.30	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	3.99	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	4.14	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	4.20	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	4.73	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	5.18	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	6.23	Taken from a uniform distribution of values between 2-50 yrs
1471-1	94846 (Chicago)	540	7.70	Taken from a uniform distribution of values between 2-50 yrs

Appendix B

Farm Size and Location

Appendix B

Farm Size and Location

The agricultural field area was assumed to be the median area for farms in each climatic region. The agricultural field sizes were taken from the county-level data provided in the Census of Agriculture. The Census of Agriculture (U.S. DOC, 1989, 1994) provides periodic and comprehensive statistics about agricultural operations, production, operators, and land use. It is conducted every 5 years for years ending in 2 and 7. Its coverage includes all operators of U.S. farms or ranches (Division A, SIC 01-02) that sold or normally would have sold at least $1,000 worth of agricultural products during the census year. In 1992, approximately 1.9 million operators produced $162 billion in crops and livestock. Data for 1987 and 1992 were averaged. The median farm size was determined for all counties in each of the 41 climatic regions. From this distribution, the average farm size for each climatic region was determined. No data on field size were available, so field size was assumed equal to farm size. The agricultural field sizes used in this analysis are presented in Table B-1. The farm size was important in this analysis for the air dispersion and deposition and soil erosion pathways. The larger the source, the greater the offsite concentrations due to air deposition and erosion.

Table B-1. Median Farm Size for Each Climatic Region

Climatic Region Name (Selected Met. Station)	Median Farm Size (Acres)
Seattle, WA	40.10
Boise, ID	194.40
Billings, MT	1241.70
Burlington, VT	159.20
Portland, OR	98.20
Bismarck, ND	923.80
Minneapolis, MN	208.60
Salem, OR	44.60
Muskegon,MI	117.10
Chicago, IL	177.60
Cleveland, OH	109.20
Winnemucca, NV	162.30
Casper, WY	829.60
Hartford, CT	50.00

(continued)

Table B-1. (continued)

Climatic Region Name (Selected Met. Station)	Median Farm Size (Acres)
San Francisco, CA	39.80
Williamsport, PA	127.10
Salt Lake City, UT	143.50
Fresno, CA	46.80
Lincoln, NE	282.20
Philadelphia, PA	39.00
Denver, CO	738.00
Harrisburg, PA	102.80
Norfolk, VA	97.50
Huntington, WV	86.70
Raleigh-Durham, NC	85.40
Nashville, TN	94.40
Asheville, NC	55.40
Las Vegas, NV	97.60
Little Rock, AR	159.10
Tulsa, OK	184.00
Albuquerque, NM	464.30
Los Angeles, CA	24.20
Charleston, SC	80.40
Atlanta, GA	105.90
Phoenix, AZ	339.70
Meridian, MS	123.00
Shreveport, LA	110.90
New Orleans, LA	90.90
Houston, TX	123.50
Miami, FL	39.60
Tampa, FL	67.00

References

U.S. DOC (Department of Commerce). 1989. *1987 Census of Agriculture. Volume1, Geographic Area Series State and County Data*. Bureau of the Census, Economics and Statistics Administration, Washington, DC.

U.S. DOC (Department of Commerce). 1994. *1992 Census of Agriculture. Geographic Area Series State and County Data*. Bureau of the Census, Washington, DC.

Appendix C

Meteorological Data

Appendix C

Meteorological Data

Five years of representative meteorological data were processed for this analysis. The data gathered included surface data, upper-air data, and precipitation data. These observational data were used as Industrial Source Complex, Short-Term Model, Version 3 (ISCST3), inputs.

Surface Data. Hourly surface meteorological data used in air dispersion modeling were processed from the Solar and Meteorological Surface Observation Network (SAMSON) CD-ROM (U.S. DOC and U.S. DOE, 1993). Variables included

- Temperature
- Pressure
- Wind direction
- Windspeed
- Opaque cloud cover
- Ceiling height
- Current weather
- Hourly precipitation.

Upper-Air Data. Twice-daily mixing-height data were calculated from upper-air data contained in the radiosonde data of the North America CD-ROM set (NCDC, 1997). This set contains upper-air data from 1946 through 1996 for most upper-air stations in the United States. The upper-air data were combined with the SAMSON data to create the mixing-height files. EPA's Support Center for Regulatory Air Models (SCRAM) bulletin board was also used to obtain mixing-height data (if available) when mixing-height data could not be successfully calculated from the radiosonde data. The mixing heights used in this risk assessment were variable and were based on hourly ceiling height observations used in the ISCST3 air model.

Filling in Missing Data. Missing surface data were identified using a program called SQAQC, which searched for incidents of missing data on the observation indicator, opaque cloud cover, temperature, station pressure, wind direction and speed, and ceiling height. Years that were missing 10 percent or more of the data were discarded (Atkinson and Lee, 1992). Verification (quality control, or QC) checks were performed on the SQAQC program by applying it to station data where the missing data were known and by intentionally degrading surface meteorological files and then running SQAQC to detect the missing values.

Missing surface data were filled in by a program called METFIX. This program fills in up to 5 consecutive hours of data for cloud cover, ceiling height, temperature, pressure, wind direction, and windspeed. For single missing values, the program follows the objective procedures developed by Atkinson and Lee (1992). For two to five consecutive missing values, other rules were developed because the subjective methods provided by Atkinson and Lee (1992) rely on professional judgment and could not be programmed. The METFIX program flagged files where missing data exceeded five consecutive values. In the few cases where this occurred and the missing data did not constitute 10 percent of the file, they were filled in manually according to procedures set forth in Atkinson and Lee (1992). If more than 10 percent of the data were missing, the station was discarded and another station in the climatic region was selected.

All upper-air files were checked for missing data using a program called QAQC. QAQC produces a log file containing occurrences of missing mixing height. Verification (QC) checks were performed on the QAQC program by applying it to station data where the missing data were known and by intentionally degrading existing mixing height files and then running QAQC to detect the missing values.

Missing mixing heights were filled in by interpolating one to five consecutive missing values. According to Atkinson and Lee (1992), if there are one to five consecutive missing values, the values should be filled in subjectively using professional judgment. Again, programming these subjective procedures was not feasible, and the program used simple linear interpolation to fill in these values automatically. Information from Atkinson and Lee (1992) was used to determine which files should be discarded (i.e., files missing more than five consecutive missing values or missing 10 percent or more of the data). After the missing mixing heights were filled in for all upper-air files, they were checked once more for missing data using the QAQC program.

Other Meteorological Data. In addition to the surface and upper-air data, air modeling requires the input of the following meteorological parameters (U.S. EPA, 1995):

- Minimum Monin-Obukhov length (m)
- Anemometer height (m)
- Roughness length (m), surface meteorological station
- Roughness length (m), area around facility
- Noontime albedo
- Bowen ratio
- Anthropogenic heat flux (W/m^2)
- Fraction net radiation absorbed by the ground.

Anemometer height was collected from local climatic data summaries (NOAA, 1983). When anemometer height was not available, the station was assigned the most common anemometer height from the other stations. This value was 6.1 m.

Land use information is required for determining a number of inputs. To obtain this information, a geographic information system (GIS) was used to determine the land use within a 3 km radius around each meteorological station by using Geographic Retrieval and Analysis System (GIRAS) spatial data with Anderson land use codes (Anderson et al., 1976).

A weighted average, based on the land use percentages for a 3 km radius around each meteorological station, was used to estimate the Bowen ratio, minimum Monin-Obukhov length, the noontime albedo, the roughness height at the meteorological station, and the fraction of net radiation absorbed by the ground. The Bowen ratio is a measure of the amount of moisture at the surface around a meteorological station. The wetness of a location was determined based on the annual average precipitation amount. For this analysis, the annual average values were applied. The minimum Monin-Obukhov length, a measure of the atmospheric stability at a meteorological station, was correlated with the land use classification. Noontime albedo values also were correlated with land use around a meteorological station. Table C-1 presents the crosswalk between the Anderson land use codes from the GIRAS database and the PCRAMMET land use designations used in the air modeling. Other data used in the ISCST3 modeling are presented in Tables C-2 through C-5. These are the Bowen ratio (C-2), the minimum Monin-Obukhov length (C-3), Albedo values (C-4), and surface roughness length (C-5).

The surface roughness length is a measure of the height of obstacles to the wind flow. It is not equal to the physical dimensions of the obstacles but is generally proportional to them. The roughness height was assumed to be the same at the meteorological station and at the farm site.

Table C-1. Relation between Anderson Land Use Codes and PCRAMMET Land Use Codes

Anderson Code and Description[a]		PCRAMMET Type and Description[b]	
51	Streams and canals	1	Water surface
52	Lakes	1	Water surface
53	Reservoirs	1	Water surface
54	Bays and estuaries	1	Water surface
41	Deciduous forest land	2	Deciduous forest
61	Forested wetland	2	Deciduous forest
42	Evergreen forest land	3	Coniferous forest
43	Mixed forest land	4	Mixed forest
62	Nonforested wetland	5	Swamp (nonforested)
84	Wet tundra	5	Swamp (nonforested)
21	Cropland and pasture	6	Agricultural
22	Orchards-groves-vineyards-nurseries-ornamental	6	Agricultural
23	Confined feeding operations	6	Agricultural
24	Other agricultural land	6	Agricultural
31	Herbaceous rangeland	7	Rangeland (grassland)
32	Shrub and brush rangeland	7	Rangeland (grassland)
33	Mixed rangeland	7	Rangeland (grassland)
11	Residential	9	Urban
12	Commercial and services	9	Urban
13	Industrial	9	Urban
14	Transportation-communication-utilities	9	Urban

(continued)

Table C-1. (continued)

Anderson Code and Description[a]		RAMMET Type and Description[b]	
15	Industrial and commercial complexes	9	Urban
16	Mixed urban or built-up land	9	Urban
17	Other urban or built-up land	9	Urban
71	Dry salt flats	10	Desert shrubland
72	Beaches	10	Desert shrubland
73	Sandy areas not beaches	10	Desert shrubland
74	Bare exposed rock	10	Desert shrubland
75	Strip mines-quarries-gravel pits	10	Desert shrubland
76	Transitional areas	10	Desert shrubland
81	Shrub and brush tundra	10	Desert shrubland
82	Herbaceous tundra	10	Desert shrubland
83	Bare ground	10	Desert shrubland
85	Mixed tundra	10	Desert shrubland
91	Perennial snowfields	10	Desert shrubland
92	Glaciers	10	Desert shrubland

[a] Anderson codes from Anderson et al. (1976).
[b] PCRAMMET codes from U.S. EPA (1995).

Table C-2. Daytime Bowen Ratio by Land Use and Season

	Spring			Summer			Autumn			Winter			Annual Average		
Land Use Type	Dry	Wet	Avg.	Dry	Wet	Avg.	Dry	Wet	Avg.	Dry	Wet	Avg.	Dry	Wet	Avg.
Water surface	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2.0	0.3	1.5	0.575	0.15	0.45
Deciduous forest	1.5	0.3	0.7	0.6	0.2	0.3	2.0	0.4	1.0	2.0	0.5	1.5	1.53	0.35	0.875
Coniferous forest	1.5	0.3	0.7	0.6	0.2	0.3	1.5	0.3	0.8	2.0	0.3	1.5	1.4	0.275	0.825
Swamp	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	2.0	0.5	1.5	0.65	0.2	0.45
Cultivated land (agricultural)	1.0	0.2	0.3	1.5	0.3	0.5	2.0	0.4	0.7	2.0	0.5	1.5	1.63	0.35	0.75
Grassland	1.0	0.3	0.4	2.0	0.4	0.8	2.0	0.5	1.0	2.0	0.5	1.5	1.75	0.425	0.825
Urban	2.0	0.5	1.0	4.0	1.0	2.0	4.0	1.0	2.0	2.0	0.5	1.5	3.0	0.75	1.6
Desert shrubland	5.0	1.0	3.0	6.0	5.0	4.0	10.0	2.0	6.0	10.0	2.0	6.0	7.75	2.5	4.75

Source: U.S. EPA (1995). Averages were computed for this effort.

Table C-3. Minimum Monin-Obukhov Length (Stable Conditions)

Urban Land Use Classification	Length (m)
Agriculture (open)	2
Residential	25
Compact residential/industrial	50
Commercial (19–40 story buildings) (> 40 story buildings)	100 150

Source: U.S. EPA (1995).

Table C-4. Albedo Values of Natural Ground Covers for Land Use Types and Seasons

Land Use Type	Spring	Summer	Autumn	Winter	Annual Average
Water surface	0.12	0.1	0.14	0.2	0.14
Deciduous forest	0.12	0.12	0.12	0.5	0.22
Coniferous forest	0.12	0.12	0.12	0.35	0.18
Swamp	0.12	0.14	0.16	0.3	0.18
Cultivated land (agricultural)	0.14	0.2	0.18	0.6	0.28
Grassland	0.18	0.18	0.20	0.6	0.29
Urban	0.14	0.16	0.18	0.35	0.21
Desert shrubland	0.3	0.28	0.28	0.45	0.33

Source: U.S. EPA (1995). Average values were computed for this analysis.

Table C-5. Surface Roughness Length for Land Use Types and Seasons (meters)

Land Use Type	Spring	Summer	Autumn	Winter	Annual Average
Water surface	0.0001	0.0001	0.0001	0.0001	0.0001
Deciduous forest	1.0	1.3	0.8	0.5	0.9
Coniferous forest	1.3	1.3	1.3	1.3	1.3
Swamp	0.2	0.2	0.2	0.05	0.16
Cultivated land (agricultural)	0.03	0.2	0.05	0.01	0.07
Grassland	0.05	0.2	0.01	0.001	0.04
Urban	1.0	1.0	1.0	1.0	1.0
Desert shrubland	0.3	0.3	0.3	0.15	0.26

Source: U.S. EPA (1995). Average values were computed for this analysis.

During daytime hours, the heat flux into the ground is parameterized as a fraction of the net radiation incident on the ground. This fraction varies based on land use. A value of 0.15 was used for rural locations. Suburban and urban locations were given values of 0.22 and 0.27, respectively (U.S. EPA, 1995).

Anthropogenic heat flux for a meteorological station can usually be neglected in areas outside of highly urbanized locations; however, in areas with high population densities or energy use, such as an industrial facility, this flux may not always be negligible (U.S. EPA, 1995). For this analysis, anthropogenic heat flux was assumed to be zero for all meteorological stations.

Meteorological Data. Meteorological stations selected for purposes of air dispersion modeling also provided long-term climatic data that were necessary for fate and transport modeling. For each of the 41 stations (see Attachment A to this appendix for details regarding station selection), the following data were compiled:

- Mean annual wind direction
- Mean annual windspeed
- Average temperature
- Average annual runoff
- Universal Soil Loss Equation (USLE) rainfall/erosivity factor.

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Appendix C

Attachment A:
Climate Region Selection

Appendix C

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Climate Region Selection

C-A1.0 Background

Dispersion and deposition of volatile and particulate contaminants and air concentrations of contaminants at specified receptor locations are estimated with EPA's Industrial Source Complex, Short-Term Model, Version 3 (ISCST3). ISCST3 calculates dispersion, deposition and air concentrations. Running ISCST3 is time consuming and requires extensive technical expertise. Therefore, dispersion and deposition were modeled using ISCST3 for selected scenarios designed to cover a broad range of characteristics. For this analysis, these scenarios include

- 41 meteorological stations, chosen to represent the nine general climate regions of the continental United States

- 41 farm sizes representing the median farm size for each climate region

The remainder of this section details how the country was divided into areas that could be adequately represented by one meteorological station.

C-A2.0 Approach

Bailey's ecoregions and subregions of the United States (Bailey et al., 1994) are used to associate coverage areas with meteorological stations. This hierarchical classification scheme is based primarily on rainfall regimes; subregions are delineated by elevation and other factors affecting ecology.

The approach used involved two main steps:

1. Identify contiguous areas that are sufficiently similar with regard to the parameters that affect dispersion that they can be reasonably represented by one meteorological station. The parameters used are

    - Surface-level meteorological data (e.g., wind patterns and atmospheric stability)

    - Physiographic features (e.g., mountains, plains)

    - Bailey's ecoregions and subregions

- Land cover (e.g., forest, urban areas).

2. For each contiguous area, select one meteorological station to represent the area. The station selection step considered the following parameters:

   - Location within the area
   - Years of meteorological data available
   - Average windspeed.

These steps are described in the following subsections.

C-A2.1 Identify Contiguous Areas

A hierarchical procedure based on features affecting wind flow was used to divide the country. The primary delineation of areas was based on geographic features affecting synoptic (broad area) winds, including mountain ranges and plains. These features are also known as physiography. The secondary delineation was based on features affecting mesoscale (10 to 1,000 km) winds, including coastal regions and basic land cover classifications of forest, agriculture, and barren lands. These land cover features were obtained from U.S. Geological Survey (1999).

The methodology for identifying contiguous areas uses wind data and atmospheric stability data derived from surface-level meteorological data as the primary consideration, modified by physiography, Bailey's ecoregions and subregions, and land cover. The approach focuses on how well the windspeed and direction and atmospheric stability patterns measured at a surface-level meteorological station represent the surrounding area. The limit of appropriate representation varies by area of the country and is substantially determined by terrain and topography. For example, a station in the Midwest, where topography and vegetation are uniform, may adequately represent a very large area, while a mountainous station, where ridges and valleys affect the winds, may represent a much smaller area.

Primary Grouping on Wind Rose and Atmospheric Stability Data. The surface-level meteorological data were downloaded from EPA's SCRAM Web site (www.epa.gov/scram001). SCRAM has these data from 1984 to 1991. A 5-year period is commonly used to obtain an averaged depiction of the winds for each station; 5 years covers most of the usual variation in meteorological conditions. Not all stations had 5 years of data in this time period. Three years of data was considered a desirable minimum for stations, therefore, stations that had less than 3 years of data during this time period were not considered for selection.

Two types of wind data were considered: wind directionality and windspeed. Wind directionality describes the tendency of winds to blow from many different directions (weakly directional) or primarily from one direction (strongly directional). Strongly directional winds will tend to disperse air pollutants in a consistent direction, resulting in higher air concentrations in that direction and higher overall maximum air concentrations. Weakly directional winds will tend to disperse pollutants in multiple directions, resulting in lower air concentrations in any one direction and lower overall maximum air concentration.

Windspeed also affects dispersion. A greater average windspeed tends to disperse pollutants more quickly, resulting in lower air concentrations than lower average windspeeds would produce. Windspeed was used in the station selection process, but not to identify contiguous areas of the country.

A wind rose is a graphical depiction of the frequency of windspeeds by wind direction. Wind roses were produced from the surface-level meteorological data for each station using WRPLOT (available from www.epa.gov/scram001/models/relat/wrplot.zip). Winds are plotted in 16 individual directions; thus, if every direction has the same frequency, the wind would blow from each direction 6.25 percent of the time. Based on the wind roses, each station was assigned to one of four bins based on the frequency of wind in the predominant direction (the direction from which the wind blows the greatest percentage of the time). These bins were as follows:

- Weakly directional: blowing from predominant direction less than 10 percent of the time

- Mildly directional: blowing from predominant direction 10 to 14 percent of the time

- Moderately directional: blowing from predominant direction 15 to 20 percent of the time

- Strongly directional: blowing from predominant direction over 20 percent of the time.

Atmospheric stability class frequency distributions were also used for some stations. Atmospheric stability is a measure of vertical movement of air and can be classified as stable, unstable, or neutral. For sources at ground level sources such as are modeled in the agricultural use scenario, pollutants tend to stay close to the ground in a stable atmosphere, thereby increasing the air concentration of the pollutant. In an unstable atmosphere, the pollutants will tend to disperse more in the vertical direction, thereby decreasing the air concentration of the pollutant. Atmospheric stability varies throughout the day and year, as well as by location, because atmospheric stability is determined from variable factors such as windspeed, strength of solar radiation, and the vertical temperature profile above the ground. In addition, the presence of large bodies of water, hills, large urban areas, and types and height of vegetation all affect atmospheric stability. If all other factors are the same at two stations, the one with stable air a larger percentage of the time will have higher air concentrations than the station with stable air a smaller percentage of the time.

Secondary Grouping Considerations. After spatially grouping the wind roses in similar bins, the next step was to delineate geographic areas around these groups of meteorological stations using maps of physiography, Bailey's ecoregions, and land cover. Physiography includes major topographic features such as mountains or plains. Land cover classifications include urban, cropland, grassland, forest, large waterbody, wetland, barren, and snow or ice. Regional boundaries were chosen to coincide with physiographic, Bailey's ecoregion, and land cover boundaries to the extent possible.

C-A2.2 Station Selection

The above approach used to delineate contiguous areas ensures that the stations grouped together are fairly similar in most cases. Therefore, the selection of an appropriate station to represent each area was based on other considerations, including

- **Number of years of surface-level meteorological data available.** More years of data provide a more realistic long-term estimate of air concentration.

- **Central location within the area.** All other factors being equal, central locations are more likely to be representative of the entire contiguous geographic area, because they have the smallest average distance from all points in the region.

- **Windspeed**. Lower windspeeds lead to less dispersion and higher air concentrations.

Windspeed was summarized as average speed in the prevailing wind direction. This value is not readily extractable from the wind roses; therefore, it was obtained from the *International Station Meteorological Climate Summary* CD (U.S. Navy et al., 1992) of meteorological data. For a few stations, this value was unrealistically low; in those cases, an average windspeed in the prevailing wind direction was estimated from the wind rose data.

EPA used a hierarchical procedure to select a representative station, as follows:

- Stations with less than 5 years of data in SCRAM were eliminated, unless no station had 5 years of data.

- Stations centrally located in the area were preferred if the above factors did not identify a clear choice.

- If all other factors were equal, stations with lower average windspeeds were selected to ensure that air concentration was not underestimated. Variations in windspeed within regions were minor.

For purposes of that discussion, we have divided the United States into the following sections: West Coast, Desert Southwest, Western Mountains, Gulf Coast, Southeast, Middle Atlantic, Northeast, Great Lakes, Central States, Alaska, and Hawaii. The process of selecting stations and delineating the region assigned to each station is discussed by these sections.

Table C-A-1 shows the selected stations for the continental United States.

Table C-A-1. Surface-Level Meteorology Stations Used in the Screening Analysis

Station Number	Station Name	State
13963	Little Rock/Adams Field	AR
23183	Phoenix/Sky Harbor International Airport	AZ
93193	Fresno/Air Terminal	CA
23174	Los Angeles/International Airport	CA
23234	San Francisco/International Airport	CA
23062	Denver/Stapleton International Airport	CO
14740	Hartford/Bradley International Airport	CT
12839	Miami/International Airport	FL
12842	Tampa/International Airport	FL
13874	Atlanta/Atlanta-Hartsfield International	GA
24131	Boise/Air Terminal	ID
94846	Chicago/O’Hare International Airport	IL
03937	Lake Charles/Municipal Airport	LA
12916	New Orleans/International Airport	LA
13957	Shreveport/Regional Airport	LA
14764	Portland/International Jetport	ME
94847	Detroit/Metropolitan Airport	MI
14840	Muskegon/County Airport	MI
14922	Minneapolis-St Paul/International Airport	MN
13865	Meridian/Key Field	MS
24033	Billings/Logan International Airport	MT
03812	Asheville/Regional Airport	NC
13722	Raleigh/Raleigh-Durham Airport	NC
24011	Bismarck/Municipal Airport	ND
14935	Grand Island/Airport	NE
23050	Albuquerque/International Airport	NM
23169	Las Vegas/McCarran International Airport	NV
24128	Winnemucca/WSO Airport	NV
14820	Cleveland/Hopkins International Airport	OH

(continued)

Table C-A-1. (continued)

Station Number	Station Name	State
13968	Tulsa/International Airport	OK
94224	Astoria/Clatsop County Airport	OR
24232	Salem/McNary Field	OR
14751	Harrisburg/Capital City Airport	PA
13739	Philadelphia/International Airport	PA
14778	Williamsport-Lycoming/County	PA
13880	Charleston/International Airport	SC
13877	Bristol/Tri City Airport	TN
13897	Nashville/Metro Airport	TN
12960	Houston/Intercontinental Airport	TX
24127	Salt Lake City/International Airport	UT
13737	Norfolk/International Airport	VA
14742	Burlington/International Airport	VT
24233	Seattle/Seattle-Tacoma International	WA
03860	Huntington/Tri-State Airport	WV
24089	Casper/Natrona Co International Airport	WY

Figure C-A-1 shows these stations and their boundaries.

C-A3.0 West Coast

The West Coast is defined by a narrow coastal plain and mountain chains running parallel to the coast of the Pacific Ocean. In many areas the mountainous region is broken by a large central valley, such as in California. The northwestern Pacific coast contains a narrow plain between the Pacific Ocean and the Coast Ranges.

The California coast is divided just north of Point Conception above Los Angeles. This northern section is represented by the **San Francisco** International Airport (23234). The wind rose shows strong directionality with an average windspeed of 12 knots.

The southern California coast contains the Los Angeles basin south to the California/Mexico border. This region is represented by the **Los Angeles** International Airport (23174). The wind rose shows strong directionality and an average windspeed of 8 knots.

Figure C-A-1. Climate regions.

The California central valley region, which encompasses the Sacramento Valley to the north and the San Joaquin Valley to the south, is defined by the Coast Range and Diablo Range on the west and the Sierra Nevada mountains on the east. The valley extends south to the northern rim of the Los Angeles basin. The region represented by **Fresno** Air Terminal (93193).

The inland portion of Washington is bounded by the Coast Ranges on the west, the edge of the Humid Temperate Domain to the east, the Washington/Canada border to the north and the Columbia River to the south. This region is represented by the **Seattle-**Tacoma International Airport (24233). Its wind rose shows moderate directionality and an average windspeed of 10 knots.

C-A4.0 Desert Southwest

The Desert Southwest is defined by various deserts and mountain ranges. One distinguishing feature is the transition between low desert in southern Arizona and high desert in northern Arizona. The southern boundary of this section is the U.S./Mexico border.

Southern Arizona contains the Sonoran Desert. This region of low desert is represented by the station at **Phoenix**/Sky Harbor International Airport (23183). The region is bounded to the north between Phoenix and Prescott, Arizona, along the southern edge of the Columbia Plateau, which represents the transition from low to high desert. The wind rose for Phoenix shows moderate directionality and an average windspeed of 6 knots.

The northern portion of Arizona, southeastern California, southern Nevada, and southern Utah are represented by the station at **Las Vegas**/McCarran International Airport (23169). This is one of the original 29 stations. This region is characterized by high desert, including the Columbia Plateau. Relatively few facilities and people are located here. The wind rose is mildly directional with an average windspeed of 10 knots.

The station at **Albuquerque** International Airport (23050), which is one of the original 29 stations, represents the mountainous region of western New Mexico and far west Texas. This region is bounded on the east by the Sacramento Mountains east of El Paso, Texas, and by the Sangre de Cristo Mountains east of Albuquerque, New Mexico. The wind rose is weakly directional and the average windspeed is 8 knots.

C-A5.0 Western Mountains

The Western Mountains include numerous mountain ranges, plateaus, and valleys that affect wind flows. Boundaries between these regions follow major terrain features.

The inland region of Oregon includes both the central valley area and the Great Sandy Desert, east to the Columbia Plateau. The western boundary is the Coast Ranges. The Black Rock Desert forms the southern boundary. This region is represented by the station at McNary Field in **Salem, Oregon** (24232). The wind rose shows moderate directionality and an average windspeed of 9 knots.

The Snake River Plain of southern Idaho forms the region represented by **Boise** Air Terminal (24131) in Idaho. This region is bounded by the Salmon River Mountains on the north and the Columbia Plateau to the west and south. The wind rose shows moderate directionality and average windspeed of 9 knots.

Northern Nevada and northeastern California are represented by the station at **Winnemucca** WSO Airport (24128) in Nevada. This is the Great Basin area. The wind rose shows mild directionality and an average windspeed of 8 knots.

The Salt Lake Basin and the Great Divide Desert in Utah and Colorado are represented by the station at **Salt Lake City** International Airport (24127) in Utah. The eastern boundary of this region is formed by the Wind River Range and the Front Range. The wind rose shows moderate directionality and an average windspeed of 9 knots.

C-A6.0 Gulf Coast

The wind regime along the Gulf of Mexico is strongly influenced by that body of water. However, its effects do not reach very far inland. A series of regions have been designated to represent the coastal section.

The middle Texas Gulf Coast is represented by the station at **Houston** Intercontinental Airport (12960). Although Houston itself is somewhat inland, it is expected to have a more coastal environment due to Galveston Bay. This region extends south past Victoria to the vegetative boundary marking Southern Texas. The wind rose in this region is only mildly directional with an average windspeed of 8 knots.

The Central Gulf Coast extends from eastern Louisiana through the Florida panhandle. This entire region is part of the Outer Coastal Plain Mixed Forest Province and is characterized by weakly directional winds. The station at **New Orleans** International Airport (12916) in Louisiana was chosen to represent this region. Its wind rose is weakly directional with an average windspeed of 8 knots.

The West Coast of the Florida Peninsula is heavily influenced by the Gulf of Mexico, which has warmer water than the Atlantic Ocean off the East Coast of the Florida Peninsula. This region extends from the Florida Panhandle to the north to Cape Romano, which is just north of the Everglades in South Florida. The station at **Tampa** International Airport (12842) was chosen to represent this region. The wind rose displays very mild directionality and average windspeed of 7 knots.

C-A7.0 Southeast

The Southeast section extends from the Atlantic coastal region of Florida and the Florida keys northward through Georgia and South Carolina. This region has an extremely broad coastal plain, requiring it to be divided between coastal region and more inland regions for Georgia and South Carolina. This section also includes the inland areas of Louisiana, Mississippi, and Alabama.

The southern tip of Florida includes the Everglades, which have been drained along the Atlantic coast to provide land for Miami, Ft. Lauderdale, West Palm Beach, and other coastal cities. This region is represented by the original station at **Miami** International Airport (12839). Its wind rose is mildly directional with an average windspeed of 9 knots. Miami was chosen to represent the keys because its directionality and average windspeed are similar to that of Key West.

A long stretch of the Southeastern Atlantic Coast extends from north of Vero Beach, Florida (i.e., just south of Cape Canaveral), through Georgia and South Carolina. The Atlantic Ocean forms the eastern boundary, and the land cover boundary between the more forested coast and more agricultural inland area forms the western boundary. Wind rose analysis reveals a different wind pattern for this region than for the southern tip of Florida. For example, the wind rose for Vero Beach Municipal Airport, which is assigned to the station at Miami, shows mild directionality, with the wind from the predominant direction 10 percent of the time. Just to the north at Daytona Beach, the wind shows weak directionality, with the predominant direction at 8 percent of the time and an average windspeed of 9 knots. Considering the length of this region, a centrally located station would have been desirable, such as the one at Jacksonville International Airport (predominant wind direction 6 percent of the time, average windspeed 8 knots). The station at **Charleston** International Airport (13880), represents this region. Its wind rose shows weak directionality and an average windspeed of 8 knots.

Further inland in Georgia and South Carolina lies the Blue Ridge region. This region is delineated by physiographic boundaries—the transition to the Coastal Plain on the coastal side and to the Appalachian Plateaus on the inland side. The station at **Atlanta** Hartsfield International Airport (13874) represents this region. The wind rose reveals mild directionality and an average windspeed of 9 knots.

The inland areas of Alabama and Mississippi are represented by the station at **Meridian** Key Field (13865), which is located in Mississippi close to the Alabama border. This region extends from the Central Gulf Coast region northward into southern Tennessee (including Memphis) and westward into the Coastal Plain region of eastern Arkansas. The wind rose for this region is mildly directional with an average windspeed of 7 knots.

The inland portion of Louisiana and eastern Texas is part of the Coastal Plain. This region extends northward to the Ouachita Mountains, which are just south of the Ozark Plateau in Arkansas. The western boundary is the vegetative transition from the forests in this region to the prairies in Texas. This region is represented by the station at **Shreveport** Regional Airport (13957) in Louisiana. The wind rose is mildly directional with an average windspeed of 9 knots.

C-A8.0 Middle Atlantic

The Middle Atlantic section includes coastal areas with bays, sounds, inlets, and barrier islands; a broad coastal plain; and the southern Appalachian Mountains. The physiographic features generally extend from northeast to southwest, parallel to the coast of the Atlantic Ocean.

The coastal region of North Carolina and Virginia is represented by the station at **Norfolk** International Airport (13737) in Virginia. This region is bounded by the Atlantic Ocean on the east, the physiographic boundary to the Piedmont section to the west, the political border between North Carolina and South Carolina to the south, and a line bisecting the Chesapeake Bay to the north. The wind rose is mildly directional with an average windspeed of 10 knots.

The Piedmont region of North Carolina and Virginia is just inland from the coastal region. This region is delineated on the east by the physiographic boundary with the coastal plain, and on the west with the physiographic boundary with the Appalachian Mountains. This region is also part of the Southeastern Mixed Forest Province of Bailey’s ecoregions. The station at **Raleigh-Durham** Airport (13722) in North Carolina represents this region, with a weakly directional wind rose and average windspeed of 8 knots.

The eastern portion of the southern Appalachian Mountains lies to the west of the Piedmont region of North Carolina and Virginia. This region extends to the southwest to include a portion of western South Carolina and northeastern Georgia. The station at **Asheville** Regional Airport (03812) in North Carolina was chosen to represent this region. Its wind rose shows moderate directionality and an average windspeed of 10 knots.

The Appalachian Mountains of West Virginia and eastern Kentucky are characterized by mountainous ridges and valleys extending from northeast to southwest. This region is represented by the station at **Huntington** Tri-State Airport (03860) in West Virginia. The wind rose is mildly directional with an average windspeed of 7 knots.

The inland region encompassing northern Virginia, part of Maryland, and eastern Pennsylvania is composed of another section of the Appalachian Mountains. Boundaries are approximated by the Bailey’s Central Appalachian Forest province. The original station at **Harrisburg**/Capital City Airport (14751) in Pennsylvania represents this region. The wind rose is mildly directional with average windspeed at 9 knots.

The northern portion of the Chesapeake Bay northward through New Jersey, eastern Pennsylvania, and New York City is characterized by the Eastern Broadleaf Forest (Oceanic) Province in the coastal plain. The original station at **Philadelphia** International Airport (13739) in Pennsylvania represents this region. The wind rose is mildly directional with an average windspeed of 9 knots.

C-A9.0 Northeast

The Northeast section includes Maine and New England. This region is characterized by forests to the north, large urban areas along the southern coastal plain, and the mountain ridges and valleys of the northern Appalachian Mountains. This section is bounded by the Atlantic Ocean on the east, the U.S. Canada border on the north, and the coastal plain of the eastern Great Lakes to the west.

The station at Bradley International Airport (14740) in **Hartford**, Connecticut, represents the New England region, which encompasses Connecticut, Massachusetts, Rhode Island and a small portion of Vermont, New Hampshire, and eastern New York. The wind rose shows mild directionality with an average windspeed of 8 knots.

Northern New England and Maine are represented by the station located at the International Jetport (14764) in **Portland**, Maine. This region includes Maine and most of New Hampshire and Vermont. The northwest portion of Vermont is in a unique location and represented separately. The wind rose for this region has mild directionality and an average windspeed of 9 knots.

The station at the International Airport (14742) in **Burlington**, Vermont, represents a very small region. Burlington is located in a valley between mountainous areas of the northern Appalachian Mountains. This location is reflected in its wind rose, which blows from its predominant direction 20 percent of the time, and average windspeed of 10 knots.

The remainder of the northern Appalachian Mountains in New York and Pennsylvania is represented by the station at **Williamsport**-Lycoming (14778) in Pennsylvania. This region is bounded on the west by the Adirondack Mountains, just to the east of the coastal plain of Lake Ontario. The wind rose for this region is mildly directional with an average windspeed of 9 knots.

C-A10.0 Great Lakes

The Great Lakes are bodies of water large enough to affect weather patterns in that portion of the country. Land and sea breezes affect wind patterns along the coasts, especially along Lake Michigan in the summer. The moisture of the lakes also affects winter precipitation patterns (i.e., lake effect snow storms). This version of IWAIR, therefore, has refined the description of the coastal regions bordering the Great Lakes.

The Eastern Great Lakes divide the United States and Canada. On the U.S. side, the western portion of New York, a small portion of Pennsylvania, and northeastern Ohio border the eastern shores of Lake Ontario and Lake Erie. Mountains form the eastern boundary. The southwestern border is drawn southward from the southern shore of Lake Erie. The original station at Hopkins International Airport (14820) in **Cleveland**, Ohio, represents this region. The wind rose is moderately directional with average windspeed of 10 knots.

The Lower Peninsula of Michigan is bordered by the Great Lakes on three sides. Although this region has relatively few topographic features, the presence of the lakes may result in different dispersion analyses for the eastern and western portions of the state. Therefore, the Lower Peninsula has been divided into two regions—East and West.

The Western region of the Lower Peninsula of Michigan is bordered by Lake Michigan on the west and the Straits of Mackinac on the north. The eastern portion of the Upper Peninsula of Michigan is also included in this region. The station at **Muskegon** County Airport (14840) represents this region, although it has only 2 years of data for this time period. Its wind rose is weakly directional and its average windspeed is 11 knots.

The western shore of Lake Michigan, which includes Green Bay, is formed by the northeastern portion of Illinois, eastern Wisconsin, and part of the Upper Peninsula of Michigan. Lake Superior forms the northern boundary of this region, and the western boundary is formed by the hills to the east of the Wisconsin River and the Upper Mississippi River. This region is represented by the station at O'Hare International Airport (94846) in **Chicago**, Illinois. The wind rose for this region is mildly directional with an average windspeed of 9 knots.

C-A11.0 Central States

This section includes the Central Lowlands (south of the Great Lakes), the Midwest, and the Great Plains. The elevation for this section is generally lowest in the Mississippi Valley, which extends through the Midwest and drains a large portion of the center of the continental United States. This section also includes other major river valleys, including the Ohio, Tennessee, and Missouri. This section is bordered on the east by the Appalachian Mountains, on the west by the Rocky Mountains, on the north by the border with Canada, and on the south by the Southeast, Texas, and the Desert Southwest.

Although definitive boundaries are rare within this section the wind roses for stations that were not selected represent additional data useful for drawing boundaries.

The region includes western Kentucky, central and western Tennessee north of Memphis, and southeastern Missouri east of the Ozark Plateau. This region is represented by the station at **Nashville** Metropolitan Airport (13897) in Tennessee. The wind rose is moderately directional with an average windspeed of 8 knots.

A large region is assigned to the station at Adams Field (13963) in **Little Rock**, Arkansas. Little Rock, however, is situated in an area heavily influenced by the Ozark Plateau and its accompanying mountains.. The wind rose for this station is weakly directional with an average windspeed of 7 knots.

The northern portion of the Midwest includes the portion of Wisconsin west of the Lake Michigan coastal plain, Minnesota, and the eastern portion of North and South Dakota. The western boundary through the Dakotas is the physiographic boundary between the Central Lowland and the Great Plains. This region is represented by the station at **Minneapolis-St. Paul** International Airport (14922) in Minnesota. The wind rose is mildly directional with an average windspeed of 11 knots.

The Great Plains lie between the Central Lowlands to the east and the Rocky Mountains to the west. The headwaters of the Mississippi and the Missouri rivers are located in the Great Plains. Lands at higher elevations are more grassland and shrub land used for cattle ranges, while the lower elevations are used more frequently for crops. The region that includes the western portion of North and South Dakota and eastern Montana is represented by the original station at **Bismarck** Municipal Airport (24011) in North Dakota. The wind rose is weakly directional with an average windspeed of 12 knots.

The central portion of Montana is more rugged, but still part of the Great Plains. The Rocky Mountains form the western and southwestern boundaries of this region, which is represented by the station at **Billings** Logan International Airport (24033) in Montana. The wind rose is strongly directional with an average windspeed of 10 knots.

The station at **Casper**/Natrona County International Airport (24089) in Wyoming represents Wyoming east of the Front Range of the Rocky Mountains, southwestern South Dakota, and western Nebraska. The wind rose is strongly directional with an average windspeed of 14 knots. In this region, most cities are located in valleys or near the base of a mountain ridge. The wind regime at Casper, therefore, may not adequately represent other locations in this region.

This region is represented by the station at Stapleton International Airport (23062) in **Denver**, Colorado The southern boundary is formed by the southern edge of the Great Plains. The wind rose for this region is mildly directional with an average windspeed of 8 knots.

The north central portion of the Great Plains includes most of Nebraska, northern Kansas, western Iowa, southwestern South Dakota, and northwestern Missouri. This region is represented by the station at **Grand Island** Airport (14935) in Nebraska (this station is labeled as Lincoln). The wind rose is moderately directional with an average windspeed of 12 knots.

The southern portion of the Great Plains includes most of Kansas, and eastern Oklahoma. This region also includes the lower area of the western Ozark Plateau in southwestern Missouri and northwestern Arkansas. This region is represented by the station at **Tulsa** International Airport (13968). The wind rose is moderately directional with an average windspeed of 11 knots.

C-A12.0 References

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Appendix D

Soil Data

Appendix D

Soil Data

This appendix describes and presents the soil data used in the sewage sludge screening analysis. To represent the nationwide variability in soil properties, soil data were collected regionally by soil texture. Because the land application scenario is agricultural, a distribution of soil textures was assembled for all cropland and pasture in each climatic region. This distribution was used for selection of soil properties during the probabilistic analysis. This section presents the data sources and methods used to collect soil textures and relate them to the hydrologic soil properties needed for modeling. Attachment A to this appendix presents the percentage of soil textures within each climate region. These data were used to derive most of the other soil properties.

D1.0 Data Sources

The primary data source for soil properties is the State Soil Geographic (STATSGO) database. STATSGO is a repository of nationwide soil properties primarily compiled by the U.S. Department of Agriculture (USDA) from county soil survey data (USDA, 1994). STATSGO includes a 1:250,000-scale geographic information system (GIS) coverage that delineates soil map units, and an associated database containing soil data for each STATSGO map unit. (Map units are areas used to spatially represent soils in the database.)

In addition, two compilations of STATSGO data, each keyed to the STATSGO map unit GIS coverage, and land use data from the Geographic Information Retrieval and Analysis System (GIRAS) land use database were used in the analysis as a convenient source of average soil properties:

1. **USSOILS.** USSOILS (Schwarz and Alexander, 1995) averages STATSGO data over the entire soil column for each map unit.

2. **CONUS.** CONUS (Miller and White, 1998) provides average STATSGO data by map unit and a set of 11 standardized soil layers.

3. **GIRAS.** The GIRAS land use database (U.S. EPA, 1994) provides comprehensive land use data, in digital GIS format, for the contiguous 48 states.

Soil properties derived directly from STATSGO, CONUS, or USSOILS data include organic matter content, USLE *K* (erodibility) and *S* (slope) factors, and pH. A complete set of hydrologic soil properties[1] was not available from STATSGO. To ensure consistent and realistic values, it was necessary to rely on established, nationwide relationships between hydrologic properties and soil texture or hydrologic soil group, both of which are available from STATSGO. Sources for these relationships include Carsel and Parrish (1988), Carsel et al. (1988), and Clapp and Hornberger (1978). These peer-reviewed references provide a consistent set of correlated hydrologic properties for each soil texture or hydrologic group. Table D-1 lists soil properties collected for this analysis and their data sources.

Table D-1. Summary of Soil of Properties Collected for Sewage Sludge Risk Analysis

Soil Variable	Units	Data Source
Properties Derived from Soil Texture		
USDA soil texture	Unitless	CONUS/STATSGO
Saturated hydraulic conductivity	cm/h	Relationship from Carsel and Parrish (1988)
Saturated water content	L/L	Relationship from Carsel and Parrish (1988)
Soil moisture coefficient *b*	Unitless	Relationship from Clapp and Hornberger (1988)
Soil bulk density	mg/L	Calculated from saturated water content
Root zone depth	cm	Relationship (with land use) from Dunne and Leopold (1978)
Properties Derived from Soil Hydrologic Class		
SCS hydrologic class	Unitless	CONUS/STATSGO
Field capacity	% (vol.)	Relationship from Carsel et al. (1988)
Wilting point	% (vol.)	Relationship from Carsel et al. (1988)
SCS curve number	Unitless	Relationship (with land use) from USDA (1986)
Properties Obtained Directly from STATSGO		
Fraction organic carbon	g/g	STATSGO
Silt content	% (wt.)	STATSGO
USLE erodibility factor (*K*)	kg/m^2	STATSGO
USLE slope (*S*)	Degrees	STATSGO
Properties Derived from Slope		
USLE slope length (*L*)	m	Relationship from Lightle and Weesies (1998)
USLE length/slope factor (*LS*)	Unitless	Calculated from *L* and *S* per Williams and Berndt (1977)

Finally, two parameters—root zone depth and Soil Conservation Service (SCS) curve number (used for recharge calculations)—required site-based land use data, as well as soil

[1] Hydrologic soil properties required for modeling include bulk density, saturated water content, residual water content, field moisture content, wilting point, saturated hydraulic conductivity, soil moisture coefficient *b*, and soil moisture retention parameters alpha and beta.

texture or hydrologic soil group. The land use data were obtained for each of the 41 climatic regions from the GIRAS land use database (U.S. EPA, 1994). GIRAS provides comprehensive land use data, in digital GIS format, for the contiguous 48 states. Land use/land cover information in GIRAS was mapped and coded using the Anderson classification system (Anderson et al., 1976), which is a hierarchical system of land use characterizations. This nationwide coverage is based on late-1970s to early-1980s satellite images and aerial photography. The relationships used to convert the land use and soil data were obtained from Dunne and Leopold (1978) for root zone depth and USDA (1986) for the SCS curve number.

D2.0 Data Collection

The soil data collection methodology begins with GIS programs (in Arc Macro Language (AML)) that overlay the boundaries of the 41 climatic regions on the STATSGO map unit coverage to determine the STATSGO map units and their area within the regions. These data are then passed to data processing programs that derive predominant soil properties within each climatic region, either through direct calculations or by applying established relationships in lookup tables. In deriving soil model inputs, the sludge soil data processing effort bases all collected soil properties on the predominant soil type (texture and hydrologic group) for the STATSGO map units having agricultural land use within each climatic region. Soil properties were derived for surface soils (top 20 cm).

To ensure consistent, realistic properties, the soil data processing effort bases all collected soil properties on the predominant soil texture for each STATSGO map unit. For each STATSGO map unit within a region, textures were determined both for surface soils (top 20 cm) from CONUS data. For surface soils, the predominant texture for each map unit is the thickest, weighted by depth, soil texture for the top three CONUS layers (20 cm). Where there was a tie, the texture of the top two layers was used as the predominant soil texture for that map unit. Twelve common soil textures were collected to develop hydrologic properties. Map units that did not have one of the 12 common soil textures (e.g., those with water or organic matter) were excluded from the analysis. Soil column texture was obtained in a similar manner, except that all CONUS layers were used.

To limit data collection to agricultural soils, GIS programs (in AML) were used to overlay the STATSGO map unit GIS coverage with the GIRAS land use GIS coverage and then determine the map units (and their respective areas) that occur in cropland use and pastureland use (i.e., Anderson land use code 21) within each meteorological region. These data were then processed to create a set of the 12 soil textures, ranked by percentage of land in agricultural use with each texture, for each region. These textures were used to derive soil properties for this analysis for each region/texture combination as described in the next section.

Because certain soil properties were derived from SCS hydrologic soil groups, it was necessary to develop a hydrologic soil group that would be consistent with the soils of each texture within a region. To do so, a table of hydrologic soil groups by STATSGO map unit was created using STATSGO data for hydrologic soil groups by the component soils within the map unit. Based on the predominant texture for each map unit, hydrologic soil groups for the component soils with the same texture were averaged across each map unit (weighted by component percent) using the numeric conversion: group A = 1, group B = 2, group C = 3, and group D = 4. These values were then averaged again (weighted by map unit area) for each soil texture occurring in a region. After this regional average by texture was calculated, the numbers were converted back to letters using the same conversion, resulting in a hydrologic soil group for each texture occurring within a meteorologic region. Hydrologic soil group applies to the entire soil column and is not layer-specific.

D3.0 Development of Soil Properties

Once the distribution of soil textures and their related hydrologic class was determined for each meteorological region, average soil properties were determined for each soil texture present in a region by relationships with soil texture or hydrologic class or by extracting the data for soils of each texture directly from STATSGO.

***Soil Properties Based on Relationship with Soil Texture*—**Several soil hydrologic properties were derived directly from the soil texture using database lookup tables relating mean properties to texture class (see Table D-2):

- **Saturated hydraulic conductivity (cm/h)** was determined for both surface soil (*Ksat_top20*) and the entire soil column (*VadSATK*) using a national relationship from Carsel and Parrish (1988).

- **Saturated water content (unitless)** was determined for both surface soil (*WCS_top20*) and the entire soil column (*VadWCS*) using a relationship from Carsel and Parrish (1988).

- **Bulk density (g/cm^3)** was calculated for surface soil (*BD_top20)* from saturated water content using the equation

$$\rho_b = 2.65(1 - \phi) \quad \text{(D-1)}$$

  where

  ρ_b = bulk density of the soil (U.S. EPA, 1997)
  2.65 = particle density in g/cm^3 (assumed to be quartz)
  ϕ = saturated water content.

- **Soil moisture coefficient (unitless)** was determined for both the surface soil (*SMb_top20*) and the entire soil column (*SMb_sub*) using a relationship from Clapp and Hornberger (1978).

- **Depth to root zone (cm)** was determined using a Dunne and Leopold (1978) table of rooting depth by vegetation type and soil texture. For each soil texture, a minimum and a maximum root zone depth (for shallow and deep-rooted crops) were used to represent the range across cropland and pastureland use. Because Dunne and Leopold included only five soil textures, these five textures were mapped across the 12 basic textures used in this analysis (see Table D-3).

Table D-2. Hydrological Soil Parameters Correlated to Soil Texture

Soil Texture	Saturated Hydralic Conductivity *Ksat*[a] (cm/h)	Storated Water Content *WCS*[a] (L/L)	Bulk Density ρB[b] (g/cm^3)	Soil Moisture Coefficient *b* *SMb*[c]
Clay (C)	0.20	0.38	1.643	11.4
Clay loam (CL)	0.26	0.41	1.5635	8.52
Loam (L)	1.04	0.43	1.5105	5.39
Loamy sand (LS)	14.59	0.41	1.5635	4.38
Silt (SI)	0.25	0.46	1.431	--
Silt loam (SIL)	0.45	0.45	1.4575	5.30
Silty clay (SIC)	0.02	0.36	1.696	10.4
Silty clay loam (SICL)	0.07	0.43	1.5105	7.75
Sand (S)	29.70	0.43	1.5105	4.05
Sandy clay (SC)	0.12	0.38	1.643	10.4
Sandy clay loam (SCL)	1.31	0.39	1.6165	7.12
Sandy loam (SL)	4.42	0.41	1.5635	4.90

[a] Carsel and Parrish (1988).
[b] Calculated from *WCS* using equation from U.S. EPA (1997).
[c] Clapp and Hornberger (1978).

Table D-3. Depth to Root Zone Values

USDA Soil Texture	Dunne and Leopold Texture	Shallow-Rooted Crops (*DRZ_Min*, cm)	Deep-Rooted Crops (*DRZ_Max*, cm)
Sand	Fine sand	50	100
Loamy sand	Fine sandy loam	50	100
Sandy loam			
Silt	Silt loam	62	125
Silt loam			
Loam			
Sandy clay loam	Clay loam	40	100
Silty clay loam			
Clay loam			
Sandy clay	Clay	25	67
Silty clay			
Clay			

Source: Derived from Dunne and Leopold (1978).

Soil Parameters Based on Relationship with Hydrologic Group—The following soil parameters are all based on the average hydrologic soil group for each texture within a meteorological region. Mean values by hydrologic group were obtained using the following relationships (see Tables D-4 and D-5):

- **Soil moisture field capacity (volume %).** A single field capacity value (*SMFC*) was obtained by hydrologic soil group by averaging the layered property values from Carsel et al. (1988).

- **Soil moisture wilting point (volume %).** A single wilting point value (*SMWP*) was obtained by hydrologic soil group by averaging the layered property values from Carsel et al. (1988).

- **SCS curve number (unitless).** Minimum and maximum SCS curve number values (*CN_min* and *CN_max*) were determined for each regional soil texture based on a USDA (1986) table of curve numbers by cover type and hydrologic soil group, assuming a good-condition pastureland use for *CN_min* and poor-condition cropland use for *CN_max*. A lookup table with minimum and maximum SCS curve numbers by hydrologic soil group was used to assign the appropriate value for each regional soil texture according to its hydrologic soil group.

Table D-4. Field Capacity (FC) and Wilting Point (WP) Values

Hydrologic Group	Layer	FC	WP
A	1	9.4	3.1
	2	8.1	2.3
	3	5.9	2.1
	4	5.8	1.9
	Avg.	*7.3*	*2.4*
B	1	19.1	8.7
	2	18.8	9.3
	3	18.7	8.9
	4	17.5	8.4
	Avg.	*18.5*	*8.8*
C	1	22.5	10.4
	2	23.2	12.1
	3	22.9	11.9
	4	21.3	11.5
	Avg.	*22.5*	*11.5*
D	1	24.2	13.8
	2	26.3	17.0
	3	25.6	16.3
	4	24.4	15.1
	Avg.	*25.1*	*15.6*

Source: Carsel et al. (1988).

Table D-5. SCS Curve Number Values by SCS Hydrologic Soil Group

SCS Hydrologic Soil Group	SCS Curve Number	
	CN_Min (Pasture)	CN_Max (Cropland)
A	39	72
B	61	81
C	74	88
D	80	91

Source: Derived from USDA (1986).

D4.0 Parameters Collected Directly from STATSGO-Based Data Sources

Several variables were obtained directly from STATSGO (Schwarz and Alexander, 1995). Although they are not derived from soil texture, they were extracted and averaged based only on soil map units with the predominant texture to ensure consistent soil properties.

- **USLE erodibility factor—top 20 cm** (ton/acre). An area-weighted average erodibility factor for the top 20 cm of soil (*K_top20*) was calculated from STATSGO data by layer and component. STATSGO layer data were translated into *K* values using standardized CONUS layers and calculating a depth-weighted average value. Further, a component percent-weighted average *K* was calculated for each CONUS layer across all components contained in each map unit. The resulting table contains *K* values by map unit and standardized CONUS layer. To get one value for *K* by map unit for the top 20 cm of soil, a depth-weighted average for the top three CONUS layers was calculated. The final *K* value by meteorological region and soil texture was obtained by averaging the map units for each surface soil texture present within the meteorological region.

- **Fraction organic carbon—top 20 cm** (mass fraction). An area-weighted average foc for surface soils (*foc_top20*) was calculated for each region and soil texture using only the map units with the predominant surface soil texture of interest within the region. Percent organic matter for the top 20 cm of soil was obtained from STATSGO organic matter data by layer and component (Schwarz and Alexander, 1995) and converted to foc by dividing by 174 (100 × 1.74 g organic matter/g organic carbon) (U.S. EPA, 1997). Percent organic matter values were translated from STATSGO layer and component into standardized CONUS layers using the same methodology described for the USLE erodibility factor *K*. Then, a depth-weighted average percent organic matter was calculated for the top three CONUS layers (top 20 cm of soil).

- **Silt content—top 20 cm** (weight percent). An area-weighted average silt content for surface soils (*Ss_top20*) was derived from STATSGO data for each region and soil texture in the same manner described for USLE erodibility factor.

The USLE's length slope factor (*LS*) was derived from STATSGO slope data. Percent slope (*Theta*) was obtained by region and soil texture by using only the map units with the predominant texture of interest. An area-weighted average slope was calculated for each texture occurring in a region. Length (*Length,* ft) was then obtained from a Lightle and Weesies (1998) lookup table of default flow lengths by slope, using slope values rounded to the nearest integer (Table D-6). All slopes less than 0.5 were given the length corresponding to 0.5 and all slopes greater than 24 were given the length corresponding to 24. The USLE length/slope factor *LS* (unitless) was then calculated using the equation from Williams and Berndt (1977):

$$LS = (L/72.6)^{m}(0.065 + 0.0454S + 0.0065S^{2}) \quad \text{(D-2)}$$

where

L = flow length
S = slope in percent

and

m = 0.2 for slope <1 percent
m = 0.3 for slope ≥1 percent and <3 percent
m = 0.4 for slope ≥3 percent and <5 percent
m = 0.5 for slope ≥5 percent.

Table D-6. Default Flow Lengths by Slope

Slope	Length (ft)	Slope	Length (ft)
≤0.5	100	13	90
1	200	14	80
2	300	15	70
3	200	16	60
4	180	17	60
5	160	18	50
6	150	19	50
7	140	20	50
8	130	21	50
9	125	22	50
10	120	23	50
11	110	≥24	50
12	100		

Source: Lightle and Weesies (1998).

D5.0 References

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Appendix E

Chemical Data

Appendix E

Chemical Data

This appendix presents values and references for the chemical-specific parameters used in the source models and the fate and transport models for this analysis. Information is presented in separate tables for each constituent, according to how the models considered the data. Constituents were modeled as either metals or organics because of their different behavior in environmental media. Nitrate and nitrite were modeled similarly to metals. The list of chemical-specific parameters is divided into the following groups:

- Biotransfer factors
- Chemical properties
- Meteorological variables
- Temperature correction factors.

In addition to the parameter values and references, Tables E-4 to E-43 indicate whether a value was taken directly from the cited source or was calculated based on equations in the cited source. Some of the chemical-specific data were processed to convert units to be consistent with model requirements.

E1.0 Biotransfer Factors

The biotransfer factors for plants and the farm food chain for organics were derived from the *Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions* (U.S. EPA, 1998). These equations require a log Kow and are based on algorithms developed by Travis and Arms (1988) and Briggs et al. (1982). When a chemical's log Kow was out of the applicable range for these equations, the biotransfer parameter was set to the maximum (for log Kow values above the range) or minimum (for log Kow values below the range) value possible for the given equation. In the aquatic food chain, all bioconcentration factors (BCF_fish) were gathered from EPIWIN (v3.10), which is an EPA software package that predicts the BCF based on the log Kow. For this analysis, there was no differentiation between fish of different trophic levels.

Biotransfer factors (plant, aquatic, and farm food chain) for metals were generally collected from several empirical sources (e.g., Baes et al., 1984).

E2.0 Chemical Properties

The major sources of chemical property data for organics include U.S. EPA references such as the *Preliminary Organo-Phosphates Cumulative Risk Assessment* (OP Risk Assessment) (U.S. EPA, 2001c), the *Reregistration Eligibility Decision document* (RED) (U.S. EPA, 2000-2002), and the *Interim Reregistration Eligibility Decision document* (I/RED) (U.S. EPA, 2000-

2002). The *Superfund Chemical Data Matrix* (SCDM) (U.S. EPA, 1996) was used as a primary source for chemicals other than pesticides. The *Parameter Guidance Document* (U.S. EPA, 1997) served as a guide for the selection of parameter values. Additional sources were used for specific parameters or chemicals as noted in the following tables.

The OP Risk Assessment, I/RED, and SCDM were the preferred sources due to the quality of their data, which have undergone public and scientific review. Values were obtained from other sources only if data were not available in these sources. The additional sources of data included the Merck Index (Budavari, 1996) and Internet databases, such as the Hazardous Substances Databank (NLM, 2002). When no empirical data were identified in the literature or on-line, values were calculated from other properties for parameters such as Henry's law constant (HLC) and diffusion coefficients (Da and Dw). Properties that were selected using a different reference hierarchy or approach are further discussed below.

Degradation Rates

The primary source of data for degradation rates (ksed, ksoil, and ksw) was Howard et al. (1991). Hydrolysis rates (kh) were mostly obtained from Kollig (1993). Several of these degradation rates were calculated from a half-life. If no data were found, the default value for these properties was 0.

Different degradation rate parameters were called for in the two models, as shown below. The source model specifies an aerobic and an anaerobic degradation rate, whereas the fate and transport model specifies degradation rates for surface water, soil, and sediment. Degradation rate data were reported as rates for specific media (i.e., surface water, soil, and sediment).

Table E-1. Use of Degradation Rate Data in Source and Fate and Transport Models

Available Degradation Rate Data	Source Model Parameter	Fate and Transport Model Parameter
Surface water degradation rates	Aerobic degradation rate	Surface water degradation rate
Soil degradation rates	NA	Soil degradation rate
Sediment degradation rates	Anaerobic degradation rate	Sediment degradation rate

Other Chemical Properties

As noted earlier, some chemical property values were taken directly from the source, and some were calculated based on equations and data from the source. The following bullets describe several chemical property values that were calculated.

- *pKa*—For chemicals that are ionizable, data were gathered from NLM (2002), Kollig (1993), and the SPARC On-line Calculator. SPARC is a Web-based tool that estimates pKa from other chemical properties (http://ibmlc2.chem.uga.edu/sparc/index.cfm).

- *Organic-carbon-normalized partition coefficient (K_{oc})*—Kollig (1993) was the preferred source for K_{oc} values. For those chemicals not covered in Kollig (1993), K_{oc} values were calculated in relation to K_{ow} using the same equations used by Kollig (1993) to estimate K_{oc} from K_{ow} at neutral pH conditions.

  For neutral compounds and organic bases (pKa<6):

$$\log K_{oc} = \log K_{ow} - 0.32$$

  For organic acids (chemicals with pKa values >9):

$$K_{oc} = 1.05 * K_{ow}^{(0.82)}$$

  For all other organic constituents (chemicals with 6<pKa values<9):

$$K_{oc} = 1.05 * K_{ow}^{(0.82)} \frac{1}{1.0 + \frac{Ka}{[H^+]}}$$

- *Soil-water partition coefficient (K_d)*—Different procedures were applied to obtain these data depending on the chemical constituents.

  Organic constituents: K_d was calculated within the model using K_{oc} using the following relationship:

$$K_d = K_{oc} \times f_{oc}$$

  where f_{oc} is the fraction organic carbon in waste or soil.

  Nitrate and nitrite: K_d was assumed to be 0.

  Metals:
  Silver: K_d values for silver were obtained from an empirical distribution of values calculated from information collected on POTW (publicly owned treatment works) effluent and sludge concentrations. These values were obtained from in *Silver Waste Streams: Management Practices, Risks, and Economics* (U.S. EPA, 1999) and are presented in the table *"K_d Data Statistics."*

  Barium and beryllium: K_d values were generated from a Loguniform distribution described in the table *"K_d Data Statistics,"* because insufficient K_d data were identified in the literature.

  Manganese: K_d values were obtained from an empirical distribution described on the table *"K_d Data Statistics."*

Table E-2. K_d Data Statistics

Metal	No. of K_{dsoil} values	No. of References	Mean	Std. Dev.	Median	Min.	Max.
Ag	16	1	6.68e+05	8.84e+05	1.40e+05	5.20e+03	3.13e+06
Source: Silver Waste Streams: Management Practices, Risks, and Economics (U.S. EPA, 1999)							
Ba	2	1	1.88e+04	2.85e+04	4.79e+03	1.20e+02	1.20e+05
Be	2	1	8.63e+03	1.36e+04	1.83e+03	6.10e+01	6.09e+04
Mn	12	4	7.53e+02	1.58e+03	1.12e+02	3.20e+01	7.13e+03

Source: Risk Assessment Technical Background Document for the Paint and Coatings Hazardous Waste Listing Determination (U.S. EPA, 2001a)

- *ChemFracNeutral*—All nonionizing chemicals were assigned a ChemFracNeutral value of 1. All ionizable organic compounds were evaluated in terms of the potential to ionize under the pH conditions of this risk assessment. For ionizable organic compounds, the following equation presented in Lee et al. (1990) was used:

$$ChemFracNeutral = (1 + 10^{pH - pKa})^{-1}$$

The pH values used to for soil and wastes were selected from distributions during the probabilistic modeling used for the screening analysis.

E3.0 Meteorological Variable

The washout ratio for particulates (WP) is a constant value of 50,000 in this analysis, irrespective of chemical (Table E-0).

E4.0 Temperature Correction Factors

All chemical properties are sent to the models at standard temperature conditions (25° C). The source models internally adjust these properties to values corresponding to the temperature within the waste management units being modeled. Parameters needed for these temperature adjustments include critical temperatures and pressures (Tc and Pc), as well as vapor pressure equation coefficients (AntB and AntC), which were obtained from Reid et al. (1977). For chemicals where no empirical data are available, the source model calculates these temperature correction factor parameters. Boiling point (tb) data were gathered from the same references that were consulted for gathering other chemical properties.

E5.0 Tabulated Values Used for Modeling

Table E-3 describes each of the chemical specific parameters and values for parameters that remain constant for all chemicals. Tables E-4 through E-43 document the specific values used for each of the constituents. These values are categorized according to parameter type for easy reference. The following is the legend for abbreviations used in the reference column of these tables.

Table Abbreviation	**Reference**
BcfWIN (v.2.14)	EPIWIN (n.d.)
ChemFate	SRC (1999)
ChemFinder	ChemFinder (1999)
EPIWIN (v. 3.10)	EPIWIN (n.d.)
HSDB	Hazardous Substances Data Bank, NLM (2002)
Merck	Budavari (1996)
RED	Reregistration Eligibility Document, U.S. EPA (2000-2002)
SCDM	Superfund Chemical Data Matrix, U.S. EPA (1996)
SPARC	System Performs Automated Reasoning in Chemistry, SPARC (2003)
US EPA OP Cumulative Risk Assessment	Organo-Phosphates Cumulative Risk Assessment, U.S. EPA (2001c)
WIN_PST	WIN_PST Pesticide Properties Database, U.S. EPA (n.d.)

Table E-3. Chemical-Specific Model Parameters

Parameter	Description	Type	Value	Reference
Biotransfer factors				
BCF_beef	Bioconcentration factor for beef (mg/kg beef)/(mg/kg DW)	Constant	Chemical specific	
BCF_milk	Bioconcentration factor for milk (mg/kg milk)/(mg/kg DW)	Constant	Chemical specific	
BCF_fish	Bioconcentration factor for fish (mg/kg fish)/(mg/L water)	Constant	Chemical Specific	
BrExfruit	Soil-to-plant bioconcentration factor, exposed fruit (mg/kg DW plant / mg/kg soil)	Constant	Chemical Specific	
BrExveg	Soil-to-plant bioconcentration factor, exposed vegetables (mg/kg DW plant / mg/kg soil)	Constant	Chemical Specific	
BrForage	Soil-to-plant bioconcentration factor, forage (mg/kg DW plant / mg/kg soil)	Constant	Chemical Specific	
BrGrain	Soil-to-plant bioconcentration factor, grain (mg/kg DW plant / mg/kg soil)	Constant	Chemical Specific	
BrProfruit	Soil-to-plant bioconcentration factor, protected fruit (mg/kg DW plant / mg/kg soil)	Constant	Chemical Specific	
BrProveg	Soil-to-plant bioconcentration factor, protected vegetables (mg/kg DW plant / mg/kg soil)	Constant	Chemical Specific	
BrRoot	Soil-to-plant bioconcentration factor, roots (mg/kg DW plant / mg/kg soil)	Constant	Chemical Specific	
BrSilage	Soil-to-plant bioconcentration factor, silage (mg/kg DW plant / mg/kg soil)	Constant	Chemical Specific	
Bs	Bioavailability of contaminant on the soil relative to the vegetation (unitless)	Constant	1	U.S. EPA, 1997
Bv	Air-to-plant biotransfer factor (ug/g DW plant / ug/g air)	Constant	Chemical Specific	
KpPar	Plant surface loss coefficient, particulate (1/yr)	Constant	18.07	U.S. EPA, 1997
RCF	Root concentration factor (ug/g - WW plant) / (ug/mL soil water)	Constant	Chemical Specific	
Chemical properties				
Da	Diffusivity of chemical in air (cm2/s)	Constant	Chemical Specific	
Density	Density of the chemical (g/mL)	Constant	Chemical Specific	
Dw	Diffusion coefficient in water (cm2/s)	Constant	Chemical Specific	
HLC	Henry's law constant atm-m3/mol	Constant	Chemical Specific	

Table E-3. Chemical-Specific Model Parameters

Parameter	Description	Type	Value	Reference
kh	Hydrolysis rate 1/day or 1/yr	Constant	Chemical Specific	
Koc	Organic carbon partition coefficient (mL/g)	Constant	Chemical Specific	
ksed	Degradation rate for sediment (1/day)	Constant	Chemical Specific	
ksoil	Degradation rate for soil (1/day)	Constant	Chemical Specific	
ksw	Degradation rate for surface-water column (1/day)	Constant	Chemical Specific	
LogKow	Octanol-water partition coeficient (unitless)	Constant	Chemical Specific	
MW	Molecular weight (g/mol)	Constant	Chemical specific	
pKa	Dissociation constant (unitless)	Constant	Chemical Specific	
Sol	Solubility (mg/L)	Constant	Chemical specific	
Temperature correction factors				
AntB	Vapor pressure equation coefficient (unitless)	Constant	Chemical specific	
AntC	Vapor pressure equation coefficient (unitless)	Constant	Chemical specific	
Pc	Critical pressure (atm)	Constant	Chemical specific	
tb	Boiling point (degC)	Constant	Chemical specific	
tc	Critical temperature (degC)	Constant	Chemical specific	

Table E-4. Chemical Parameters for Acetone (67-64-1)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.40E-06	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		3.20E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		5.30E+01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		8.00E-04	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		8.40E-01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		1.06E-01	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		0.7899	SCDM
Dw	(cm2/s)		1.15E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		3.88E-05	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		1.00E+00	HSDB
ksed	(1/day)		2.48E-02	Howard et al., 1991
ksoil	(1/day)		9.90E-02	Howard et al., 1991
ksw	(1/day)		9.90E-02	Howard et al., 1991
LogKow	(unitless)		-2.40E-01	SCDM
MW	(g/mol)		58.08	SCDM
pKa	(unitless)		-5.178908574	SPARC
Sol	(mg/L)		1.00E+06	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		56	SCDM
tc	(degC)		-9999	No data

Table E-5. Chemical Parameters for Acetophenone (98-86-2)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.80E-06	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		4.70E-01	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		4.40E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		2.90E-01	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.37E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		6.52E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.0281	SCDM
Dw	(cm2/s)		8.72E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.07E-05	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		1.82E+01	Kollig, 1993
ksed	(1/day)		1.16E-02	EPIWIN (v3.10)
ksoil	(1/day)		4.62E-02	EPIWIN (v3.10)
ksw	(1/day)		4.62E-02	EPIWIN (v3.10)
LogKow	(unitless)		1.64E+00	SCDM
MW	(g/mol)		120.15	SCDM
pKa	(unitless)		-5.11	SPARC
Sol	(mg/L)		6.13E+03	SCDM
Temperature correction factors				
AntB	(unitless)		1641.80	Reid et al., 1977
AntC	(unitless)		-354.3	Reid et al., 1977
Pc	(atm)		38	Reid et al., 1977
tb	(degC)		202	SCDM
tc	(degC)		427.85	Reid et al., 1977

Table E-6. Chemical Parameters for Anthracene (120-12-7)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	7.13E-03	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.51E-03	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		6.00E+02	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		9.10E-02	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		6.00E+01	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		9.63E+01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		3.90E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.28	SCDM
Dw	(cm2/s)		7.85E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		6.50E-05	SCDM
kh	1/day or 1/yr		0.00E+00	Default assumption
Koc	(mL/g)		1.70E+04	Calculated based on Kollig, 1993
ksed	(1/day)		3.77E-04	Howard et al., 1991
ksoil	(1/day)		1.51E-03	Howard et al., 1991
ksw	(1/day)		9.78E+00	Howard et al., 1991
LogKow	(unitless)		4.55E+00	SCDM
MW	(g/mol)		178.23	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		4.34E-02	SCDM
Temperature correction factors				
AntB	(unitless)		2819.12	Reid et al., 1977
AntC	(unitless)		-299.28	Reid et al., 1977
Pc	(atm)		-9999	No data
tb	(degC)		339.9	SCDM
tc	(degC)		609.85	Reid et al., 1977

Table E-7. Chemical Parameters for Azinphos methyl (86-50-0)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.06E-04	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		2.60E+01	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		1.00E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		1.20E+04	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		3.75E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.33E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.44	SCDM
Dw	(cm2/s)		5.96E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		3.66E-09	RED/IRED
kh	1/day or 1/yr	Converted from a hydrolysis half-life.	1.87E-02	US EPA OP Cumulative Risk Assessment
Koc	(mL/g)		2.51E+02	Calculated based on Kollig, 1993
ksed	(1/day)		1.75E-03	US EPA OP Cumulative Risk Assessment
ksoil	(1/day)		7.23E-03	US EPA OP Cumulative Risk Assessment
ksw	(1/day)		3.62E-03	US EPA OP Cumulative Risk Assessment
LogKow	(unitless)		2.73E+00	RED/IRED
MW	(g/mol)		317.32	US EPA OP Cumulative Risk Assessment
pKa	(unitless)		-5.24	SPARC
Sol	(mg/L)		2.51E+01	US EPA OP Cumulative Risk Assessment
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		-9999	No data
tc	(degC)		-9999	No data

Table E-8. Chemical Parameters for Barium and compounds (7440-39-3)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.20E-03	Baes et al., 1984
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	5.60E-03	Baes et al., 1984
BCF_fish	(mg/kg fish)/(mg/L water)		3.20E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		1.50E-02	Baes et al., 1984
BrExveg	(mg/kg DW plant / mg/kg soil)		1.50E-01	Baes et al., 1984
BrForage	(mg/kg DW plant / mg/kg soil)		1.50E-01	Baes et al., 1984
BrGrain	(mg/kg DW plant / mg/kg soil)		1.50E-02	Baes et al., 1984
BrProfruit	(mg/kg DW plant / mg/kg soil)		1.50E-02	Baes et al., 1984
BrProveg	(mg/kg DW plant / mg/kg soil)		1.50E-02	Baes et al., 1984
BrRoot	(mg/kg DW plant / mg/kg soil)		1.50E-01	Baes et al., 1984
BrSilage	(mg/kg DW plant / mg/kg soil)		1.50E-01	Baes et al., 1984
Chemical properties				
Da	(cm2/s)		9.29E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		3.51	SCDM
Dw	(cm2/s)		1.68E-05	Calculated based on WATER9, U.S. EPA, 2001
MW	(g/mol)		137.33	SCDM
Sol	(mg/L)		1.00E+06	Default
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		1640	SCDM
tc	(degC)		-9999	No data

Table E-9. Chemical Parameters for Benzoic acid (65-85-0)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.46E-05	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		5.00E+00	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		3.30E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		3.50E+00	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.64E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		7.02E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.2659	SCDM
Dw	(cm2/s)		9.79E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.54E-06	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		7.76E-01	Kollig, 1993
ksed	(1/day)		1.16E-02	EPIWIN (v3.10)
ksoil	(1/day)		4.62E-02	EPIWIN (v3.10)
ksw	(1/day)		4.62E-02	EPIWIN (v3.10)
LogKow	(unitless)		1.86E+00	SCDM
MW	(g/mol)		122.12	SCDM
pKa	(unitless)		4.18	Kollig, 1993
Sol	(mg/L)		3.50E+03	SCDM
Temperature correction factors				
AntB	(unitless)		1819.67	Reid et al., 1977
AntC	(unitless)		-398.35	Reid et al., 1977
Pc	(atm)		45	Reid et al., 1977
tb	(degC)		249.2	SCDM
tc	(degC)		478.85	Reid et al., 1977

Table E-10. Chemical Parameters for Beryllium and compounds (7440-41-7)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.00E-03	Baes et al., 1984
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.44E-05	Baes et al., 1984
BCF_fish	(mg/kg fish)/(mg/L water)	BCF_T3W was used as a surrogate. -	1.90E+01	Barrows et al., 1980
BrExfruit	(mg/kg DW plant / mg/kg soil)		1.50E-03	Baes et al., 1984
BrExveg	(mg/kg DW plant / mg/kg soil)		1.00E-02	Baes et al., 1984
BrForage	(mg/kg DW plant / mg/kg soil)		1.00E-02	Baes et al., 1984
BrGrain	(mg/kg DW plant / mg/kg soil)		1.50E-03	Baes et al., 1984
BrProfruit	(mg/kg DW plant / mg/kg soil)		1.50E-03	Baes et al., 1984
BrProveg	(mg/kg DW plant / mg/kg soil)		1.50E-03	Baes et al., 1984
BrRoot	(mg/kg DW plant / mg/kg soil)		1.00E-02	Baes et al., 1984
BrSilage	(mg/kg DW plant / mg/kg soil)		1.00E-02	Baes et al., 1984
Chemical properties				
Da	(cm2/s)		4.82E-01	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.8477	SCDM
Dw	(cm2/s)		5.87E-05	Calculated based on WATER9, U.S. EPA, 2001
MW	(g/mol)		9.01218	SCDM
Sol	(mg/L)		1.00E+06	Default
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		2970	SCDM
tc	(degC)		-9999	No data

Table E-11. Chemical Parameters for Biphenyl, 1,1- (92-52-4)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.83E-03	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.16E-03	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		2.80E+02	SRC Measured Database (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		2.00E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		3.10E+00	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		3.38E+01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		4.71E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.04	SCDM
Dw	(cm2/s)		7.56E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		3.00E-04	SCDM
kh	1/day or 1/yr		0.00E+00	Default assumption
Koc	(mL/g)		4.37E+03	Calculated based on Kollig, 1993
ksed	(1/day)		2.48E-02	Howard et al., 1991
ksoil	(1/day)		9.90E-02	Howard et al., 1991
ksw	(1/day)		9.90E-02	Howard et al., 1991
LogKow	(unitless)		3.96E+00	SCDM
MW	(g/mol)		154.21	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		6.03E+00	SCDM
Temperature correction factors				
AntB	(unitless)		1998.36	Reid et al., 1977
AntC	(unitless)		-343.57	Reid et al., 1977
Pc	(atm)		38	Reid et al., 1977
tb	(degC)		256.1	SCDM
tc	(degC)		515.85	Reid et al., 1977

Table E-12. Chemical Parameters for Butyl benzyl phthalate (85-68-7)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.39E-02	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.80E-03	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		6.60E+02	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		6.20E-02	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		6.30E+03	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.61E+02	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.08E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.117	HSDB
Dw	(cm2/s)		5.17E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.26E-06	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		1.70E+04	Kollig, 1993
ksed	(1/day)		3.85E-03	Howard et al., 1991
ksoil	(1/day)		9.90E-02	Howard et al., 1991
ksw	(1/day)		9.90E-02	Howard et al., 1991
LogKow	(unitless)		4.84E+00	SCDM
MW	(g/mol)		312.3654	SCDM
pKa	(unitless)		-5.66	SPARC
Sol	(mg/L)		2.69E+00	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		370	HSDB
tc	(degC)		-9999	No data

Table E-13. Chemical Parameters for Carbon disulfide (75-15-0)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.01E-05	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		6.00E+01	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		2.70E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		2.50E-04	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.87E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		1.06E-01	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.2632	SCDM
Dw	(cm2/s)		1.30E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		3.03E-02	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		4.79E+01	Calculated based on Kollig, 1993
ksed	(1/day)		1.16E-02	EPIWIN (v3.10)
ksoil	(1/day)		3.47E-01	WIN_PST Online Pesticide Properties Database
ksw	(1/day)		4.62E-02	EPIWIN (v3.10)
LogKow	(unitless)		2.00E+00	SCDM
MW	(g/mol)		76.14	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		1.19E+03	SCDM
Temperature correction factors				
AntB	(unitless)		1168.41	Reid et al., 1977
AntC	(unitless)		-304.77	Reid et al., 1977
Pc	(atm)		78.0	Reid et al., 1977
tb	(degC)		46	SCDM
tc	(degC)		278.85	Reid et al., 1977

Table E-14. Chemical Parameters for Chloroaniline, 4- (106-47-8)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.42E-05	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		1.00E+01	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		3.30E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		1.60E+01	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.62E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		7.04E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.429	SCDM
Dw	(cm2/s)		1.03E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		3.31E-07	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		4.07E+01	Kollig, 1993
ksed	(1/day)		9.63E-04	Howard et al., 1991
ksoil	(1/day)		3.85E-03	Howard et al., 1991
ksw	(1/day)		0.00E+00	No data
LogKow	(unitless)		1.85E+00	SCDM
MW	(g/mol)		127.57	SCDM
pKa	(unitless)		4.08	SPARC
Sol	(mg/L)		5.30E+03	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		232	SCDM
tc	(degC)		-9999	No data

Table E-15. Chemical Parameters for Chlorobenzene (108-90-7)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.46E-04	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	9.20E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		2.30E+01	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		8.60E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		1.70E-02	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		4.81E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		7.21E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.1058	SCDM
Dw	(cm2/s)		9.48E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		3.70E-03	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		3.78E+02	Kollig, 1993
ksed	(1/day)		1.16E-03	Howard et al., 1991
ksoil	(1/day)		4.62E-03	Howard et al., 1991
ksw	(1/day)		4.62E-03	Howard et al., 1991
LogKow	(unitless)		2.86E+00	SCDM
MW	(g/mol)		112.56	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		4.72E+02	SCDM
Temperature correction factors				
AntB	(unitless)		1430.79	Reid et al., 1977
AntC	(unitless)		-328.75	Reid et al., 1977
Pc	(atm)		44.6	Reid et al., 1977
tb	(degC)		131.7	SCDM
tc	(degC)		359.25	Reid et al., 1977

Table E-16. Chemical Parameters for Chlorobenzilate (510-15-6)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.82E-03	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	3.06E-03	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		4.30E+02	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		1.10E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		3.60E+04	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		7.12E+01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.18E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.2816	SCDM
Dw	(cm2/s)		5.48E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		7.24E-08	Chemfate
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		1.10E+04	Kollig, 1993
ksed	(1/day)		6.19E-03	Howard et al., 1991
ksoil	(1/day)		1.98E-02	Howard et al., 1991
ksw	(1/day)		1.98E-02	Howard et al., 1991
LogKow	(unitless)		4.38E+00	SCDM
MW	(g/mol)		325.19	SCDM
pKa	(unitless)		13.6	Kollig, 1993
Sol	(mg/L)		1.11E+01	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		157	SCDM
tc	(degC)		-9999	No data

Table E-17. Chemical Parameters for Chlorpyrifos (2921-88-2)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.01E-02	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	6.37E-03	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		1.30E+03	RED/IRED
BrExfruit	(mg/kg DW plant / mg/kg soil)		7.40E-02	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		1.30E+03	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.26E+02	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.18E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.398	HSDB
Dw	(cm2/s)		5.51E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		4.20E-06	US EPA OP Cumulative Risk Assessment
kh	1/day or 1/yr	Converted from a hydrolysis half-life.	9.63E-03	US EPA OP Cumulative Risk Assessment
Koc	(mL/g)		2.40E+04	Calculated based on Kollig, 1993
ksed	(1/day)		5.47E-03	US EPA OP Cumulative Risk Assessment
ksoil	(1/day)		9.00E-03	US EPA OP Cumulative Risk Assessment
ksw	(1/day)		4.50E-03	US EPA OP Cumulative Risk Assessment
LogKow	(unitless)		4.70E+00	RED/IRED
MW	(g/mol)		351	US EPA OP Cumulative Risk Assessment
pKa	(unitless)		-5.15	SPARC
Sol	(mg/L)		2.00E+00	US EPA OP Cumulative Risk Assessment
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		377.43	EPIWIN (v3.10)
tc	(degC)		-9999	No data

Table E-18. Chemical Parameters for Cresol, o- (95-48-7)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.96E-05	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		1.10E+01	SRC Measured Database (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		2.70E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		6.10E+00	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.85E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		7.59E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.135	SCDM
Dw	(cm2/s)		9.86E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.20E-06	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		5.75E+01	Kollig, 1993
ksed	(1/day)		2.48E-02	Howard et al., 1991
ksoil	(1/day)		9.90E-02	Howard et al., 1991
ksw	(1/day)		9.90E-02	Howard et al., 1991
LogKow	(unitless)		1.99E+00	SCDM
MW	(g/mol)		108.14	SCDM
pKa	(unitless)		9.8	Kollig, 1993
Sol	(mg/L)		2.60E+04	SCDM
Temperature correction factors				
AntB	(unitless)		1435.25	Reid et al., 1977
AntC	(unitless)		-381.15	Reid et al., 1977
Pc	(atm)		49.4	Reid et al., 1977
tb	(degC)		191	SCDM
tc	(degC)		424.45	Reid et al., 1977

Table E-19. Chemical Parameters for Diazinon (333-41-5)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.01E-04	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.53E-04	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		5.40E+02	RED/IRED
BrExfruit	(mg/kg DW plant / mg/kg soil)		4.80E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		1.30E+02	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.05E+01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.10E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.1088	SCDM
Dw	(cm2/s)		5.23E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.40E-06	US EPA OP Cumulative Risk Assessment
kh	1/day or 1/yr	Converted from a hydrolysis half-life.	5.02E-03	US EPA OP Cumulative Risk Assessment
Koc	(mL/g)		9.55E+02	Calculated based on Kollig, 1993
ksed	(1/day)		4.23E-03	US EPA OP Cumulative Risk Assessment
ksoil	(1/day)		1.69E-02	US EPA OP Cumulative Risk Assessment
ksw	(1/day)		8.45E-03	US EPA OP Cumulative Risk Assessment
LogKow	(unitless)		3.30E+00	RED/IRED
MW	(g/mol)		304.34	US EPA OP Cumulative Risk Assessment
pKa	(unitless)		0.76	SPARC
Sol	(mg/L)		4.00E+01	US EPA OP Cumulative Risk Assessment
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		87.5	SCDM
tc	(degC)		-9999	No data

Table E-20. Chemical Parameters for Dichloroethene, 1,2-trans- (156-60-5)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.36E-05	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		8.10E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		2.50E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		9.50E-04	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.19E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		8.76E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.2565	SCDM
Dw	(cm2/s)		1.12E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		9.38E-03	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		3.98E+01	Kollig, 1993
ksed	(1/day)		4.62E-03	EPIWIN (v3.10)
ksoil	(1/day)		1.85E-02	EPIWIN (v3.10)
ksw	(1/day)		1.85E-02	EPIWIN (v3.10)
LogKow	(unitless)		2.07E+00	SCDM
MW	(g/mol)		96.94	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		6.30E+03	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		54.38	HSDB
tb	(degC)		48.7	SCDM
tc	(degC)		243.55	HSDB

Table E-21. Chemical Parameters for Dichloromethane (75-09-2)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.40E-06	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		1.60E+01	SRC Measured Database (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		7.30E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		5.50E-04	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.10E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		9.99E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.3266	SCDM
Dw	(cm2/s)		1.25E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		2.19E-03	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		8.51E+00	Calculated based on Kollig, 1993
ksed	(1/day)		6.19E-03	Howard et al., 1991
ksoil	(1/day)		2.48E-02	Howard et al., 1991
ksw	(1/day)		2.48E-02	Howard et al., 1991
LogKow	(unitless)		1.25E+00	SCDM
MW	(g/mol)		84.93	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		1.30E+04	SCDM
Temperature correction factors				
AntB	(unitless)		1138.71	Reid et al., 1977
AntC	(unitless)		-314.85	Reid et al., 1977
Pc	(atm)		60	Reid et al., 1977
tb	(degC)		40	SCDM
tc	(degC)		236.85	Reid et al., 1977

Table E-22. Chemical Parameters for Dioxane, 1,4- (123-91-1)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.40E-06	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		1.00E+00	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		6.50E+01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		4.50E-03	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		8.35E-01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		8.74E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.0337	SCDM
Dw	(cm2/s)		1.05E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		4.80E-06	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		1.54E-01	Kollig, 1993
ksed	(1/day)		9.63E-04	Howard et al., 1991
ksoil	(1/day)		3.85E-03	Howard et al., 1991
ksw	(1/day)		3.85E-03	Howard et al., 1991
LogKow	(unitless)		-3.90E-01	SCDM
MW	(g/mol)		88.11	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		1.00E+06	SCDM
Temperature correction factors				
AntB	(unitless)		1288.27	Reid et al., 1977
AntC	(unitless)		-335.3	Reid et al., 1977
Pc	(atm)		51.4	Reid et al., 1977
tb	(degC)		101.5	SCDM
tc	(degC)		313.85	Reid et al., 1977

Table E-23. Chemical Parameters for Endrin (72-20-8)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.30E-02	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.46E-02	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		4.60E+03	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		4.60E-02	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		1.80E+03	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		2.38E+02	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.30E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.7	HSDB
Dw	(cm2/s)		5.90E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		7.52E-06	SCDM
kh	1/day or 1/yr		1.51E-04	Kollig, 1993
Koc	(mL/g)		3.98E+04	Kollig, 1993
ksed	(1/day)		1.16E-03	EPIWIN (v3.10)
ksoil	(1/day)		1.61E-04	WIN_PST Online Pesticide Properties Database
ksw	(1/day)		4.62E-03	EPIWIN (v3.10)
LogKow	(unitless)		5.06E+00	SCDM
MW	(g/mol)		380.93	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		2.50E-01	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		340.17	EPIWIN (v3.10)
tc	(degC)		-9999	No data

Table E-24. Chemical Parameters for Ethyl p-nitrophenyl phenylphosphorothioate (2104-64-5)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.42E-03	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.99E-04	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		7.20E+02	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		2.30E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		5.40E+03	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		2.78E+01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.17E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.27	SCDM
Dw	(cm2/s)		5.47E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.30E-07	HSDB
kh	1/day or 1/yr		0.00E+00	Default assumption
Koc	(mL/g)		3.39E+03	Calculated based on Kollig, 1993
ksed	(1/day)		4.62E-03	EPIWIN (v3.10)
ksoil	(1/day)		4.62E-02	WIN_PST Online Pesticide Properties Database
ksw	(1/day)		1.85E-02	EPIWIN (v3.10)
LogKow	(unitless)		3.85E+00	SCDM
MW	(g/mol)		323.31	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		4.31E+00	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		420.48	EPIWIN (v3.10)
tc	(degC)		-9999	No data

Table E-25. Chemical Parameters for Fluoranthene (206-44-0)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.65E-02	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.68E-02	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		1.90E+03	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		4.30E-02	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		9.80E+02	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		2.64E+02	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.76E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.252	SCDM
Dw	(cm2/s)		7.18E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.61E-05	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		4.27E+04	Kollig, 1993
ksed	(1/day)		3.94E-04	Howard et al., 1991
ksoil	(1/day)		1.58E-03	Howard et al., 1991
ksw	(1/day)		2.64E-01	Howard et al., 1991
LogKow	(unitless)		5.12E+00	SCDM
MW	(g/mol)		202.26	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		2.06E-01	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		384	SCDM
tc	(degC)		-9999	No data

Table E-26. Chemical Parameters for Hexachlorocyclohexane, alpha- (319-84-6)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.26E-03	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.02E-04	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		7.10E+02	SRC Measured Database (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		2.50E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		5.90E+01	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		2.55E+01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.75E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.87	HSDB
Dw	(cm2/s)		7.35E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.06E-05	SCDM
kh	1/day or 1/yr		2.87E-03	Kollig, 1993
Koc	(mL/g)		2.69E+03	Kollig, 1993
ksed	(1/day)		1.73E-02	Howard et al., 1991
ksoil	(1/day)		5.13E-03	Howard et al., 1991
ksw	(1/day)		5.13E-03	Howard et al., 1991
LogKow	(unitless)		3.80E+00	SCDM
MW	(g/mol)		290.85	HSDB
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		2.00E+00	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		288	HSDB
tc	(degC)		-9999	No data

Table E-27. Chemical Parameters for Hexachlorocyclohexane, beta- (319-85-7)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.30E-03	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-04	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		3.00E+02	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		2.40E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		8.60E+02	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		2.59E+01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.77E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.89	SCDM
Dw	(cm2/s)		7.40E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		7.43E-07	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		2.69E+03	Kollig, 1993
ksed	(1/day)		7.37E-03	Howard et al., 1991
ksoil	(1/day)		5.59E-03	Howard et al., 1991
ksw	(1/day)		5.59E-03	Howard et al., 1991
LogKow	(unitless)		3.81E+00	SCDM
MW	(g/mol)		290.83	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		2.40E-01	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		60	SCDM
tc	(degC)		-9999	No data

Table E-28. Chemical Parameters for Isobutyl alcohol (78-83-1)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.40E-06	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		3.20E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		1.40E+01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		3.00E-02	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		9.34E-01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		8.97E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		0.8018	SCDM
Dw	(cm2/s)		1.00E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.18E-05	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		2.75E+00	Kollig, 1993
ksed	(1/day)		2.40E-02	Howard et al., 1991
ksoil	(1/day)		9.61E-02	Howard et al., 1991
ksw	(1/day)		9.61E-02	Howard et al., 1991
LogKow	(unitless)		7.50E-01	SCDM
MW	(g/mol)		74.12	SCDM
pKa	(unitless)		15.8	Kollig, 1993
Sol	(mg/L)		8.50E+04	SCDM
Temperature correction factors				
AntB	(unitless)		1248.25	Reid et al., 1977
AntC	(unitless)		-373.45	Reid et al., 1977
Pc	(atm)		42.4	Reid et al., 1977
tb	(degC)		107.8	SCDM
tc	(degC)		274.55	Reid et al., 1977

Table E-29. Chemical Parameters for Manganese (7439-96-5)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	3.20E-03	Baes et al., 1984
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	5.60E-03	Baes et al., 1984
BCF_fish	(mg/kg fish)/(mg/L water)		2.30E+01	ECOTOX
BrExfruit	(mg/kg DW plant / mg/kg soil)		5.00E-02	Baes et al., 1984
BrExveg	(mg/kg DW plant / mg/kg soil)		2.50E-01	Baes et al., 1984
BrForage	(mg/kg DW plant / mg/kg soil)		2.50E-01	Baes et al., 1984
BrGrain	(mg/kg DW plant / mg/kg soil)		5.00E-02	Baes et al., 1984
BrProfruit	(mg/kg DW plant / mg/kg soil)		5.00E-02	Baes et al., 1984
BrProveg	(mg/kg DW plant / mg/kg soil)		5.00E-02	Baes et al., 1984
BrRoot	(mg/kg DW plant / mg/kg soil)		2.50E-01	Baes et al., 1984
BrSilage	(mg/kg DW plant / mg/kg soil)		2.50E-01	Baes et al., 1984
Chemical properties				
Da	(cm2/s)		2.43E-01	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		7.2	SCDM
Dw	(cm2/s)		4.48E-05	Calculated based on WATER9, U.S. EPA, 2001
MW	(g/mol)		54.93805	SCDM
Sol	(mg/L)		8.72E+04	EPIWIN (v3.10)
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		1962	SCDM
tc	(degC)		-9999	No data

Table E-30. Chemical Parameters for Methyl ethyl ketone (78-93-3)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.40E-06	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		3.20E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		2.70E+01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		2.00E-03	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		8.70E-01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		9.17E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		0.8054	SCDM
Dw	(cm2/s)		1.02E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		5.59E-05	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		9.33E-01	Kollig, 1993
ksed	(1/day)		2.48E-02	Howard et al., 1991
ksoil	(1/day)		9.90E-02	Howard et al., 1991
ksw	(1/day)		9.90E-02	Howard et al., 1991
LogKow	(unitless)		2.80E-01	SCDM
MW	(g/mol)		72.11	SCDM
pKa	(unitless)		-5.164094999	SPARC
Sol	(mg/L)		2.23E+05	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		79.5	SCDM
tc	(degC)		-9999	No data

Table E-31. Chemical Parameters for MIBK (108-10-1)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.40E-06	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		2.00E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		7.90E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		7.50E-03	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.07E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		6.98E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		0.7978	SCDM
Dw	(cm2/s)		8.36E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.38E-04	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		7.41E+00	Kollig, 1993
ksed	(1/day)		2.48E-02	Howard et al., 1991
ksoil	(1/day)		9.90E-02	Howard et al., 1991
ksw	(1/day)		9.90E-02	Howard et al., 1991
LogKow	(unitless)		1.19E+00	SCDM
MW	(g/mol)		100.16	SCDM
pKa	(unitless)		-5.04	SPARC
Sol	(mg/L)		1.90E+04	SCDM
Temperature correction factors				
AntB	(unitless)		1256.47	Reid et al., 1977
AntC	(unitless)		-343.9	Reid et al., 1977
Pc	(atm)		32.3	Reid et al., 1977
tb	(degC)		116.5	SCDM
tc	(degC)		297.85	Reid et al., 1977

Table E-33. Chemical Parameters for Naled (300-76-5)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.82E-06	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		3.80E-01	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		6.20E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		1.50E+01	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.17E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.46E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.96	HSDB
Dw	(cm2/s)		6.43E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.13E-07	US EPA OP Cumulative Risk Assessment
kh	1/day or 1/yr	Converted from a hydrolysis half-life.	1.08E+00	US EPA OP Cumulative Risk Assessment
Koc	(mL/g)		1.15E+01	Calculated based on Kollig, 1993
ksed	(1/day)		1.54E-01	US EPA OP Cumulative Risk Assessment
ksoil	(1/day)		6.93E-01	US EPA OP Cumulative Risk Assessment
ksw	(1/day)		4.62E-01	US EPA OP Cumulative Risk Assessment
LogKow	(unitless)		1.38E+00	HSDB
MW	(g/mol)		381	US EPA OP Cumulative Risk Assessment
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		2.00E+03	US EPA OP Cumulative Risk Assessment
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		327.79	EPIWIN (v3.10)
tc	(degC)		-9999	No data

Table E-32. Chemical Parameters for Nitrosodiphenylamine, N- (86-30-6)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.90E-04	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.84E-04	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		2.20E+02	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		5.80E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		2.60E+01	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		8.19E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.84E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.23	ChemFinder
Dw	(cm2/s)		7.19E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		5.00E-06	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		6.92E+02	Kollig, 1993
ksed	(1/day)		5.10E-03	Howard et al., 1991
ksoil	(1/day)		2.04E-02	Howard et al., 1991
ksw	(1/day)		2.04E-02	Howard et al., 1991
LogKow	(unitless)		3.16E+00	SCDM
MW	(g/mol)		198.22	SCDM
pKa	(unitless)		-34.84	SPARC
Sol	(mg/L)		3.51E+01	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		-9999	No data
tc	(degC)		-9999	No data

Table E-34. Chemical Parameters for Phenol (108-95-2)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	6.07E-06	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		2.00E+01	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		5.40E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		5.30E+00	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.24E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		8.34E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.0545	SCDM
Dw	(cm2/s)		1.03E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		3.97E-07	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		1.70E+01	Kollig, 1993
ksed	(1/day)		2.48E-02	Howard et al., 1991
ksoil	(1/day)		6.93E-02	Howard et al., 1991
ksw	(1/day)		2.94E-01	Howard et al., 1991
LogKow	(unitless)		1.48E+00	SCDM
MW	(g/mol)		94.11	SCDM
pKa	(unitless)		10	Kollig, 1993
Sol	(mg/L)		8.28E+04	SCDM
Temperature correction factors				
AntB	(unitless)		1515.80	Reid et al., 1977
AntC	(unitless)		-371.74	Reid et al., 1977
Pc	(atm)		60.5	Reid et al., 1977
tb	(degC)		181.8	SCDM
tc	(degC)		421.05	Reid et al., 1977

Table E-35. Chemical Parameters for Pyrene (129-00-0)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.59E-02	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.63E-02	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		7.80E+02	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		4.30E-02	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		1.40E+03	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		2.60E+02	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.78E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.271	SCDM
Dw	(cm2/s)		7.25E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		1.10E-05	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		8.32E+04	Kollig, 1993
ksed	(1/day)		9.12E-05	Howard et al., 1991
ksoil	(1/day)		3.65E-04	Howard et al., 1991
ksw	(1/day)		8.15E+00	Howard et al., 1991
LogKow	(unitless)		5.11E+00	SCDM
MW	(g/mol)		202.26	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		1.35E-01	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		404	SCDM
tc	(degC)		-9999	No data

Table E-36. Chemical Parameters for Silver and compounds (7440-22-4)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.40E-02	Baes et al., 1984
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	3.20E-01	Baes et al., 1984
BCF_fish	(mg/kg fish)/(mg/L water)	BCF_T3W was used as a surrogate. -	0.00E+00	Barrows et al., 1980
BrExfruit	(mg/kg DW plant / mg/kg soil)		1.00E-01	Baes et al., 1984
BrExveg	(mg/kg DW plant / mg/kg soil)		4.00E-01	Baes et al., 1984
BrForage	(mg/kg DW plant / mg/kg soil)		4.00E-01	Baes et al., 1984
BrGrain	(mg/kg DW plant / mg/kg soil)		1.00E-01	Baes et al., 1984
BrProfruit	(mg/kg DW plant / mg/kg soil)		1.00E-01	Baes et al., 1984
BrProveg	(mg/kg DW plant / mg/kg soil)		1.00E-01	Baes et al., 1984
BrRoot	(mg/kg DW plant / mg/kg soil)		4.00E-01	Baes et al., 1984
BrSilage	(mg/kg DW plant / mg/kg soil)		4.00E-01	Baes et al., 1984
Chemical properties				
Da	(cm2/s)		1.75E-01	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		10.49	SCDM
Dw	(cm2/s)		3.75E-05	Calculated based on WATER9, U.S. EPA, 2001
MW	(g/mol)		107.8682	SCDM
Sol	(mg/L)		1.00E+06	Default
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		2212	SCDM
tc	(degC)		-9999	No data

Table E-37. Chemical Parameters for Sodium nitrite (7632-00-0)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	0.00E+00	No data
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	0.00E+00	No data
BCF_fish	(mg/kg fish)/(mg/L water)		3.20E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrExveg	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrForage	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrGrain	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrProfruit	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrProveg	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrRoot	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrSilage	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
Chemical properties				
Da	(cm2/s)		1.43E-01	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		2.26	HSDB
Dw	(cm2/s)		1.95E-05	Calculated based on WATER9, U.S. EPA, 2001
MW	(g/mol)		69	HSDB
Sol	(mg/L)		1.00E+06	EPIWIN (v3.10)
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		320	ChemFinder
tc	(degC)		-9999	No data

Table E-38. Chemical Parameters for Total Nitrate Nitrogen (14797-55-8)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	0.00E+00	No data
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	0.00E+00	No data
BCF_fish	(mg/kg fish)/(mg/L water)		3.20E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrExveg	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrForage	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrGrain	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrProfruit	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrProveg	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrRoot	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
BrSilage	(mg/kg DW plant / mg/kg soil)		0.00E+00	No data
Chemical properties				
Da	(cm2/s)		1.24E-01	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		2.26	HSDB
Dw	(cm2/s)		1.72E-05	Calculated based on WATER9, U.S. EPA, 2001
MW	(g/mol)		85.01	HSDB
Sol	(mg/L)		9.21E+05	HSDB
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		380	HSDB
tc	(degC)		1047.85	HSDB

Table E-39. Chemical Parameters for Trichlorofluoromethane (75-69-4)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	6.81E-05	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.21E-05	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		1.80E+01	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		1.30E+00	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		2.90E-04	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		2.68E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		6.55E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.494	Merck
Dw	(cm2/s)		1.01E-05	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		9.70E-02	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		1.29E+02	Kollig, 1993
ksed	(1/day)		4.81E-04	Howard et al., 1991
ksoil	(1/day)		1.93E-03	Howard et al., 1991
ksw	(1/day)		1.93E-03	Howard et al., 1991
LogKow	(unitless)		2.53E+00	SCDM
MW	(g/mol)		137.37	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		1.10E+03	SCDM
Temperature correction factors				
AntB	(unitless)		1042.82	Reid et al., 1977
AntC	(unitless)		-309.45	Reid et al., 1977
Pc	(atm)		43.5	Reid et al., 1977
tb	(degC)		23.7	SCDM
tc	(degC)		198.05	Reid et al., 1977

Table E-40. Chemical Parameters for Trichlorophenoxy) propionic acid, 2-(2,4,5- (93-72-1)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.26E-03	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	8.02E-04	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		3.20E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		2.50E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		8.00E+06	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		2.55E+01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.34E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.2085	HSDB
Dw	(cm2/s)		5.92E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		7.83E-11	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		5.50E+01	Kollig, 1993
ksed	(1/day)		4.62E-03	EPIWIN (v3.10)
ksoil	(1/day)		3.30E-02	WIN_PST Online Pesticide Properties Database
ksw	(1/day)		1.85E-02	EPIWIN (v3.10)
LogKow	(unitless)		3.80E+00	SCDM
MW	(g/mol)		269.51	SCDM
pKa	(unitless)		3.4	Kollig, 1993
Sol	(mg/L)		1.40E+02	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		353.28	EPIWIN (v3.10)
tc	(degC)		-9999	No data

Table E-41. Chemical Parameters for Trichlorophenoxyacetic acid, 2,4,5- (93-76-5)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.10E-04	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.59E-04	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		3.20E+00	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		4.70E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		2.20E+04	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		1.07E+01	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.89E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.8	HSDB
Dw	(cm2/s)		7.76E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		8.68E-09	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		2.69E+01	Kollig, 1993
ksed	(1/day)		3.85E-03	Howard et al., 1991
ksoil	(1/day)		3.47E-02	Howard et al., 1991
ksw	(1/day)		3.47E-02	Howard et al., 1991
LogKow	(unitless)		3.31E+00	SCDM
MW	(g/mol)		255.48	SCDM
pKa	(unitless)		3.0	Kollig, 1993
Sol	(mg/L)		2.68E+02	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		348.68	EPIWIN (v3.10)
tc	(degC)		-9999	No data

Table E-42. Chemical Parameters for Trifluralin (1582-09-8)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	4.20E-02	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.66E-02	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		4.20E+03	SRC Measured Data-base (Meylan et al.)
BrExfruit	(mg/kg DW plant / mg/kg soil)		3.30E-02	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		9.80E+02	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		3.77E+02	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		2.21E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		1.36	HSDB
Dw	(cm2/s)		5.57E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		2.64E-05	SCDM
kh	1/day or 1/yr		0.00E+00	Default assumption
Koc	(mL/g)		1.00E+05	Calculated based on equation (7) in Kollig
ksed	(1/day)		1.16E-03	EPIWIN (v3.10)
ksoil	(1/day)		1.16E-02	WIN_PST Online Pesticide Properties Database
ksw	(1/day)		4.62E-03	EPIWIN (v3.10)
LogKow	(unitless)		5.32E+00	SCDM
MW	(g/mol)		335.28	SCDM
pKa	(unitless)		-3.03	SPARC
Sol	(mg/L)		8.11E+00	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		140	SCDM
tc	(degC)		-9999	No data

Table E-43. Chemical Parameters for Xylenes (1330-20-7)

Parameter	Units	Comment	Value	Reference
Biotransfer factors				
BCF_beef	(mg/kg beef)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	2.98E-04	Travis and Arms, 1988
BCF_milk	(mg/kg milk)/(mg/kg DW)	Converted from a biotransfer factor (BTF).	1.87E-04	Travis and Arms, 1988
BCF_fish	(mg/kg fish)/(mg/L water)		5.00E+01	EPIWIN (v3.10)
BrExfruit	(mg/kg DW plant / mg/kg soil)		5.70E-01	Travis and Arms, 1988
Bv	(ug/g DW plant / ug/g air)		2.00E-02	IEM/MPE, U.S. EPA, 1998
RCF	(ug/g - WW plant) / (ug/mL soil water)		8.33E+00	Briggs et al., 1982
Chemical properties				
Da	(cm2/s)		6.87E-02	Calculated based on WATER9, U.S. EPA, 2001
Density	(g/mL)		0.8684	Merck
Dw	(cm2/s)		8.49E-06	Calculated based on WATER9, U.S. EPA, 2001
HLC	atm-m3/mol		6.73E-03	SCDM
kh	1/day or 1/yr		0.00E+00	Kollig, 1993
Koc	(mL/g)		1.20E+03	Kollig, 1993
ksed	(1/day)		1.93E-03	Howard et al., 1991
ksoil	(1/day)		2.48E-02	Howard et al., 1991
ksw	(1/day)		2.48E-02	Howard et al., 1991
LogKow	(unitless)		3.17E+00	SCDM
MW	(g/mol)		106.17	SCDM
pKa	(unitless)		NO DATA	Insufficient data.
Sol	(mg/L)		1.75E+02	SCDM
Temperature correction factors				
AntB	(unitless)		-9999	No data
AntC	(unitless)		-9999	No data
Pc	(atm)		-9999	No data
tb	(degC)		140.6	SCDM
tc	(degC)		-9999	No data

E6.0 References

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Table F-1. Biota Parameters

Parameter	Description	Value	Reference
Beef cattle diet fractions (DF)			
DF_feed_beef	Fraction of feed (unitless)	0.48	U.S. EPA, 2000
DF_grass_beef	Fraction of grass (unitless)	0.48	Used forage as a surrogate for feed (U.S. EPA, 2000).
DF_soil_beef	Fraction of soil (unitless)	0.04	U.S. EPA, 2000
Dairy cattle diet fractions (DF)			
DF_feed_milk	Fraction of feed (unitless)	0.9	U.S. EPA, 2000
DF_grass_milk	Fraction of forage (unitless)	0.08	U.S. EPA, 2000
DF_soil_milk	Fraction of soil (unitless)	0.02	U.S. EPA, 2000
Feedlot factor (FF)			
FF	Feedlot factor (<=1 for beef fat and =1 for milk fat) (unitless)	1	Best professional judgment
Fraction contaminated			
F_feed	Fraction of feed grown on contaminated soil and eaten (unitless)	1	Used silage as a surrogate for feed (U.S. EPA, 1997).
F_grass	Fraction of grasses grown on contaminated soil and eaten (unitless)	1	Used forage as a surrogate for grass (U.S. EPA, 1997).
Crop yield (Yp)			
Yp_exfruit	For exposed fruit (kg DW/m2)	1.17	U.S. EPA, 2000
Yp_exveg	For exposed vegetables (kg DW/m2)	1.17	U.S. EPA, 2000
Yp_feed	For feed (kg DW/m2)	0.63	U.S. EPA, 2000
Yp_forage	For forage (kg DW/m2)	0.15	Use grass as a surrogate for forage (U.S. EPA, 2000).
Yp_grass	For grass (kg DW/m2)	0.15	U.S. EPA, 2000
Yp_silage	For silage (kg DW/m2)	0.9	U.S. EPA, 2000
Empirical correction factors (VG)			
VG_bg	For belowground vegetables (unitless)	0.25	U.S. EPA, 2000
VG_exfruit	For exposed fruit (unitless)	0.01	U.S. EPA, 1997
VG_exveg	For exposed vegetables (unitless)	0.01	U.S. EPA, 1997
VG_feed	For feed (unitless)	0.5	U.S. EPA, 2000
VG_forage	For forage (unitless)	1	U.S. EPA, 1997
VG_grass	For grass (unitless)	1	U.S. EPA, 2000
VG_silage	For silage (unitless)	0.5	U.S. EPA, 1997

Table F-1. Biota Parameters

Parameter	Description	Value	Reference
Interception fractions (Rp)			
Rp_exfruit	For exposed fruit (unitless)	0.48	U.S. EPA, 2000
Rp_exveg	For exposed vegetation (unitless)	0.48	U.S. EPA, 2000
Rp_feed	For feed (unitless)	0.62	U.S. EPA, 2000
Rp_forage	For forage (unitless)	0.35	Used grass as a surrogate (U.S. EPA, 2000).
Rp_grass	For grass (unitless)	0.35	U.S. EPA, 2000
Rp_silage	For silage (unitless)	0.5	U.S. EPA, 2000
Moisture adjustment factors (MAF)			
MAF_bg	For root vegetables (% water)	87.32	U.S. EPA, 1997
MAF_exfruit	For exposed fruits (% water)	85	U.S. EPA, 1997
MAF_exveg	For exposed vegetables (% water)	91.77	U.S. EPA, 1997
MAF_feed	For feed (% water)	69.3	Used silage as a surrogate for feed (Loy, 1993).
MAF_forage	For forage (% water)	91.77	Used MAF for exposed vegetables as a surrogate for forage (U.S. EPA, 1997).
MAF_grain	For grain (% water)	89.59	Used MAF for protected fruit as a surrogate for grain (U.S. EPA, 1997).
MAF_grass	For grass (% water)	91.77	Used MAF for exposed vegetables as a surrogate (U.S. EPA, 1997).
MAF_profruit	For protected fruits (% water)	89.59	U.S. EPA, 1997
MAF_proveg	For protected vegetables (% water)	80.225	U.S. EPA, 1997
MAF_silage	For silage (% water)	69.3	Loy, 1993

Appendix G

Surface Impoundment Model Documentation

Appendix G

Surface Impoundment Model Documentation

For the sewage sludge lagoon assessed in this analysis, the Surface Impoundment (SI) Module from the Multimedia, Multipathway, Multireceptor Risk Assessment (3MRA) was selected to model the movement of sludge chemicals into the surrounding air and groundwater systems. The following documentation details the functionality of the SI Module in the 3MRA modeling system. The specific parameters and values modeled for the sewage sludge screening analysis are presented in Attachment A to this appendix.

G1.0 Module Overview and Summary of Functionality

The SI Module is a source module used in the 3MRA modeling system to model the management of wastewaters in surface impoundments. Surface impoundments are commonly used for the management of wastewaters for flow equalization, storage, treatment (typically biological treatment or neutralization), and solids settling (clarification). The SI Module was developed to simulate both aerated and quiescent surface impoundments. Consequently, the SI Module contains both the well-mixed, steady-state mass balance solution and a time-dependent mass balance solution for simulating plug-flow, batch, or disposal surface impoundments.

Mass transport equations are used to describe volatile contaminant losses from surface impoundments. A surface impoundment may have some degree of solids settling, although solids settling and accumulation is more significant for quiescent units.[1] When significant solid accumulation occurs, the surface impoundment must be cleaned or dredged to remove the accumulated solids. In addition, there is leaching loss from bottom of the surface impoundment.

The SI Module functionality may be summarized as follows:

- Mass balance approach taking into consideration contaminant removal by volatilization, biodegradation, hydrolysis, leaching, and partitioning to solids
- Estimation of volatilization rates for both aerated and quiescent surfaces
- Estimation of infiltration rate and contaminant leachate flux rates
- Estimation of suspended solids removal (settling) efficiency
- Estimation of temperature effects.

[1] Sewage sludge lagoons are modeled as quiescent disposal impoundments.

G2.0 Inputs and Outputs

The SI Module calculates volatile emissions flux from a surface impoundment. The unit has only volatile emissions (no particulates), and the bottom of a surface impoundment is pervious so that contaminant leaching can occur. There is no runoff and overland flow of contaminant. The SI Module is a quasi-steady-state module, and emissions and leaching occur only while the unit operates. The module uses monthly average meteorological data and adjusts the operating temperature in the unit as a function of the ambient temperature and hydraulic residence time so that chemical property information can be calculated as a function of the unit temperature. The program may also generate warning messages (e.g., if the calculated unit temperature is below freezing, a warning is generated).

The output from the SI Module provides input for calculations of air transport of contaminant using an air model and for groundwater transport of contaminant using a groundwater model. The volatile flux is calculated for a number of years specified either as the total number of years of the simulation or the number of years the unit is operated. Groundwater infiltration is assumed to be driven by the hydrostatic pressure head produced by the wastewater in the unit; when the unit ceases operation, it is assumed that no additional contaminant leaches from the source. Annual liquid infiltration rates and contaminant leachate flux rates are both calculated at the base of the unit and are output for use to estimate groundwater concentrations.

Table G-1 summarizes the input and output variables for the SI Module.

Table G-1. Summary of Inputs and Outputs for SI Source Module

Source File	Variable Name	Units	Data Type	Variable Name in Module Code	Description
HD.SSF	CPDirectory		String	m_pathname, pathname	Path for location of chemical properties files
	MetData		String	MetPath	Path for location of meteorological files
SL.SSF	SrcArea	m^2	Real	m_A_wmu, A_wmu, A_tot	Area of the waste management unit
	SiteLatitude	degrees	Real	m_Lat	Latitude of the site
	SiteLongitude	degrees	Real	m_Long	Longitude of the site
	MetSta		String	m_MetSta, MetSta	ID number for meteorological station associated with site
	NyrMax	years	Integer	m_NyrMax	Maximum module simulation time

(continued)

Table G-1. (continued)

Source File	Variable Name	Units	Data Type	Variable Name in Module Code	Description
	SrcPh	pH units	Real	m_pH, pH	Waste pH
	SrcTemp	degrees Celsius	Real	m_T_waste, T_waste	Temperature of the waste
	SrcType		String	m_WMUType, WMUType	Type of waste management unit
	SrcNumLWS		Integer	m_SrcNumLWS, SrcNumLWS	Number of local watersheds
	SrcLWSNumSubArea		Integer	m_SrcLWSNumSubArea[ ]	Number of subareas in the local watershed
	SrcLWSSubAreaIndex	unitless	Integer	m_SrcLWSSubAreaIndex[ ]	Local watershed subarea containing SI
	SrcLWSSubAreaArea	m^2	Real	m_SrcLWSSubAreaArea[ ]	Area of a subarea in the local watershed
	TermFrac	fraction	Real	m_TermFrac	Peak output fraction for simulation termination
	SrcDepth	m	Real	m_SrcDepth	Depth of source
	NumVad		Integer	m_NumVad, NumVad	Number of vadose zones
	N_stot[a]	unitless	Integer	m_N_stot, N_stot	Number of subsurface soil layers (currently hardwired to 1)[a]
	VadSATK	cm/h	Real	m_hydc_s[ ], hydc_s[ ]	Saturated hydraulic conductivity in the subsurface soil layer
	VadThick[a]	m	Real	m_d_s[ ][ ], d_s[ ]	Thickness of the subsurface soil layer[a]
	VadALPHA	1/cm	Real	m_alpha_s[ ], alpha_s[ ]	Alpha soil parameter for subsurface soil
	VadBETA	unitless	Real	m_beta_s[ ], beta_s[ ]	Beta soil parameter for subsurface soil
SI.SSF or AT.SSF	VadSATK	cm/h	Real	m_hydc_liner, hydc_liner	Hydraulic conductivity of the liner
	d_liner	m	Real	m_d_liner, d_liner	Thickness of SI liner (currently hardwired to 0.5 m)

(continued)

Table G-1. (continued)

Source File	Variable Name	Units	Data Type	Variable Name in Module Code	Description
	VadALPHA	1/cm	Real	m_alpha_liner, alpha_liner	Alpha soil parameter for SI liner
	VadBETA	unitless	Real	m_beta_liner, beta_liner	Beta soil parameter for SI liner
	hydc_sed	m/s	Real	m_hydc_sed, hydc_sed	Hydraulic conductivity of the sediment that accumulates in the unit
	bio_yield	g/g	Real	m_bio_yield, bio_yield	Biomass yield in g dry wt biomass/g CBOD
	CBOD	g/cm^3	Real	m_CBOD, CBOD	Carbonaceous biochemical oxygen demand for the chemical
	C_in	mg/L	Real	m_C_in, C_in	Concentration of chemical in hazardous waste
	EconLife	year	Integer	m_EconLife, EconLife	Economic life of the unit
	NumEcon		Integer	m_NumEcon, NumEcon	Number of economic lifetimes that the unit operates
	d_imp	cm	Real	m_d_imp, d_imp	Diameter of the impeller used to aerate the unit
	dmeanTSS	cm	Real	m_m, m	Mean particle of an influent particle
	d_setpt	fraction	Real	m_d_setpt, d_setpt	Fraction full of sediment at which unit is dredged
	d_wmu	m	Real	m_d_wmu, d_wmu, d_tot	Depth of the waste management unit
	F_aer	fraction	Real	m_F_aer, F_aer	Fraction of the unit surface area that is aerated
	focW	mass fraction	Real	m_foc, foc	Fraction of organic carbon in the waste

(continued)

Table G-1. (continued)

Source File	Variable Name	Units	Data Type	Variable Name in Module Code	Description
	fwmu	mass fraction	Real	m_fwmu, fwmu	Fraction of waste that is hazardous
	J	lb O_2/h-hp	Real	m_J, J	O_2 transfer rating of aerator
	kba1	unitless	Real	m_kba1, kba1	Ratio of biologically active solids to the total solids concentration
	k_dec	1/s	Real	m_k_dec, k_dec	Anaerobic digestion/decay constant of the organic sediment
	u_l	g/cm-s	Real	m_mu_H2O, mu_H2O	Viscosity of water
	MWt_H2O	g/mol	Real	m_MWt_H2O, MWt_H2O	Molecular weight of water
	n_imp	unitless	Integer	m_n_imp, n_imp	Number of impellers/aerators
	O2Eff	unitless	Real	m_O2eff, O2eff	O_2 transfer correction factor
	Powr	hp	Real	m_Powr, Powr	Total power to aerators/impellers
	Q_wmu	m^3/s	Real	m_Q_wmu, Q_wmu, Q_in	Total influent flow rate into the unit
	rho_l	g/cm^3	Real	m_rho_H2O, rho_H2O	Density of water
	rho_part	g/cm^3	Real	m_rho_part, rho_part	Density of particles in the influent waste
	TSS_in	g/cm^3	Real	m_TSS_in, TSS_in	Total suspended solids concentration in the influent
	w_imp	rad/s	Real	m_w_imp , w_imp	Rotational speed of impellers
CP.SSF	NumChem		Integer	m_NumChem,	Number of chemical species
	ChemType		String	m_ChemType, ChemType	Type of chemical
	ChemADiff	cm^2/s	Real	m_Da, Da	Diffusivity of chemical in air

(continued)

Table G-1. (continued)

Source File	Variable Name	Units	Data Type	Variable Name in Module Code	Description
	ChemWDiff	cm^2/s	Real	m_Dw, Dw	Diffusivity of chemical in water
	ChemHLC	$(atm\ m^3)$ / mol	Real	m_HLC, HLC	Henry's law constant for the chemical
	ChemKoc	mL/g	Real	m_Koc, Koc	Soil-water partitioning coefficient for the chemical
	ChemAnaBioRate	1/day	Real	m_kbiou, kbs	Biodegradation / decay rate of contaminant in sediment compartment
	ChemAerBioRate[b]	1/day	Real	m_kbioa, kbm	Complex first-order biodegradation rate constant for the chemical[b]
	ChemHydRate	1/day	Real	m_k_hyd, k_hyd	Hydrolysis rate for the chemical
	ChemSol	mg/L	Real	m_Sol, Sol	Chemical solubility
	ChemCASID		String	m_CAS, CAS	Chemical CAS ID number
	ChemName		String	m_ChemName, ChemName	Chemical name
	ChemKd	L/kg	Real	m_Kds, Kds	Solid/water partition coefficient
Met data file	---	°C	Real	m_AvgTemp[ ][ ]	Average monthly temperature
	---	m/s	Real	m_um[y][z]	Monthly average windspeed
	---	m/d	Real	m_AvgPpt[ ][ ]	Average monthly precipitation
	---	m/d	Real	m_E[ ][ ]	Average monthly evaporation
	---		Integer	NyrMet	Number of years of meteorological data
SR.GRF	VENY		Integer	VENumOut	number of years in VE outputs
	VEYR	year	Integer	VEOutYear[ ]	Year associated with VE output

(continued)

Table G-1. (continued)

Source File	Variable Name	Units	Data Type	Variable Name in Module Code	Description
	VE	$g/m^2/d$	Real	E_wmu_t[ ]	Volatile emission rate
	LeachFluxNY		Integer	LeachFluxNumOut[ ]	Number of years in leach flux outputs
	LeachFluxYR	year	Integer	LeachFluxOutYear[ ][ ]	Year associated with leach flux output
	LeachFlux	$g/m^2/d$	Real	L_wmu_t[ ]	Leachate contaminant flux
	NyrMet	year	Integer	nyrs	Number of years in the available met record (set equal to number of year unit operates)
	AnnInfil	m/d	Real	Infil_t[ ]	Annual average leachate infiltration rate
	SrcOvl		Logic	l_SrcOvl	Flag for overland flow presence
	SrcSoil		Logic	l_SrcSoil	Flag for soil presence
	SrcLeachSrc		Logic	l_SrcLeachSrc	Flag for leachate presence when leachate is not met-driven (unit is active)
	SrcLeachMet		Logic	l_SrcLeachMet	Flag for leachate presence when leachate is met-driven
	SrcVE		Logic	l_SrcVE	Flag for volatile emissions presence
	SrcCE		Logic	l_SrcCE	Flag for chemical sorbed to particulates emissions presence
	SrcH2O		Logic	l_SrcH2O	Flag for surface water presence

[a] The module currently assumes there is one native soil layer and that the thickness of the underlying soil layer is assumed to be a minimum of 1 meter thick. If the regional vadose zone thickness is less than $1+d_{wmu}$, then the impoundment is assumed to be built up (via an earthen berm) so that there is 1 meter of soil between the bottom of the surface impoundment and the groundwater.

[b] If normalized biodegradation rate constants are unavailable, normalized biodegradation rates constants are estimated from first-order biodegradation rate constants developed for soil systems by assuming the effective biomass in the soil system is 2.0×10^{-6} Mg/m^3. This value was developed by RTI as an interim estimate until a more rigorously developed value for this parameter is available from EPA.

G3.0 Assumptions and Limitations

The general construct used for the SI Module includes losses due to volatilization from aerated and/or quiescent surfaces, biodegradation, hydrolysis, solids settling/accumulation, and leaching. This general module construct can be useful for a wide variety of surface impoundment applications. Certain applications of surface impoundments, such as chemical precipitation, may not be well modeled with this module construct. However, with judicious selection of the input parameters, the general module construct can provide accurate fate estimates for chemicals on surface impoundments. For example, if the precipitation rate for chemical precipitation is known, the input parameters used for "biomass" growth could be manipulated to simulate the solids generation rate caused by precipitation (rather than biomass growth).

The following assumptions are used in the development of the SI Module solution:

- Three-compartment model: each compartment has a fixed volume for a given monthly solution; volumes readjusted to account for solids accumulation
- Well-mixed and time-dependent solutions
- First-order kinetics for volatilization in liquid compartment
- First-order kinetics for hydrolysis in both liquid and sediment compartment
- First-order kinetics for biodegradation with respect to both contaminant concentration and biomass concentration in liquid compartment
- First-order kinetics for biodegradation in sediment compartment
- Darcy's law for calculating the infiltration rate
- First-order kinetics for solids settling
- Monod kinetics for biomass growth rate with respect to total biological oxygen demand (BOD) loading
- First-order biomass decay rate within the accumulating sediment compartment
- No contaminant in precipitation/rainfall
- Linear contaminant partitioning among adsorbed solids, dissolved phases, and vapor phases.

Because of the simplicity of the biodegradation rate module employed and the use of Henry's law partitioning coefficients, the module is most applicable to dilute aqueous wastes. At higher contaminant concentrations, biodegradation of toxic constituents may be expected to exhibit zero-order or even inhibitory rate kinetics. For waste streams with high contaminant or high total organic concentrations, vapor-phase contaminant partitioning may be better estimated using partial pressure (Raoult's law) rather than Henry's law. Also, because daughter products are not included in the module, any contaminant emissions or leachate generated as a reaction intermediate or end product from either biodegradation or hydrolysis is not included in the module output.

G4.0 Theory and Algorithms

The surface impoundment is divided into three primary compartments: a "liquid" compartment, an "unconsolidated sediment" compartment, and a "consolidated sediment" compartment. Mass balances are performed on these primary compartments at time intervals small enough that the hydraulic retention time in the liquid compartment is not significantly influenced by the solids settling and accumulation. Figure G-1 provides a general schematic of a module construct for a surface impoundment.

In the liquid compartment, there is flow both into and out of the surface impoundment. There is also a leachate flow to the sediment compartment and out the bottom of the surface impoundment. Within the liquid compartment, contaminant loss occurs through volatilization, hydrolysis, biodegradation (presumably aerobic), and particle burial (net sedimentation). The sediment compartments have contaminant losses due to (anaerobic) biodegradation and hydrolysis. Some contaminant mixing between the compartments occurs as a result of contaminant diffusion and particle sedimentation and resuspension.

Solids generation occurs in the liquid compartment as a result of biological growth; solids destruction occurs in the sediment compartment as a result of sludge digestion. Using the well-mixed assumption, the suspended solids concentration within the surface impoundment is assumed to be constant throughout. However, some stratification of sediment is expected across the length and depth of the surface impoundment so that the effective total suspended solids (TSS) concentration is assumed to be a function of the unit's TSS removal efficiency rather than equal to the effluent TSS concentration. The liquid (dissolved)-phase contaminant concentration within the unit, however, is assumed to be equal to the effluent dissolved-phase concentration for the well-mixed model solution.

The primary outputs of the SI Module are the annual average volatilization rate, the annual average surface water concentration, the annual average infiltration rate, and the annual average leachate contaminant flux rate from the surface impoundment.

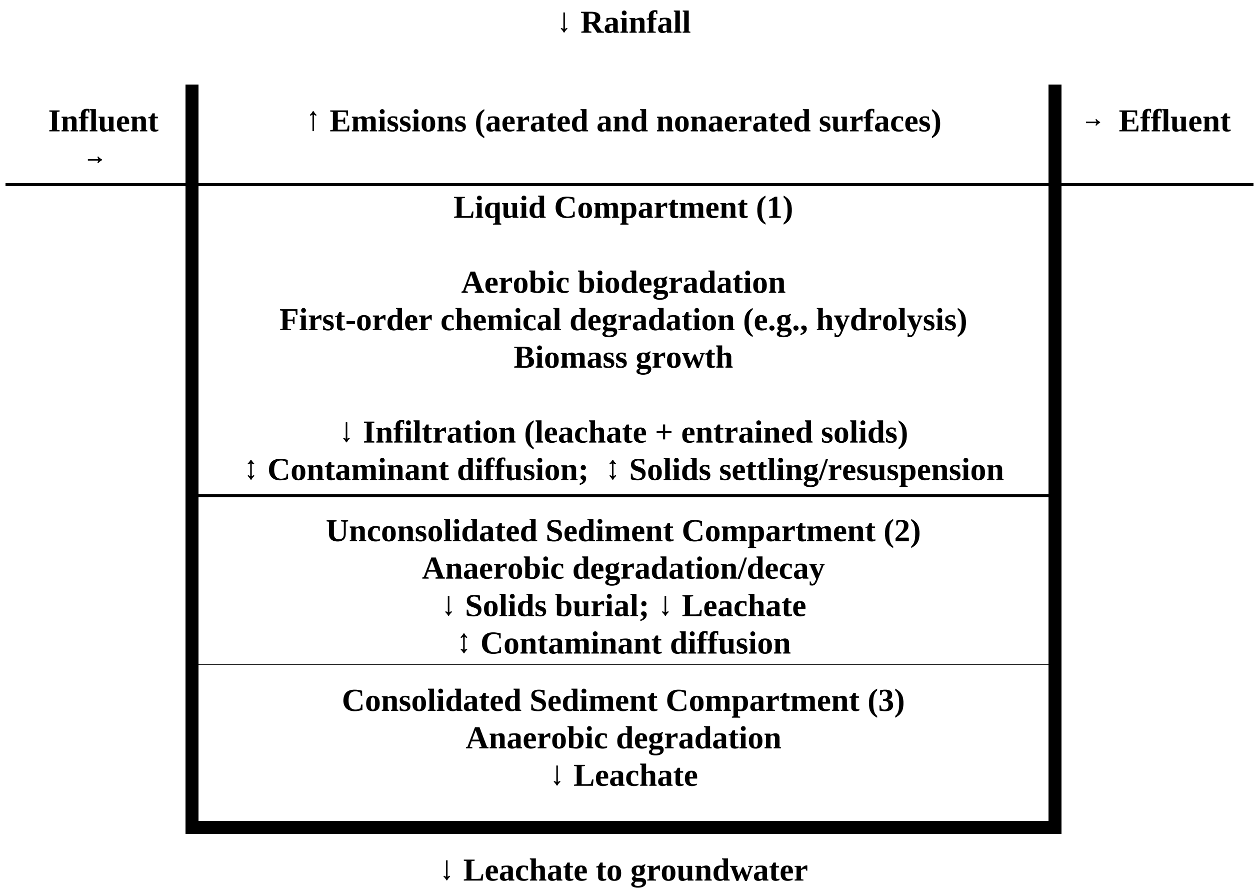

Figure G-1. Schematic of module construct for surface impoundments.

G4.1 Mass Balance Equations and General Solution

G4.1.1 Constituent Mass Balance for Liquid Compartment

In the liquid compartment, contaminant loss occurs through volatilization, hydrolysis, and biodegradation. There is infiltration (denoting liquid flow of both liquid and entrained solids) into the sediment compartment and leachate (filtered liquid flow) out the bottom of the surface impoundment. Within the liquid compartment, contaminant is also transported across the liquid/sediment compartment interface by solids settling and resuspension, contaminant diffusion, and leachate flow. The time-dependent constituent mass balance for the liquid compartment is

$$\begin{aligned} \frac{-\partial(V_1\ C_{tot,1})}{\partial t} = {} & Q_{leach}\ C_{tot,1} + f_{d,1}\ K_{OL}\ A\ C_{tot,1} + V_1\ (k_{bm}\ k_{ba}\ [TSS]_1 + k_{hyd})\ C_{tot,1} \\ & + v_{sed}\ A\ f_{p,1}\ C_{tot,1} - v_{res}\ A\ f_{p,2}\ C_{tot,2} - v_{diff12}\ A\ \theta_{liq,2}\ (f_{d,2}\ C_{tot,2} - f_{d,1}\ C_{tot,1}) \end{aligned} \qquad \text{(G-1)}$$

where

$C_{tot,x}$	=	total contaminant concentration in compartment x (mg/L = g/m^3)
Q_{leach}	=	leachate flow rate from surface impoundment (m^3/sec)
K_{OL}	=	overall volatilization mass transfer coefficient (m/sec)
A	=	total surface area of surface impoundment (m^2)
k_{hyd}	=	hydrolysis rate (1/sec)
V_1	=	volume of liquid compartment in surface impoundment = d_1 A (m^3)
d_1	=	depth of liquid compartment (m)
k_{bm}	=	complex first order biodegradation rate constant (m^3 /Mg-sec)
k_{ba}	=	ratio of biologically active solids to the total solids concentration (i.e., k_{ba} = $[MLVSS]_1/[TSS]_1$)
$[TSS]_1$	=	concentration of total suspended solids in liquid compartment (g/cm^3 = Mg/m^3)
$[MLVSS]_1$	=	concentration of biomass as mixed liquor volatile suspended solids (MLVSS) liquid compartment (g/cm^3 = Mg/m^3) $C_{tot,1}$ = total contaminant concentration in the surface impoundment (mg/L = g/m^3)
ν_{sed}	=	solids settling or sedimentation velocity (m/sec)
ν_{res}	=	solids resuspension velocity (m/sec)
ν_{diff12}	=	mass transfer coefficient between liquid compartment (1) and unconsolidated sediment compartment (2) (m/sec)
$f_{d,x}$	=	ratio of liquid-phase contaminant concentration to total contaminant concentration in compartment x

$$f_{d,x} = \frac{C_{liq,x}}{C_{tot,x}} = \frac{1}{(\theta_{liq,x} + k_{ds}[TSS]_x)} \tag{G-2}$$

$f_{p,x}$	=	particulate-phase contaminant fraction in compartment x

$$f_{p,x} = \frac{C_{sol,x}[TSS]_x}{C_{tot,x}} = \frac{k_{ds}[TSS]_x}{(\theta_{liq,x} + k_{ds}[TSS]_x)} \tag{G-3}$$

$\theta_{liq,x}$ = volumetric liquid fraction of compartment x (m^3/m^3)

$C_{liq,x}$ = liquid-phase contaminant concentration in compartment x (mg/L = g/m^3)

$C_{sol,x}$ = solid-phase contaminant concentration in compartment x (mg/kg = g/Mg)

$[TSS]_x$ = concentration of TSS in compartment x ($g/cm^3 = Mg/m^3$)

k_{ds} = solid-water partition coefficient (m^3/Mg) = $K_{oc} \times f_{oc}$ for organics

K_{oc} = soil-water partitioning (m^3/Mg)

f_{oc} = fraction organic carbon in the waste (mass fraction).

For the time-dependent solution, the influent flow rates are included in the initial conditions. The well-mixed constituent mass balance for the liquid compartment is similar to the time-dependent equation provided in Equation G-1, except the left-hand side of the equation would be

$$Q_{infl} \ C_{tot,infl} - Q_{out} \ C_{tot,out} \tag{G-4}$$

where

Q_{infl} = influent flow rate to the surface impoundment (m^3/sec)

$C_{tot,infl}$ = total contaminant concentration in the surface impoundment influent (mg/L = g/m^3)
= $C_{tot,haz} \times f_{wmu}$

Q_{out} = effluent flow rate from the surface impoundment, (m^3/sec)

$C_{tot,out}$ = total contaminant concentration in surface impoundment effluent (mg/L = g/m^3)

$C_{tot,haz}$ = total contaminant concentration in the characterized hazardous waste (mg/L = g/m^3)

f_{wmu} = fraction of the influent waste that is hazardous (volume fraction).

G4.1.2 Constituent Mass Balance for Unconsolidated Sediment Compartment

Within the sediment compartment, contaminant loss occurs through hydrolysis and biodegradation. Additionally, contaminant is transported across the liquid/sediment compartment interface by solids settling and resuspension and by contaminant diffusion. There is also infiltration flow from the liquid compartment (which includes entrained sediment) and "filtered" leachate out the bottom of the compartment. The time-dependent constituent mass balance for the unconsolidated sediment compartment is

$$\begin{aligned} \frac{-\partial(V_2\ C_{tot,2})}{\partial t} = & \ Q_{leach}\, f_{d,2}\ C_{tot,2} - Q_{leach}\ C_{tot,1} + (k_{bs} + k_{hyd})\ V_2\ C_{tot,2} \\ & + (v_{res} + v_b)\ A\ f_{p,2}\ C_{tot,2} - v_{sed}\ A\ f_{p,1}\ C_{tot,1} \\ & + v_{diff12}\ A\ \theta_{liq,2}\ (f_{d,2}\ C_{tot,2} - f_{d,1}\ C_{tot,1}) \\ & + v_{diff23}\ A\ \theta_{liq,3}\ (f_{d,2}\ C_{tot,2} - f_{d,3}\ C_{tot,3}) \end{aligned} \qquad \text{(G-5)}$$

where

V_2 = volume of unconsolidated sediment compartment (m^3)

k_{bs} = (anaerobic) biodegradation decay rate of contaminant (1/sec)

v_b = solids burial velocity (m/sec)

v_{diff23} = mass transfer coefficient between unconsolidated sediment compartment (2) and consolidated sediment compartment (3) (m/sec).

For the well-mixed-model solution, the left-hand side of Equation G-5 is set to zero.

G4.1.3 Constituent Mass Balance for Consolidated Sediment Compartment

Within the sediment compartment, contaminant loss occurs through hydrolysis and biodegradation. Additionally, contaminant is transported across the liquid/sediment compartment interface by solids settling and resuspension and by contaminant diffusion. There is also "filtered" leachate flow from the unconsolidated sediment compartment and out the bottom of the surface impoundment. The time-dependent constituent mass balance for the consolidated sediment compartment follows:

$$\begin{aligned} \frac{-\partial(V_3\ C_{tot,3})}{\partial t} = & \ Q_{leach}\, f_{d,3}\ C_{tot,3} - Q_{leach}\, f_{d,2}\ C_{tot,2} + (k_{bs} + k_{hyd})\ V_3\ C_{tot,3} \\ & + v_{diff23}\ A\ \theta_{liq,3}\ (f_{d,3}\ C_{tot,3} - f_{d,2}\ C_{tot,2}) \end{aligned} \qquad \text{(G-6)}$$

where

V_3 = volume of consolidated sediment compartment (m^3).

For the well-mixed-model solution, the left-hand side of Equation G-6 is set to zero.

G4.1.4 Time-Dependent Model Solution

The SI Module updates the physical and chemical properties of the contaminant on a monthly basis based on temperature variations. Additionally, a water balance is applied based on monthly rainfall and evaporation rate data and the calculated infiltration rate to estimate an effective average working depth of the impoundment. Thus, for any given time interval for which Equations G-1, G-3 and G-4 are applied, V_1, V_2, V_3, and all other parameters are fixed except the contaminant concentrations in the liquid and sediment compartment and the TSS concentration in the liquid compartment ([TSS_2] and [TSS_3] are fixed for a given surface impoundment). If an effective average TSS concentration in the liquid compartment can be estimated (or if a time interval is selected so that one can be established), then Equations G-1, G-5, and G-6 can be solved directly to calculate $C_{1,\,tot}$, $C_{2,tot}$, and $C_{3,tot}$ as a function of time.

For a given time periods where an effectively constant value for [TSS_1] can be set, Equations G-1, G-5, and G-6 can be written as

$$\frac{\partial C_{tot,1}}{\partial t} = - K_{11}\ C_{tot,1} + K_{12}\ C_{tot,2} \tag{G-7}$$

$$\frac{\partial C_{tot,2}}{\partial t} = K_{21}\ C_{tot,1} - K_{22}\ C_{tot,2} + K_{23}\ C_{tot,3} \tag{G-8}$$

$$\frac{\partial C_{tot,3}}{\partial t} = K_{32}\ C_{tot,2} - K_{33}\ C_{tot,3} \tag{G-9}$$

where

$$K_{11} = \frac{Q_{leach}}{V_1} + f_{d,1}\ a_{v1}\ (K_{OL} + v_{diff12}\ \theta_{liq,2}) + [TSS]_1\ k_{bm}\ k_{ba} + k_{hyd} + v_{sed}\ a_{v1}\ f_{p,1} \tag{G-10}$$

$$K_{12} = v_{res}\ a_{v1}\ f_{p,2} + v_{diff12}\ \theta_{liq,2}\ a_{v1}\ f_{d,2} \tag{G-11}$$

$$K_{21} = \frac{Q_{leach}}{V_2} + v_{sed}\ a_{v2}\ f_{p,1} + v_{diff12}\ \theta_{liq,2}\ a_{v2}\ f_{d,1} \tag{G-12}$$

$$K_{22} = \frac{Q_{leach}\, f_{d,2}}{V_2} + k_{bs} + k_{hyd} + (v_{res} + v_b)\, a_{v2}\, f_{p,2} + f_{d,2}\, (v_{diff12}\, \theta_{liq,2} + v_{diff23}\, \theta_{liq,3})\, a_{v2} \qquad \text{(G-13)}$$

$$K_{23} = v_{diff23}\, \theta_{liq,3}\, a_{v2}\, f_{d,3} \qquad \text{(G-14)}$$

and

$$K_{32} = \frac{Q_{leach}\, f_{d,2}}{V_3} + v_{diff23}\, \theta_{liq,3}\, a_{v3}\, f_{d,2} \qquad \text{(G-15)}$$

where

$$K_{33} = \frac{Q_{leach}\, f_{d,3}}{V_3} + k_{bs} + k_{hyd} + f_{d,3}\, v_{diff23}\, \theta_{liq,3}\, a_{v3} \qquad \text{(G-16)}$$

a_{v1} = surface area to volume ratio for liquid compartment, $a_{vx} = A/V_x$ (m^{-1})

a_{v2} = surface area to volume ratio for unconsolidated sediment compartment (m^{-1}).

a_{v3} = surface area to volume ratio for consolidated sediment compartment (m^{-1}).

The key to the solution is that K_{11}, K_{12}, K_{21}, K_{22}, K_{23}, K_{32}, and K_{33} are constants for a given time period, provided the time period is small enough so that the liquid compartment TSS concentration remains relatively constant. Equations G-7 through G-8 can be solved simultaneously using Laplace transforms. The time-dependent total contaminant concentrations for the three compartments can be written as

$$C_{tot,1}(t) = X_{11}\, e^{r_1 t} + X_{12}\, e^{r_2 t} + X_{13}\, e^{r_3 t} \qquad \text{(G-17)}$$

$$C_{tot,2}(t) = X_{21}\, e^{r_1 t} + X_{22}\, e^{r_2 t} + X_{23}\, e^{r_3 t} \qquad \text{(G-18)}$$

$$C_{tot,3}(t) = X_{31}\, e^{r_1 t} + X_{32}\, e^{r_2 t} + X_{33}\, e^{r_3 t} \qquad \text{(G-19)}$$

where r_1, r_2, and r_3 are the roots of the matrix:

$$\begin{vmatrix} s+k_{11} & -k_{12} & 0 \\ -k_{21} & s+k_{22} & -k_{23} \\ 0 & -k_{32} & s+k_{33} \end{vmatrix} \qquad \text{(G-20)}$$

The matrix results in a cubic equation of the form:

$$0 = s^3 + b\,s^2 + c\,s + d \qquad \text{(G-21)}$$

where

s = the Laplace transform variable
b = $k_{11} + k_{22} + k_{33}$
c = $k_{11}k_{22} + k_{11}k_{33} + k_{22}k_{33} - k_{32}k_{23} - k_{21}k_{12}$
d = $k_{11}k_{22}k_{33} - k_{11}k_{32}k_{23} - k_{21}k_{12}k_{33}$

Assuming that there are three unequal real roots to Equation G-21, the roots can be found as follows:

$$r_i = \mp 2\sqrt{-p/3}\,\cos[\phi/3 + 120(i-1)] - b/3 \qquad \text{(G-22)}$$

where

p = $(3c - b^2)/3$

$\phi = \cos^{-1}\sqrt{\dfrac{q^2/4}{-p^3/27}}$

q = $(27d - 9bc + 2b^3)/27$

There are three unequal real roots so long as $(p/3)^3 + (q/2)^2 < 0$.

The X_{ij} parameters are found by solving the following series of equations:

$$\frac{\begin{vmatrix} C_{1,t=0} & -k_{12} & 0 \\ C_{2,t=0} & s+k_{22} & -k_{23} \\ C_{3,t=0} & -k_{32} & s+k_{33} \end{vmatrix}}{(s-r_1)(s-r_2)(s-r_3)} = \frac{X_{11}}{(s-r_1)} + \frac{X_{12}}{(s-r_2)} + \frac{X_{13}}{(s-r_3)} \tag{G-23}$$

$$\frac{\begin{vmatrix} s+k_{11} & C_{1,t=0} & 0 \\ -k_{21} & C_{2,t=0} & -k_{23} \\ 0 & C_{3,t=0} & s+k_{33} \end{vmatrix}}{(s-r_1)(s-r_2)(s-r_3)} = \frac{X_{21}}{(s-r_1)} + \frac{X_{22}}{(s-r_2)} + \frac{X_{23}}{(s-r_3)} \tag{G-24}$$

$$\frac{\begin{vmatrix} s+k_{11} & -k_{12} & C_{1,t=0} \\ -k_{21} & s+k_{22} & C_{2,t=0} \\ 0 & -k_{32} & C_{3,t=0} \end{vmatrix}}{(s-r_1)(s-r_2)(s-r_3)} = \frac{X_{31}}{(s-r_1)} + \frac{X_{32}}{(s-r_2)} + \frac{X_{33}}{(s-r_3)} \tag{G-25}$$

These equations can be solved by multiplying both the right-hand side and left-hand side of these equations by $(s-r_1)(s-r_2)(s-r_3)$, and then sequentially setting the Laplace transform variable to $s = r_1$ (to solve for X_{i1}); $s = r_2$ (to solve for X_{i2}); and $s = r_3$ (to solve for X_{i3}). Thus, the X_{ij} terms are

$$X_{11} = \frac{[(r_1 + k_{22})(r_1 + k_{33}) - k_{32}k_{23}]C_{1,t=0} + k_{12}(r_1 + k_{33})C_{2,t=0} + k_{12}k_{23}C_{3,t=0}}{(r_1 - r_2)(r_1 - r_3)} \tag{G-26}$$

$$X_{12} = \frac{[(r_2 + k_{22})(r_2 + k_{33}) - k_{32}k_{23}]C_{1,t=0} + k_{12}(r_2 + k_{33})C_{2,t=0} + k_{12}k_{23}C_{3,t=0}}{(r_2 - r_1)(r_2 - r_3)} \tag{G-27}$$

$$X_{13} = \frac{[(r_3 + k_{22})(r_3 + k_{33}) - k_{32}k_{23}]C_{1,t=0} + k_{12}(r_3 + k_{33})C_{2,t=0} + k_{12}k_{23}C_{3,t=0}}{(r_3 - r_1)(r_3 - r_2)} \tag{G-28}$$

$$X_{21} = \frac{k_{21}(r_1 + k_{33})\ C_{1,t=0} + (r_1 + k_{11})(r_1 + k_{33})\ C_{2,t=0} + k_{23}(r_1 + k_{11})\ C_{3,t=0}}{(r_1 - r_2)(r_1 - r_3)} \tag{G-29}$$

$$X_{22} = \frac{k_{21}(r_2 + k_{33})\ C_{1,t=0} + (r_2 + k_{11})(r_2 + k_{33})\ C_{2,t=0} + k_{23}(r_2 + k_{11})\ C_{3,t=0}}{(r_2 - r_1)(r_2 - r_3)} \tag{G-30}$$

$$X_{23} = \frac{k_{21}(r_3 + k_{33})\ C_{1,t=0} + (r_3 + k_{11})(r_3 + k_{33})\ C_{2,t=0} + k_{23}(r_3 + k_{11})\ C_{3,t=0}}{(r_3 - r_2)(r_3 - r_2)} \qquad \text{(G-31)}$$

where

$C_{1,t=0}$ = liquid compartment total concentration at start of time step (g/m^3)

$$X_{31} = \frac{k_{21}k_{32}C_{1,t=0} + (r_1 + k_{11})k_{32}C_{2,t=0} + [(r_1 + k_{11})(r_1 + k_{22}) - k_{21}k_{12}]C_{3,t=0}}{(r_1 - r_2)(r_1 - r_3)} \qquad \text{(G-32)}$$

$$X_{32} = \frac{k_{21}k_{32}C_{1,t=0} + (r_2 + k_{11})k_{32}C_{2,t=0} + [(r_2 + k_{11})(r_2 + k_{22}) - k_{21}k_{12}]C_{3,t=0}}{(r_2 - r_1)(r_2 - r_3)} \qquad \text{(G-33)}$$

$$X_{33} = \frac{k_{21}k_{32}C_{1,t=0} + (r_3 + k_{11})k_{32}C_{2,t=0} + [(r_3 + k_{11})(r_3 + k_{22}) - k_{21}k_{12}]C_{3,t=0}}{(r_3 - r_1)(r_3 - r_2)} \qquad \text{(G-34)}$$

$C_{2,t=0}$ = unconsolidated sediment compartment total concentration at start of time step (g/m^3).

$C_{3,t=0}$ = consolidated sediment compartment total concentration at start of time step (g/m^3).

The average concentration over an integration period for any compartment, i, is

$$C_{ave,i} = \frac{1}{t_{step}} \left[\frac{X_{i1}}{r_1}\ e^{r_1 t_{step}} + \frac{X_{i2}}{r_2}\ e^{r_2 t_{step}} + \frac{X_{i3}}{r_3}\ e^{r_3 t_{step}} - \frac{X_{i1}}{r_1} - \frac{X_{i2}}{r_2} - \frac{X_{i3}}{r_3} \right] \qquad \text{(G-35)}$$

where

t_{step} = time step for model calculation (sec).

The average volatilization or leachate flux rate can be calculated for a given time interval as follows:

$$J_{vol,ave} = K_{OL}\ f_{d,1}\ C_{ave,1} \qquad \text{(G-36)}$$

$$J_{leach,ave} = I\, f_{d,3}\; C_{ave,3} \tag{G-37}$$

where

$J_{vol,ave}$ = average contaminant volatilization flux rate (g/m^2-sec)

$J_{leach,ave}$ = average contaminant leachate flux rate (g/m^2-sec)

I = infiltration rate for given time step = Q_{leach} / A (m/sec).

G4.1.5 Well-Mixed Model Solution

The well-mixed model governing equations are similar to the time-dependent governing equations, except steady-state operation is assumed. The simplified governing equations analogous to Equations G-7 and G-8 of the time-dependent solution are

$$C_{tot,infl}\; Q_{infl} = -\; K_{11}\; C_{tot,1} + K_{12}\; C_{tot,2} \tag{G-38}$$

where

$$0 = K_{21}\; C_{tot,1} - K_{22}\; C_{tot,2} + K_{23}\; C_{tot,3} \tag{G-39}$$

$$0 = K_{32}\; C_{tot,2} - K_{33}\; C_{tot,3} \tag{G-40}$$

$$\begin{aligned} K_{11} = {} & Q_{out}\,\frac{f_{d,1}}{f_{d,out}} + Q_{leach} + f_{d,1}(K_{OL}\; A + v_{diff12}\; A\; \theta_{liq,2}) \\ & + ([TSS]_1\; k_{bm}\; k_{ba} + k_{hyd})\; V_1 + v_{sed}\; A\; f_{p,1} \end{aligned} \tag{G-41}$$

$$K_{12} = v_{res}\; A\; f_{p,2} + v_{diff12}\; A\; \theta_{liq,2}\; f_{d,2} \tag{G-42}$$

$$K_{21} = Q_{leach} + v_{sed}\; A\; f_{p,1} + v_{diff12}\; A\; \theta_{liq,2}\; f_{d,1} \tag{G-43}$$

$$\begin{aligned} K_{22} = {} & [Q_{leach} + (v_{diff12}\; \theta_{liq,2} + v_{diff23}\; \theta_{liq,3})\; A]\; f_{d,2} \\ & + (k_{bs} + k_{hyd})V_2 + (v_{res} + v_b)A\; f_{p,2} \end{aligned} \tag*{G-44)}$$

$$K_{23} = v_{diff23} \, A \, \theta_{liq,3} \, f_{d,3} \tag{G-45}$$

$$K_{32} = (Q_{leach} + v_{diff23} \, A \, \theta_{liq,3}) \, f_{d,2} \tag{G-46}$$

and

$$K_{33} = (Q_{leach} + v_{diff23} \, A \, \theta_{liq,3}) \, f_{d,3} + (k_{bs} + k_{hyd}) V_3 \tag{G-47}$$

These K_{xy} definitions are essentially the same as in the time-dependent solution, except that the terms were not divided by the compartment volumes. Because the K_{xy} values are constants for a given month's solution, Equations G-38 through G-40 are simply three algebraic equations with three unknowns. Using a matrix solution, the steady-state total contaminant concentrations for the three compartments can be written as

$$C_{tot,1} = \frac{Q_{infl} \, C_{infl} \, (K_{22} \, K_{33} - K_{32} \, K_{23})}{K_{11} \, (K_{22} \, K_{33} - K_{32} \, K_{23}) - K_{21} \, K_{12} \, K_{33}} \tag{G-48}$$

$$C_{tot,2} = \frac{Q_{infl} \, C_{infl} \, K_{21} \, K_{33}}{K_{11} \, (K_{22} \, K_{33} - K_{32} \, K_{23}) - K_{21} \, K_{12} \, K_{33}} \tag{G-49}$$

$$C_{tot,3} = \frac{Q_{infl} \, C_{infl} \, K_{21} \, K_{32}}{K_{11} \, (K_{22} \, K_{33} - K_{32} \, K_{23}) - K_{21} \, K_{12} \, K_{33}} \tag{G-50}$$

The volatilization or leachate flux rate can be calculated for any given month as follows:

$$J_{vol} = K_{OL} \, f_{d,1} \, C_{tot,1} \tag{G-51}$$

$$J_{leach} = \frac{Q_{leach} \, f_{d,3} \, C_{tot,3}}{A} \tag{G-52}$$

where

J_{vol} = contaminant volatilization flux rate (g/m^2-sec)

J_{leach} = contaminant leachate flux rate (g/m^2-sec).

G4.1.6 Calculation of the Time-Dependent TSS Concentration in the Liquid Compartment

The solids mass balance for the liquid compartment is

$$\frac{-\partial(V_1[TSS]_1)}{\partial t} = r_{BOD}\lambda\ k_{ba}[TSS]_1 V_1 + v_{res}[TSS]_2 A - Q_{leach}[TSS]_1 - v_{sed}A[TSS]_1 \quad \text{(G-53)}$$

where

r_{BOD} = normalized biodegradation rate of BOD_5 (g-BOD/g-biomass/sec)

λ = biomass yield (g-biomass (dry basis)/g-BOD consumed).

The normalized BOD_5 biodegradation rate is estimated using a Monod equation as follows:

$$r_{BOD} = \frac{K_{bmax}\ C_{BOD}}{(K_{b2} + C_{BOD})} \quad \text{(G-54)}$$

where

$C_{BOD,infl}$ = BOD_5 concentration in the influent to within the surface impoundment (g/cm^3 or Mg/m^3)

$C_{BOD,1}$ = BOD_5 concentration in the liquid compartment (g/cm^3 or Mg/m^3)

K_{bmax} = maximum BOD_5 biodegradation rate (g-BOD/g-biomass/sec or Mg/Mg/sec)
= $6.94\times10^{-6} \times T_{corr}$ (the value of 6.94×10^{-6} comes from the maximum rate of 0.6 g-BOD/g-biomass/hr ÷ 86,400 sec/hr)

K_{b2} = half-saturation constant = 0.00005 (g/cm^3 or Mg/m^3)

T_{corr} = temperature correction factor for the biodegradation rate constants (see Section G4.5.5)

The maximum BOD_5 degradation rate constant is estimated based on typical design values for F/M (food-to-biomass ratio) for activated sludge systems. Eckenfelder et al. (circa 1984) reported design values for F/M for activated sludge systems ranging from 0.2 to 0.6 g BOD/g MLVSS-d), but F/M ratios of 0.2 to 1.2 g BOD/g MLVSS-d have been observed in practice (Hermann and Jeris, 1992). From these data, a value of 0.6 g BOD/g MLVSS-d was selected to estimate the BOD removal capacity of the unit.

Half-saturation rate constants reported in the literature for various degradable compounds range from 1 to 300 mg/L. Tabak et al. (1989) reported rate constants for a number of chemicals. The half-saturation rate constants ranged from 11 to 88 mg/L for selected benzene compounds; from 6 to 44 mg/L for selected phenolic compounds; from 11 to 42 for selected ester compounds; and from 10 to 27 for selected ketone compounds. Gaudy and Kincannon (1977) reported a half-saturation constant of 105 mg/L from bench-scale pilot plant treatability studies. Goldsmith and Balderson (1989) reported a half-saturation constant of 81 mg/L (as COD) for model diesel fuel degradation. Rozich et al. (1985) reported measured half-saturation constants for phenol ranging from 1.3 to 266 mg/L with a mean value of 75 mg/L. From these data, a value of 50 mg/L (0.00005 g/cm^3) was selected as a typical value for the half-saturation constant (K_{b2}).

The unconsolidated sediment compartment TSS concentration is fixed for a given unit. Furthermore, r_{BOD} is assumed to be constant (either because zero order kinetic region applies or a small enough time interval is selected that the BOD_5 concentration cannot change significantly). Based on these assumptions, Equation G-53 can be written as follows:

$$\frac{-\partial[TSS]_1}{\partial t} = aa\ [TSS]_1 + bb \qquad \text{(G-55)}$$

where

$$aa = r_{BOD}\ \lambda\ k_{ba} - \frac{Q_{leach}}{V_1} - v_{sed}\ a_{v1} \qquad \text{(G-56)}$$

$$bb = v_{res}\ a_{v1}\ [TSS_2] \qquad \text{(G-57)}$$

The time-dependent TSS concentration in the liquid compartment can be written as

$$[TSS_1](t) = k_8 + k_9 \; e^{aa \times t} \tag{G-58}$$

where

$$k_8 = -\frac{bb}{aa} \tag{G-59}$$

$$k_9 = \frac{bb + aa \; [TSS_1]_{t=0}}{aa} \tag{G-60}$$

Thus, the average TSS concentration for a given time step is

$$[TSS]_{ave} = k_8 + \frac{k_9}{aa \times t_{step}} \left(e^{aa \times t_{step}} - 1\right) \tag{G-61}$$

where

$[TSS]_{ave}$ = average concentration of TSS in liquid compartment over a given time step ($g/cm^3 = Mg/m^3$).

The number of time steps used over the integration period in the overall time-dependent solution is dependent on how quickly the TSS and BOD_5 concentrations vary. An initial time step is selected based on the initial concentrations of TSS and BOD_5. This initial time step is selected so that BOD_5 concentrations are effectively constant. Then, the TSS concentration is calculated at the end of the initially selected time step is compared to the starting TSS concentration. If the TSS concentration over the time step changes by more than a factor of 5, the number of time steps is increased until the starting and ending TSS concentrations differ by less than a factor of 5. In this manner, an effective average TSS concentration can be determined for a given time step and used in the constituent mass balance solution equations.

G4.1.7 Calculation of the Effective TSS Concentration in the Well-Mixed Liquid Compartment

The TSS mass removal efficiency of the unit is predicted by the module based on the influent TSS concentration, the size and density of the influent TSS particles, and the “upflow” velocity in the liquid compartment (the module estimation methodology is described in Section G4.4). This TSS removal efficiency is considered to apply to both the influent TSS and the TSS generated within the unit through the decomposition of organic constituents so that the TSS mass removal efficiency can be written as follows:

$$\epsilon_{TSS} = 1 - \frac{Q_{out}\ [TSS]_{out}}{Q_{infl}\ ([TSS]_{infl} + \lambda\ \epsilon_{BOD}\ C_{BOD,infl})} \tag{G-62}$$

where

ϵ_{TSS}	=	total suspended solids mass removal efficiency in surface impoundment (unitless)
λ	=	biomass yield (g-biomass (dry basis)/g-BOD)
ϵ_{BOD}	=	biological oxygen demand removal efficiency of surface impoundment (unitless)
$C_{BOD,infl}$	=	biological oxygen demand of influent (Mg/m^3)
$[TSS]_{infl}$	=	concentration of total suspended solids in the influent ($g/cm^3 = Mg/m^3$).
$[TSS]_{out}$	=	concentration of total suspended solids in the effluent ($g/cm^3 = Mg/m^3$).

Equation G-48 can be written to solve for the effluent TSS as follows:

$$[TSS]_{out} = \frac{Q_{infl}}{Q_{out}}\ (1 - \epsilon_{TSS})\ ([TSS]_{infl} + \lambda\ \epsilon_{BOD}\ C_{BOD,infl}) \tag{G-63}$$

To account for anticipated gradients of TSS concentration with surface impoundment length and depth, the effective TSS concentration within the surface impoundment is estimated to be the log-mean average between the influent and effluent TSS concentrations (based on first-order sedimentation). Given the influent and effluent TSS concentrations, the effective (mean) TSS concentration in the liquid compartment is

$$[TSS]_1 = \exp\left[\frac{(\ln[TSS]_{infl}) + \ln([TSS]_{out})}{2}\right] \tag{G-64}$$

However, the BOD_5 removal efficiency is dependent on the effective TSS concentration. Consequently, the effective TSS concentration is calculated using an iterative process of calculations between estimating the BOD_5 removal efficiency and the effective TSS concentration. Because the BOD_5 degradation rate is used primarily to determine the bioproduction rate of TSS within the impoundment, decreases in BOD_5 concentrations due to dilution with precipitation are neglected. Thus, for the purposes of the BOD_5 mass balance, the influent flow rate is assumed to be equal to the effluent flow rate plus the leachate flow rate. The same biodegradation rate model used for the time-dependent solution is used for overall BOD_5 removal rate. Consequently, the steady-state BOD_5 mass balance can be written as follows:

$$Q_{infl}\ C_{BOD,infl} = \frac{K_{bmax}\ k_{ba}\ [TSS]_1\ V_1\ C_{BOD,1}}{K_{b2} + C_{BOD,1}} + Q_{infl}\ C_{BOD,1} \tag{G-65}$$

Equation G-51 yields a quadratic equation whose solution is

$$C_{BOD,1} = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \tag{G-66}$$

where

a = Q_{infl}

b = $(K_{bmax}\ T_{corr})\ k_{ba}\ [TSS]_1\ V_1 + Q_{infl}\ (K_{b2} - C_{BOD,infl})$

c = $-Q_{infl}\ C_{BOD,infl}\ K_{b2}$

The efficiency of BOD_5 removal is then calculated as follows:

$$\varepsilon_{BOD} = 1 - \left(\frac{C_{BOD,1}}{C_{BOD,infl}} \right) \tag{G-67}$$

where

ϵ_{BOD} = the BOD_5 removal efficiency.

An iterative process is used to estimate effective TSS concentration and the BOD_5 removal efficiency for the first month's simulation. For all subsequent months, the effective TSS concentration within the liquid compartment from the previous month is used in Equation G-65 to calculate the BOD_5 removal efficiency, and that value is used to calculate the effective TSS concentration for the current month's simulation.

G4.2 Mass Transfer Rate Equations

The overall mass transfer coefficient that determines the rate of volatilization is determined based on a two-resistance module: a liquid-phase mass transfer resistance and a gas-phase mass transfer resistance. The liquid- and gas-phase mass transfer resistances are very different for turbulent surfaces compared to quiescent (laminar flow) surfaces. Therefore, the overall mass transfer coefficient is a composite of the overall mass transfer coefficient for the turbulent surface area and the overall mass transfer coefficient for the quiescent surface area based on an area-weighted average as follows:

$$K_{OL} = \frac{K_{OL,t}\ A_t + K_{OL,q}\ A_q}{A} \tag{G-68}$$

where

K_{OL} = overall mass transfer coefficient for the surface impoundment (m/s)
$K_{OL,t}$ = overall mass transfer coefficient for turbulent surface areas (m/s)
A_t = turbulent surface area = f_{aer} A (m^2)
f_{aer} = fraction of total surface area affected by aeration
$K_{OL,q}$ = overall mass transfer coefficient for quiescent surface areas (m/s)
A_q = quiescent surface area = (1-f_{aer}) A, m^2 (Note: $A_t + A_q$ must equal A).

The overall mass transfer coefficient for turbulent surface areas based on the two-resistance module is

$$K_{OL,t} = \left(\frac{1}{k_{l,t}} + \frac{1}{H' \ k_{g,t}} \right)^{-1} \tag{G-69}$$

where

$k_{l,t}$ = liquid-phase mass transfer coefficient for turbulent surface areas (m/s)
H' = dimensionless Henry's law constant = H/RT_H
H = Henry's law constant (atm-m^3/mol)
R = ideal gas law constant = 0.00008205 (atm-m^3/mol-K)
T_H = temperature at which Henry's law constant was evaluated = 298 K
$k_{g,t}$ = gas-phase mass transfer coefficient for turbulent surface areas (m/s).

Similarly, the overall mass transfer coefficient for quiescent surface areas is

$$K_{OL,q} = \left(\frac{1}{k_{l,q}} + \frac{1}{H' \ k_{g,q}} \right)^{-1} \tag{G-70}$$

where

$k_{l,q}$ = liquid-phase mass transfer coefficient for quiescent surface areas (m/s)
$k_{g,q}$ = gas-phase mass transfer coefficient for quiescent surface areas (m/s).

The mass transfer correlations used in this module to estimate the individual mass transfer coefficients are the same as those used in the WATER8 and CHEMDAT8 emission modules developed by EPA. The documentation of these mass transfer correlations can be accessed from EPA's Internet site (http://www.epa.gov/ttn/chief/software.html; select "Water8 and Chemdat8"). Only the basic equations are provided here. For a more detailed discussion of these mass transfer correlations, the reader is referred to Chapter 5 of the CHEMDAT8 Module documentation (U.S. EPA, 1994).

G4.2.1 Liquid-Phase Mass Transfer Coefficient for Turbulent Surfaces

The liquid-phase turbulent surface mass transfer coefficient is calculated as follows:

$$k_{l,t} = \left(\frac{8.22 \times 10^{-3} \times J \times P_{tot} \times 1.024^{(T-20)} \times O_{cf} \times MW_l}{10.76 \times A_t \times \rho_l} \right) \left(\frac{D_{i,l}}{D_{O2,l}} \right)^{0.5} \qquad \text{(G-71)}$$

where

J	=	oxygen transfer factor (lb/h/hp)
P_{tot}	=	total power to the impellers (hp)
T	=	liquid temperature in surface impoundment (°C)
O_{cf}	=	oxygen correction factor
MW_l	=	molecular weight of liquid (water) (g/mol)
ρ_l	=	density of liquid (water) ($g/cm^3 = Mg/m^3$)
$D_{i,l}$	=	diffusivity in liquid (water) (cm^2/s)
$D_{O2,l}$	=	diffusivity of oxygen in liquid (water) (cm^2/s).

G4.2.2 Gas-Phase Mass Transfer Coefficient for Turbulent Surfaces

The gas-phase turbulent surface mass transfer coefficient is calculated as follows:

$$k_{g,t} = 1.35 \times 10^{-7} \times Re_g^{1.42} \times p^{0.4} \times Sc_g^{0.5} \times Fr^{-0.21} \times D_{i,a} \times MW_a \times d_{imp}^{-1} \qquad \text{(G-72)}$$

where

Re_g	=	gas-phase Reynolds number = $(d_{imp}^2\ w\ \rho_g)/\mu_g$
ρ_g	=	density of gas (air) (g/cm^3)
μ_g	=	viscosity of gas (air) (g/cm-s)
p	=	power number = $0.85\ (550\ P_{tot}/N_{aer})\ g_{c,2}\ /\ [(62.428\rho_l)w^3\ (d_{imp}/30.48)^5]$
$g_{c,2}$	=	gravitational constant = 32.17 $lb_m\text{-}ft/s^2\text{-}lb_f = 0.03283\ g_c$
N_{aer}	=	number of aerators
w	=	rotational speed (rad/s)
Sc_g	=	gas-phase Schmidt number = $\mu_g/(\rho_g\ D_{i,a})$
Fr	=	Froud number = $[w^2\ (d_{imp}/30.48)]/\ g_{c,2}$
$D_{i,a}$	=	diffusivity of constituent in air (cm^2/s)
MW_a	=	molecular weight of air (g/mol)
d_{imp}	=	impeller diameter (cm)
g_c	=	gravitational constant = 980 cm/s^2.

G4.2.3 Liquid-Phase Mass Transfer Coefficient for Quiescent Surfaces

The appropriate correlation to use to estimate the liquid-phase mass transfer coefficient is dependent on the windspeed and the fetch-to-depth ratio of the impoundment. The fetch is the linear distance across the surface impoundment, and it is calculated from the surface impoundment's surface area assuming a circular shape for the surface impoundment. That is,

$$F = \left(\frac{4\ A}{\pi} \right)^{0.5} \qquad \text{(G-73)}$$

where

F = fetch of the surface impoundment (m)

For windspeeds less than 3.25 m/s, the following correlation is used regardless of the fetch-to-depth ratio (F/d_{liq}):

$$k_{l,q} = 2.78 \times 10^{-6} \left(\frac{D_{i,l}}{D_{ether}} \right)^{\frac{2}{3}} \qquad \text{(G-74)}$$

where

$k_{l,q}$ = liquid-phase quiescent surface mass transfer coefficient (m/s)
$D_{i,l}$ = diffusivity of constituent in liquid (water) (cm^2/s)
D_{ether} = diffusivity of ether in water = 8.5×10^{-6} cm^2/s.

For windspeeds greater than or equal to 3.25 m/s, the appropriate correlation is dependent on the fetch-to-depth ratio as follows:

$$For \quad \frac{F}{d_{liq}} < 14 \quad k_{l,q} = 1.0 \times 10^{-6} + (a \times 10^{-4})\ (U^*)^b\ Sc_{liq}^{-0.5} \qquad \text{(G-75)}$$

where

a = equation constant, a = 34.1 for $U^* > 0.3$ m/s; a = 144 for $U^* < 0.3$ m/s
U^* = friction velocity, m/s = $0.01U\ (6.1 + 0.63U)^{0.5}$
b = equation constant, b = 1 for $U^* > 0.3$ m/s; b = 2.2 for $U^* < 0.3$ m/s
Sc_{liq} = liquid-phase Schmidt number = $\mu_l/(\rho_l\ D_{i,l})$
μ_l = viscosity of water (g/cm-s)
ρ_l = density of water (g/cm^3)

$$For \quad 14 \le \frac{F}{d_{liq}} \le 51.2,$$

$$k_{l,q} = \left[2.605 \times 10^{-9}\left(\frac{F}{d_{liq}}\right) + 1.277 \times 10^{-7}\right] U^2 \left(\frac{D_{i,l}}{D_{ether}}\right)^{\frac{2}{3}} \qquad \text{(G-76)}$$

$$For \quad \frac{F}{d_{liq}} > 51.2, \quad k_{l,q} = 2.611 \times 10^{-7}\ U^2 \left(\frac{D_{i,l}}{D_{ether}}\right)^{\frac{2}{3}} \qquad \text{(G-77)}$$

G4.2.4 Gas-Phase Mass Transfer Coefficient for Quiescent Surfaces

The gas-phase mass transfer coefficient for quiescent surface areas is estimated as follows:

$$k_{g,q} = (4.82 \times 10^{-3})\ U^{0.78}\ Sc_g^{-0.67}\ F^{-0.11} \qquad \text{(G-78)}$$

G4.2.5 Estimating the Effective Diffusion Velocity

The effective diffusion velocity between the liquid and the unconsolidated sediment compartments is estimated based on the liquid-phase mass transfer coefficient for quiescent surfaces as calculated in Section G4.2.3 and the porosity of the sediment compartment using the following two-resistance model:

$$v_{diff} = \left(\frac{1}{k_{l,q}} + \frac{1}{k_{eff,2}}\right)^{-1} \qquad \text{(G-79)}$$

where

$k_{l,q}$ = liquid-phase mass transfer coefficient for quiescent surface areas as calculated in Section G4.2.3 (m/s)

$k_{eff,2}$ = effective liquid mass transfer coefficient in sediment compartment (m/s).

To determine the effective liquid mass transfer coefficient in the sediment compartment, the effective liquid diffusion rate is first calculated from the porosity of the sediment layer using a Millington-Quirk (Millington and Quirk, 1961) tortuosity module as follows:

$$D_{eff,2} = \theta_{liq,2}^{\frac{4}{3}} \times D_{i,l} \qquad \text{(G-80)}$$

where

$\theta_{liq,2}$ = volumetric porosity (assumed to be liquid filled) of sediment compartment = $1 - [TSS]_2 / \rho_{TSS}$.

Because the liquid-phase quiescent mass transfer coefficient is primarily a function of the liquid diffusivity raised to the two-thirds power, the effective liquid mass transfer coefficient for the sediment layer is estimated from the liquid compartment as follows:

$$k_{eff,2} = k_{l,q} \left(\frac{D_{eff,2}}{D_{i,1}} \right)^{\frac{2}{3}} = k_{l,q} \ \theta_{liq,2}^{\frac{8}{9}} \qquad \text{(G-81)}$$

Substituting Equation G-81 into Equation G-79 and simplifying yields

$$v_{diff} = \frac{k_{l,q} \ \theta_{liq,2}^{0.89}}{1 + \theta_{liq,2}^{0.89}} \qquad \text{(G-82)}$$

The effective diffusion velocity between the unconsolidated and consolidated sediment compartments, v_{diff23}, is estimated in the same manner to yield the following equation:

$$v_{diff23} = k_{l,q} \left[\frac{(\theta_{liq,2} \ \theta_{liq,3})^{0.89}}{\theta_{liq,2}^{0.89} + \theta_{liq,3}^{0.89}} \right] \qquad \text{(G-83)}$$

$k_{l,q}$ = liquid-phase mass transfer coefficient for quiescent surface (m/s)
$\theta_{liq,2}$ = volumetric liquid content of unconsolidated sediment compartment (m^3/m^3)
$\theta_{liq,3}$ = volumetric liquid content of consolidated sediment compartment (m^3/m^3).

G4.3 Estimation of Leachate and Effluent Flow Rates

G4.3.1 General Infiltration Rate Module Construct

For surface impoundments, the leachate flow rate is estimated from liquid depth and from the hydraulic conductivities and thicknesses of the sediment compartment, the clogged native soil layer, and the underlying soil layer. The procedure used to determine the leaching rate follows the method outlined in the EPA Composite Module for Leachate Migration with Transformation Products (EPACMTP) background document (U.S. EPA, 1996). There are two important differences: (1) the liquid depth is known, and (2) there is a sediment layer between the liquid and the liner. Figure G-2 presents a schematic of the leaching module construct.

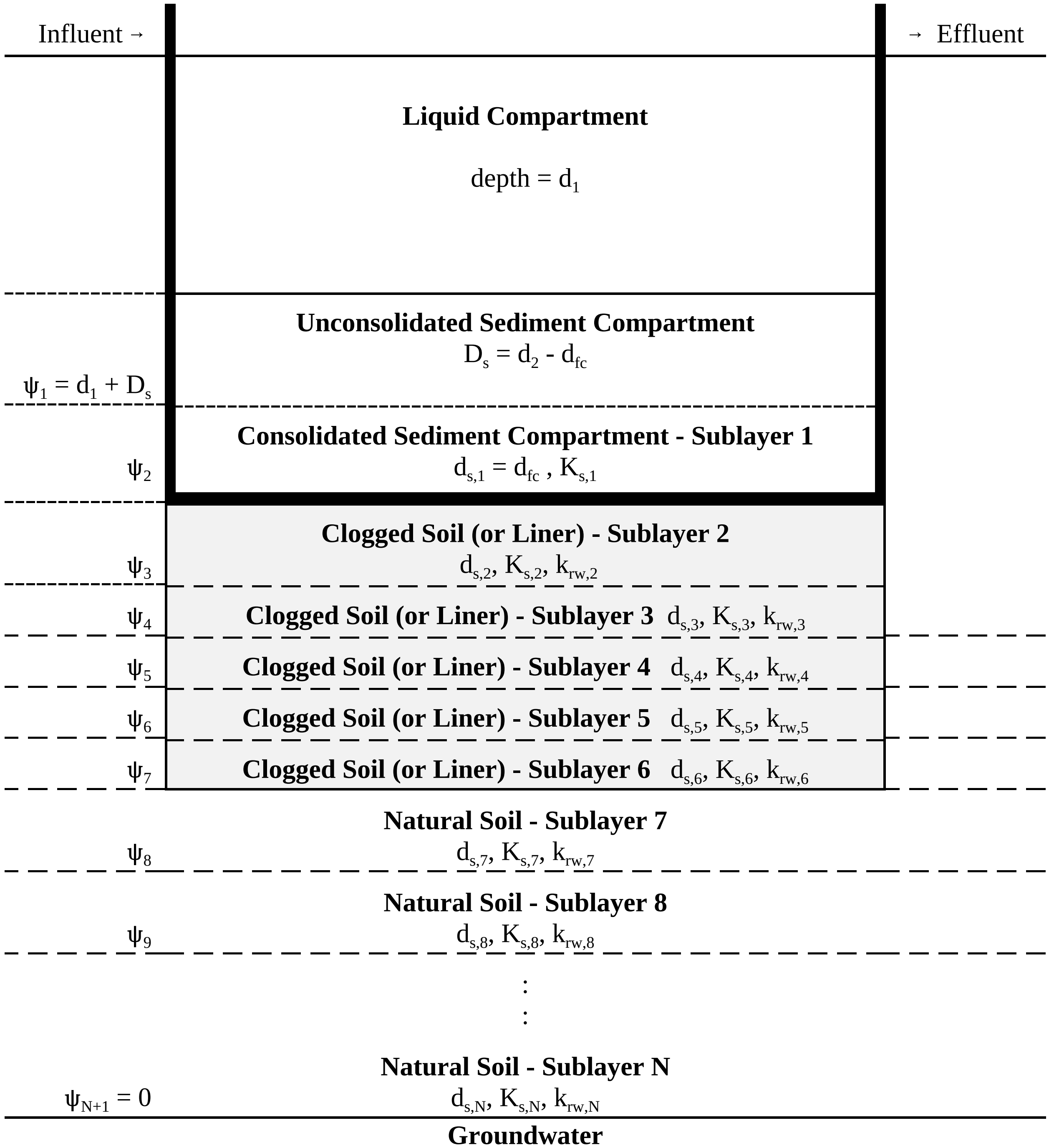

Figure G-2. Schematic of general module construct for leaching from surface impoundments.

The unconsolidated sediment layer is treated as free liquid so that the pressure head on the consolidated sediment layer is known ($\Psi_1 = d_1 + D_s$). The general solution algorithm is to guess the infiltration rate, calculate the pressure profile in the underlying soil, and compare the calculated pressure head at the groundwater surface with the boundary condition (i.e., $\Psi_{N+1} = 0$). Successive estimates of the infiltration rate are made until the boundary conditions are met.

According to Darcy's law, the leaching (infiltration) rate for a given soil sublayer is

$$I_n = K_{s,n} k_{rw,n} \left(\frac{\psi_n - \psi_{n+1}}{d_{s,n}} + 1 \right) \tag{G-84}$$

where

$K_{s,n}$ = hydraulic conductivity of the n^{th} soil sublayer (m/d)
$k_{rw,n}$ = relative permeability of the n^{th} soil sublayer (dimensionless)
Ψ_n = pressure head at top of the n^{th} soil sublayer (m)
Ψ_{n+1} = pressure head at base of the n^{th} soil sublayer (m).

The relative permeability is a function of the effective saturation and can be expressed by soil class parameters as follows (U.S. EPA, 1996):

$$if\ \psi \geq 0 \qquad k_{rw,n} = 1 \tag{G-85}$$

$$if\ \psi < 0 \qquad k_{rw,n} = \frac{(1 - (-\alpha_n\psi_n)^{\beta_n - 1}[1 + (-\alpha_n\psi_n)^{\beta_n}]^{-\gamma_n})^2}{[(1 + (-\alpha_n\psi_n)^{\beta_n}]^{\gamma_n/2}} \tag{G-86}$$

where

α_n = first soil retention module parameter for n^{th} soil sublayer (1/m)
β_n = second soil retention module parameter for n^{th} soil sublayer (dimensionless)
γ_n = third soil retention module parameter for n^{th} soil sublayer = $1 - 1/\beta_n$.

The SI Module employs a weighting factor for determining the average or "effective" pressure head, $\psi_{eff,n}$, for the soil layer based on the pressure head at both the top and bottom of the soil layer, but recommends using the effective pressure head for a soil layer as the pressure head at the top of that soil layer (termed an "upstream-weighted approximation"). The sediment layer is assumed to be saturated so that no discretization is needed for the sediment layer. The liner or clogged soil layer and each subsequent soil layer is divided into five sublayers. For a given soil layer, the top sublayer is one-half the total depth of that layer, the second layer is one-quarter the total depth, the third layer is one-eighth the total depth, and the fourth and fifth layers are one-sixteenth the total depth. The diagram shows the nomenclature for the discrete sublayers, but not the relative depths.

G4.3.2 Effective Hydraulic Conductivity of Consolidated Filter Cake (HydroGeoLogic, 1999)

As sediment accumulates at the base of the impoundment, the weight of the liquid and upper sediments tends to compress (or consolidate) the lower sediments. This consolidated sediment acts as a filter cake, and its hydraulic conductivity may be much lower than the nonconsolidated sediment. Shown in Figure G-3 is a snapshot of a compartmentalized surface impoundment with stratified sediment. It is assumed that the system has attained a pseudo-steady-state condition and all sediment layer thicknesses are near stationary and approximately constant. The initial depth of the sediment layer for the surface impoundment is set at 20 cm to account for sediment and compaction created during the excavation of the impoundment.

Initially, the effective stress in the sediment is assumed to be nonexistent. The final stress in the consolidated sediment after the deformation and dissipation of fluid pressure is given by

$$\begin{aligned} \sigma_{vf} = {} & (H - D_s - D_{fc})\rho_w g + (1-\theta)\rho_s g D_s + \theta\rho_w g D_s \\ & + (1-\theta)\rho_s g z + \theta\rho_w g z - [(H - D_{fc})\rho_w g - \frac{z}{D_{fc}}(H - D_{fc})\rho_w g] \end{aligned} \qquad \text{(G-87)}$$

where

σ_{vf}	=	vertical effective stress in the z direction (Mg/m-s^2)
H	=	total depth of a given surface impoundment (height from bottom) (m)
D_s	=	thickness of unconsolidated sediment (m)
D_{fc}	=	thickness of filter cake or consolidated sediment (height from bottom) (m)
ρ_w	=	water density (Mg/m^3)
g	=	gravitational acceleration (m/s^2)
ρ_s	=	sediment grain density (Mg/m^3)
θ	=	porosity, volume fraction
z	=	vertically downward distance from the top of the consolidated sediment (m).

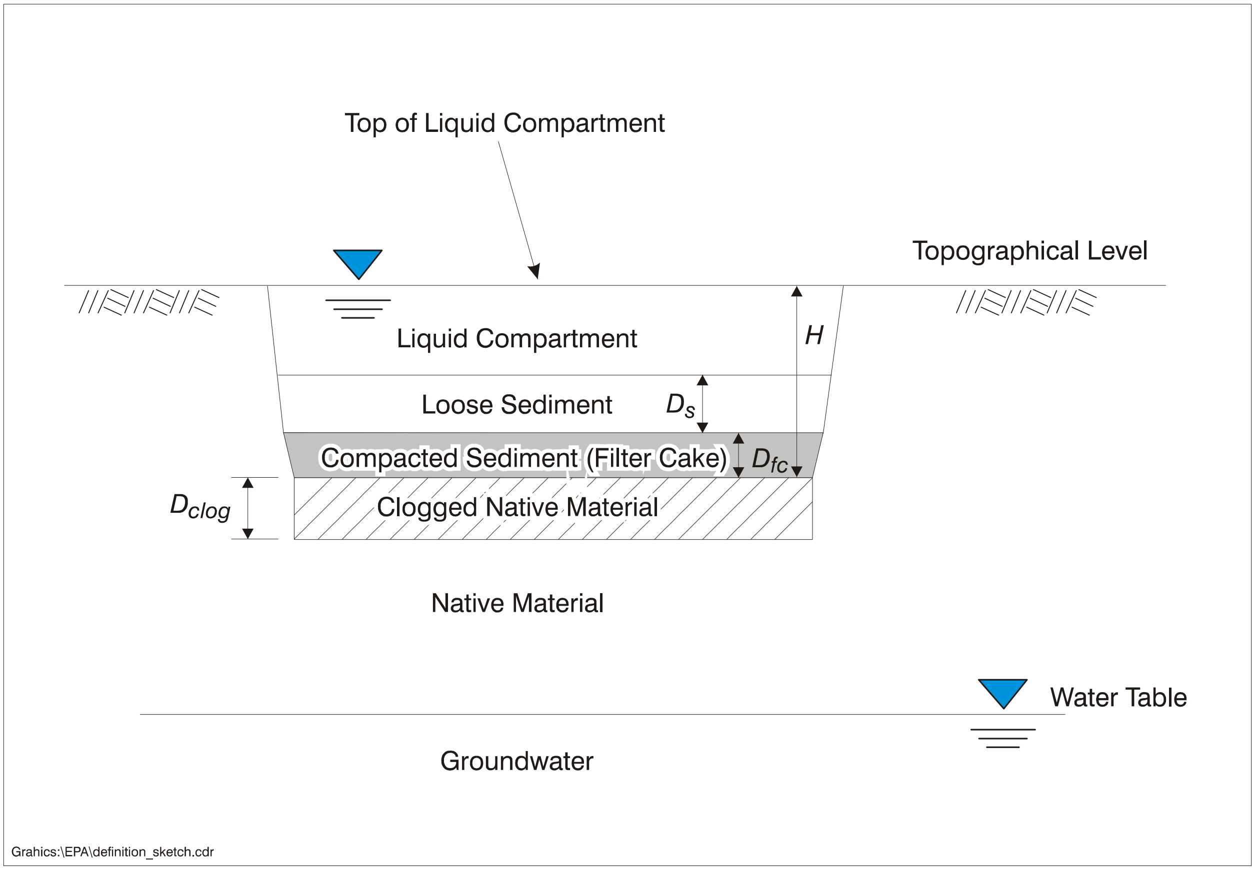

Figure G-3. Filter cake and clogged native material components to the surface impoundment infiltration rate module. Shown in the figure are, in descending order: the liquid compartment, the sediment compartment (with loose and compacted sediments), and the vadose zone (with clogged and unaffected native materials).

The following limits are imposed on the filter cake thickness:

$$D_{fcMin} \leq D_{fc} = f_D(D_s + D_{fc}) \qquad \text{(G-88)}$$

where

D_{fcMin} = minimum permissible thickness of filter cake, m = 0.1 m
f_D = fraction of total sediment depth that is consolidated = 0.5.

The compressibility of the consolidated sediment is determined from

$$a_v = \frac{0.435 C_c}{\frac{1}{2}\sigma_{vf}\big|_{z=\frac{1}{2}D_{fc}}} \tag{G-89}$$

where

C_c = compression index = 1.02

and

$$\Delta e = -a_v \Delta\sigma_{vf} \tag{G-90}$$

where

e = void ratio

The change in void ratio can be determined by

$$e^{/} = e_0 + \Delta e \tag{G-91}$$

where

e_0 = initial void ratio (based on initial hydraulic conductivity at no stress condition)
= 2.0

or

$$e^{/} = e_0 - a_v \Delta\sigma_{vf} \tag{G-92}$$

According to a number of laboratory observations (see Lambe and Whitman, 1969), hydraulic conductivity, K, of the sediment can be expressed as a function of void ratio as follows:

$$\log(e) = \log(A) + b \ \log(K) \tag{G-93}$$

or

$$\left(\frac{e}{A}\right)^{\frac{1}{b}} = K \tag{G-94}$$

where A and b are constants and

A = 1,120
b = 0.337.

Using Equations G-87, G-89, G-92, and G-94 gives

$$K(e') = [(e_0 - a_v((H - D_s - D_{fc})\rho_w g + (1-\theta)\rho_s g D_s + \theta\rho_w g D_s + (1-\theta)\rho_s g z + \theta\rho_w g z - [(H - D_{fc})\rho_w g - \frac{z}{D_{fc}}(H - D_{fc})\rho_w g]))\frac{1}{A}]^{\frac{1}{b}} \quad \text{(G-95)}$$

or simply

$$K(e') = (C_1 + C_2 z)^{\frac{1}{b}} \quad \text{(G-96)}$$

where

C_1, C_2 = constants.

The effective hydraulic conductivity of the consolidated sediment is

$$\frac{1}{K_{FcEff}} = \frac{1}{D_{fc}}\int_0^{D_{fc}} \frac{1}{(C_1 + C_2 z)^{\frac{1}{b}}} dz \quad \text{(G-97)}$$

Integrating Equation G-97 obtains

$$\frac{1}{K_{FcEff}} = \frac{1}{D_{fc}(1 - \frac{1}{b})C_2}\left((C_1 + C_2 D_{fc})^{1-\frac{1}{b}} - (C_1)^{1-\frac{1}{b}}\right) \quad \text{(G-98)}$$

G4.3.3 Effective Hydraulic Conductivity of Clogged Native Material (HydroGeoLogic, 1999)

The values of saturated hydraulic conductivity of the clogged zone are commonly lower than those of the pristine native material, or

$$K_{clogged} = C_{fact} K_{sat} \quad \text{(G-99)}$$

where

C_{fact} = clogging factor = 0.1
K_{sat} = saturated hydraulic conductivity of the native vadose zone material (m/d).

The following conditions are imposed on the hydraulic conductivity of the clogged native material:

$$K_{fc} \leq K_{Clogged} \leq K_{sat} \tag{G-100}$$

Penetration depth of up to about 0.45 m has been observed; the depth of the clogged layer is assumed to be fixed at 0.5 m.

G4.3.4 Estimating Leachate Flow Rate

The following equations and nomenclature are based on **sublayers** as illustrated in Figure G-2 using the upstream-weighted approximation (specifically, $\psi_{eff,n} = \psi_n$).

The unconsolidated sediment layer is assumed to be loose (fluid) so that the effective pressure head for the consolidated sediment layer is simply the liquid depth (d_1) plus the depth of the unconsolidated sediment (D_s). It is assumed that the system is at steady state. Therefore, a water balance dictates that the infiltration rate is the same for all sublayers. Assuming the pressure head at the groundwater interface is zero, the general solution for the infiltration rate becomes, from Equation G-84,

$$I = \frac{(d_1 + D_s + \sum d_{s,sn})}{\Sigma\left(\dfrac{d_{s,n}}{K_{s,n}k_{rw,n}}\right)} \tag{G-101}$$

where

I	=	saturated infiltration rate (m/d)
$K_{5,2}$	=	saturated hydraulic conductivity of the sediment layer (m/d)
$d_{s,n}$	=	thickness of the n^{th} soil (or liner) sublayer (m).

The relative permeabilities (k_{rw}) of the clogged native material and native soil sublayers are a function of whether the previous sublayer is saturated (i.e., $\psi_n \geq 0$). There are two potential initial assumptions that can be made to provide an initial guess for the leaching rate. For the first initial approximation, the clogged native material is assumed to be the primary flow restriction (at small sediment depths), and the pressure head at the base of Sublayer 3 is assumed to be zero (i.e., $\psi_4 = 0$). Equation G-101 then reduces to

$$I_{g1} = \frac{(d_1 + D_s + d_{s,1} + d_{s,2} + d_{s,3})}{\left[\dfrac{d_{s,1}}{K_{s,1}} + \dfrac{d_{s,2}}{K_{s,2}} + \left(\dfrac{d_{s,3}}{K_{s,3}k_{rw,3}}\right)\right]} \tag{G-102}$$

To solve Equation G-102, one first needs an estimate of ψ_3 to subsequently calculate $k_{rw,3}$ using Equation G-86. By setting the infiltration rate for the sediment and the first two sublayers equal to each other (steady-state water balance), the pressure head at the top of the second sublayer corresponding to the assumptions for Equation G-102 is

$$\psi_3 = \frac{\left(\frac{d_{s,3}}{K_{s,3}k_{rw,3}}\right)(d_1 + D_s + d_{s,1} + d_{s,2}) - d_{s,3}\left(\frac{d_{s,1}}{K_{s,1}} + \frac{d_{s,2}}{K_{s,2}}\right)}{\left[\frac{d_{s,1}}{K_{s,1}} + \frac{d_{s,2}}{K_{s,2}} + \left(\frac{d_{s,3}}{K_{s,3}k_{rw,3}}\right)\right]} \qquad \text{(G-103)}$$

Equation G-103 is solved for ψ_1 by first assuming $k_{rw,2}$ is equal to 1. Then $k_{rw,2}$ is calculated using Equation G-85 or G-86, as appropriate, and Equation G-103 is resolved for ψ_1. Using a limited number of successive iterations on ψ_1, a value of $k_{rw,2}$ is estimated for use in Equation G-102.

For the second potential initial approximation, it is assumed that all of the soil layers are saturated. The infiltration rate estimate is then calculated as follows:

$$I_{g2} = \frac{(d_1 + D_s + \sum d_{s,n})}{\left[\Sigma\left(\frac{d_{s,n}}{K_{s,n}}\right)\right]} \qquad \text{(G-104)}$$

The infiltration rate is then set equal to the smallest of the initial approximations as

$$I^i = \min(I_{g1}, I_{g2}) \qquad \text{(G-105)}$$

Given the infiltration rate, Equation G-84 can be rearranged to solve for the base pressure head of any soil (or the liner) sublayer as follows:

$$\psi_{n+1} = \psi_n - d_{s,n}\left(\frac{I^i}{K_{s,n}k_{rw,n}} - 1\right) \qquad \text{(G-106)}$$

The solution algorithm starts at the consolidated sediment layer, where $\psi_1 = d_1 + D_s$. The relative permeability, $k_{rw,n}$, is based on ψ_n (upstream weighted relative permeability calculation) and is calculated using Equation G-85 or G-86, as appropriate. Equation G-106 is then used to calculate successively values for ψ_2 through ψ_{N+1}. The final value of ψ_{N+1} is then compared to the boundary condition at the groundwater interface of $\psi_{N+1} = 0$. Based on that result, a new estimate of the infiltration rate is made (I^i), and Equation G-106 is again solved to calculate the pressure profile in the underlying soil. This process is repeated until the boundary condition at the groundwater interface is met within a 0.001 m tolerance.

For certain surface impoundment input operating conditions, very small changes in the infiltration rate caused large changes in the calculated pressure head at the groundwater interface. As such, convergence on the groundwater interface boundary condition was difficult.

Therefore, when incremental estimates of the infiltration rate were different by less than 0.01 percent, convergence on the infiltration rate was considered to be completed. Under this circumstance, the final pressure profile was recalculated using this infiltration rate and an upstream calculational algorithm for the pressure profile. That is, the pressure at the groundwater interface was set equal to zero ($\psi_{N+1} = 0$). The value for ψ_N was then estimated and Equation G-106 was solved for ψ_{N+1}. Iterative estimates of ψ_N were made until the value of ψ_{N+1} calculated from Equation G-106 matched the boundary condition (($\psi_{N+1} = 0$). Successive estimates of the upstream pressure head were made using the following chord-slope convergence algorithm

$$\psi_n^{i+1} = \psi_n^i + (\psi_n^i - \psi_n^{i-1}) \left(\frac{\psi_{n+1} - \psi_{n+1}^i}{\psi_{n+1}^i - \psi_{n+1}^{i-1}} \right) \qquad \text{(G-107)}$$

where

i	=	iteration number
Ψ_n^i	=	i^{th} estimate of the pressure head at top of the n^{th} soil sublayer (m)
Ψ_{n+1}	=	known pressure head at bottom of the n^{th} soil sublayer (m)
Ψ_{n+1}^i	=	pressure head at bottom of the n^{th} soil sublayer calculated from Equation G-106 for the i^{th} iteration of Ψ_n (m).

Convergence is assumed when $\Psi_{n+1} - \Psi_{n+1}^i$ is within a 0.001 m tolerance. At this point, ψ_N is “known” and the solution proceeds to the next higher soil sublayer (ψ_{N-1}) and so on until the entire pressure profile is calculated up to all of the ψ_1. At this point, ψ_1 is compared to $d_1 + D_s$ to confirm pressure profile (and infiltration rate) convergence.

The volumetric leachate flow rate is then calculated from the infiltration rate as follows:

$$Q_{leach}\ (m^3/s) = \frac{I \times A}{24 \times 3600} \qquad \text{(G-108)}$$

G4.3.5 Limitations on Maximum Infiltration Rate

If the infiltration rate calculated using the equations in Section G4.3.4 exceeds the rate at which the saturated zone can transport the groundwater, the groundwater level will rise into the unsaturated zone, and the assumption of zero pressure head at the base of the unsaturated zone is violated. This groundwater “mounding” will reduce the effective infiltration rate. The maximum infiltration rate is estimated as the one that does not cause the groundwater mound to rise to the bottom elevation of the surface impoundment unit. The maximum allowable infiltration rate may be approximated by (HydroGeoLogic, 1999):

$$I_{Max} \leq \frac{2K_{aqsat}D_{aqsat}(D_{vadose} - H)}{R_0^2 \ln\frac{R_\infty}{R_0}} \qquad \text{(G-109)}$$

where

I_{Max} = infiltration rate (m/d)

K_{aqsat} = hydraulic conductivity of the saturated zone (m/d)

D_{aqsat} = depth of the saturated zone (m)

D_{vadose} = vadose zone thickness (m)

R_0 = equivalent source radius (m)

R_∞ = length between the center of the source and the downgradient boundary where the boundary location has no perceptible effects on the heads near the source (m).

The equivalent source radius may be calculated from (HydroGeoLogic, 1999):

$$R_0 = \sqrt{\frac{A}{\pi}} \qquad \text{(G-110)}$$

where

A = source area (m^2).

If Equation G-109 is used to limit the infiltration (leachate flow) rate, the program will output a warning message stating that the infiltration rate is being capped to prevent groundwater mounding.

G4.3.6 Estimating Liquid Depth and Effluent Flow Rate

A volumetric water balance on the surface impoundment can be arranged to calculate the effluent flow rate as follows:

$$d_{1,end} = d_{1,0} + \frac{Q_{infl} - Q_{out} - Q_{leach}}{2{,}628{,}000\ A} + \frac{P_{rain} - P_{evap}}{30.42} \qquad \text{(G-111)}$$

where

$d_{1,end}$ = depth of the liquid compartment at the end of the month (m)

$d_{1,0}$ = depth of the liquid compartment at the start of the month (m)

P_{rain} = monthly precipitation rate (m/d)

P_{evap} = monthly evaporation rate (m/d).

The liquid depth at the end of the month is initially assumed to be equal to the starting liquid depth. The infiltration rate is calculated at this liquid depth. The ending liquid depth is then estimated assuming that the effluent flow rate is zero for the time dependent solution or 1 percent of the influent flow rate for the well-mixed, steady-state solution. If the ending liquid depth exceeds the available liquid compartment depth in the surface impoundment (given the current sediment depth), then the ending liquid depth is capped at this available liquid compartment depth. Conversely, the ending liquid depth is not allowed to fall below 0.01 m. Thus, the limits on the ending liquid depth are as follows:

$$Max(d_{1,end}) = d_{wmu} - D_s - D_{fc} \tag{G-112}$$

$$Min(d_{1,end}) = 0.01 \tag{G-113}$$

If the ending liquid depth calculated differs more than 2 cm (0.02 m) from the initial estimate, then an average liquid depth is calculated $[(d_{1,0} + d_{1,end})/2]$ for the month, and the infiltration rate is calculated for this new liquid depth. Once convergence is achieved on the ending liquid depth (and average monthly depth), the effluent flow rate is calculated using Equation 110 rearranged to solve for Q_{out}. Using this algorithm, the effluent flow rate from a well-mixed surface impoundment always exists and is set at a minimum of 1 percent of the influent flow rate. The time dependent solution does not require that there be an effluent flow rate. If Equation 113 is triggered, a warning message is output stating that the evaporation rate was capped to prevent the impoundment from drying out.

G4.4 Sediment Deposition, Resuspension, and Burial

The sediment movement between the liquid and sediment compartment is expected to vary primarily with the dimensions and flow characteristics of the surface impoundment and with the relative surface area affected by turbulent mixing. The general approach used to estimate the various sediment transport rates is based on the theoretical TSS mass removal efficiency given a vertical flow ("upflow") velocity. The resuspension velocity is determined by the sediment transport created by the upflow velocity and the sedimentation velocity is adjusted to achieve the calculated TSS mass removal efficiency.

G4.4.1 Estimating Design Sediment Removal Efficiency

The surface impoundment quiescent surface area and flow rate are used to calculate the upflow velocity of the impoundment as follows:

$$v_{upflow} = \frac{Q_{infl}}{A_q} \qquad \text{(G-114)}$$

where

ν_{upflow} = upflow velocity (m/s).

The upflow velocity is assumed to act on the liquid compartment and effect an upward flux of particles. The sediment removal efficiency of the surface impoundment is estimated from surface impoundment characteristics (flow rate and surface area, i.e., the upflow velocity) and the particle size distribution characteristics (mean particle size and relative standard deviation) by considering the terminal settling velocity of the particles. If a particle has a terminal settling velocity greater than the upflow velocity, it is assumed to settle within the surface impoundment. If a particle has a terminal velocity less than this upflow velocity, it is assumed to be entrained in the effluent.

The suspended solids are assumed to be spherical for calculating the terminal velocity (or critical particle diameter) and the mass to volume ratio of the particles. The terminal velocity of the suspended solids is dependent on the friction factor (or drag coefficient) and the particle Reynolds number. For a sphere falling at terminal velocity, the friction factor is

$$f = \frac{4}{3}\,\frac{g_c\, d_{part}}{v_{part}^2}\left(\frac{\rho_{part} - \rho_l}{\rho_l}\right) \qquad \text{(G-115)}$$

where

f	=	friction factor for sphere at terminal velocity
d_{part}	=	mean diameter of suspended particles (cm)
ν_{part}	=	particle velocity (cm/s)
ρ_l	=	density of water (g/cm^3).

There are three possible correlations that may be used to describe the correlation between the friction factor and the Reynolds number depending on the value of the Reynolds number (Bird et al., 1960, Figure 6.3-1, p. 192). The three possible correlations between the friction factor and the Reynolds number are

$$For \quad Re_p < 0.1 \qquad f = \frac{24}{Re_p} \tag{G-116a}$$

$$For \quad 0.1 \leq Re_p \leq 500 \qquad f = \frac{24}{Re_p^{0.6}} \tag{G-116b}$$

$$For \quad Re_p > 500 \qquad f = 0.44 \tag{G-116c}$$

where

Re_p = Reynolds number for particle = $d_{part}\ \nu_{part}\ \rho_l / \mu_l$
μ_l = viscosity of water (g/cm-s).

By substituting in the expressions for both the friction factor and the Reynolds number into Equations G-116(a-c), these equations can be solved in terms of the particle diameter associated with a given terminal velocity as follows:

$$Assuming \quad Re_p < 0.1 \qquad d_{part} = \left(\frac{18\ v_{part}\ \mu_l}{g_c\ (\rho_{part} - \rho_l)} \right)^{0.5} \tag{G-117a}$$

$$Assuming \quad 0.1 \leq Re_p \leq 500 \qquad d_{part} = \left[\frac{3}{4}\ \frac{v_{part}^{1.4}}{g_c} \left(\frac{18.5\ \mu_l^{0.6}\ \rho_l^{0.4}}{(\rho_{part} - \rho_l)} \right) \right]^{\frac{1}{1.6}} \tag{G-117b}$$

$$Assuming \quad Re_p > 500 \qquad d_{part} = \frac{3}{4}\ v_{part}^2\ \frac{0.44\ \rho_l}{g_c\ (\rho_{part} - \rho_l)} \tag{G-117c}$$

The evaluation of the critical particle diameter is determined by an iterative calculation assuming $\nu_{part} = \nu_{upflow}$. First, Equation G-117a is used to estimate d_{part}, and then the resulting d_{part} is used to calculate the Reynolds number to see if the assumption for the Reynolds number was correct. If the Reynolds number value fits the assumed range, the calculation is complete. If not, Equation G-117b is employed to estimate d_{part}. Again the assumption for the Reynolds number is checked. If the Reynolds number falls within the assumed range, the calculation is complete; otherwise, Equation G-117c is used to estimate d_{part}.

Once d_{part} is estimated, the mass sediment removal efficiency of the surface impoundment is calculated by the particle size distribution (assumed to be lognormally distributed) and the mass of particles of a given diameter (based on spherical particles). The lognormal distribution density function is

$$\phi(d_{part}) = \frac{1}{d_{part}\ \sigma\ (2\pi)^{½}} \times \exp\left(\frac{-[\ln(d_{part}/d_{mean})]^2}{2\sigma^2}\right) \qquad \text{(G-118)}$$

where

$\phi(d_{part})$ = distribution density function for sediment particles
σ = standard deviation of $\ln(d_{part})$
d_{mean} = geometric mean particle diameter = exp[mean of $\ln(d_{part}$] (cm).

A weighting factor is then calculated based on the mass of a particle of a given diameter as follows:

$$WtFactor_{part} = \frac{\pi}{6}\ d_{part}^3 \qquad \text{(G-119)}$$

The “design” mass solids removal efficiency is then calculated as follows:

$$\epsilon_{TSS,o} = \frac{\int_{d_{crit}}^{+\infty} [\phi(d_{part}) \times WtFactor_{part}]}{\int_{0}^{+\infty} [\phi(d_{part}) \times WtFactor_{part}]} \qquad \text{(G-120)}$$

where

$\epsilon_{TSS,o}$ = design mass solids removal efficiency of surface impoundment (mass fraction).

Because of the solution algorithm selected, the equations become unsteady as $\epsilon_{TSS,o}$ approaches 1. To prevent taking the logarithm of zero, the design mass solids removal efficiency is capped at 99.9 percent. That is, if $\epsilon_{TSS,o}$ >0.999 from Equation G-120, $\epsilon_{TSS,o}$ is set equal to 0.999.

G4.4.2 Estimating Resuspension, Sedimentation, and Burial Velocities for Time-Dependent Model Solution

The time-dependent model uses the design removal efficiency to set a target effluent concentration. The sedimentation velocity is calculated as the terminal velocity for the mean particle size diameter using Equations G-117(a-c) re-arranged to solve for ν_{part}. The resuspension velocity is set so that the total mass of sediment resuspended will equal the mass settling when the average TSS concentration in the liquid compartment equals the target effluent concentration. The burial rate is then calculated for each individual time step based on the difference in the sedimentation and resuspension rates at the average liquid compartment TSS concentration for that time step. The necessary equations follow:

$$v_{sed} = 100 \times v_{part,mean} \tag{G-121}$$

$$v_{res} = v_{sed} \frac{[TSS]_{target}}{[TSS]_2} \tag{G-122}$$

$$v_b = \left(\frac{Q_{leach}}{A} + v_{sed} \right) \frac{[TSS]_{ave}}{[TSS]_2} - v_{res} \tag{G-123}$$

where

$v_{part.mean}$	=	particle settling velocity of a mean-diameter particle (cm/s)
$[TSS]_{target}$	=	target effluent TSS concentration = $[TSS]_{infl}$ (1- $\epsilon_{TSS,o}$) (g/cm^3 = Mg/m^3)
$[TSS]_{ave}$	=	average TSS concentration in the liquid compartment for a given time interval (from Equation G-61) (g/cm^3 = Mg/m^3).

As constructed, the time-dependent solution assumes the mass rate of sediment resuspension will equal the mass rate of sediment settling at the target or design effluent TSS concentration. The rate at which the target TSS concentration is reached is dependent on the particle characteristics, as well as the growth rate of biomass (i.e., the BOD_5 consumption rate). The actual effluent TSS concentration predicted by the model may not reach the target TSS concentration at very low hydraulic residence times or where significant quantity of sludge is produced. As sediment accumulates in the surface impoundment, the corresponding change in the hydraulic residence time may also affect the predicted effluent TSS concentration.

G.4.4.3 Estimating Resuspension, Sedimentation, and Burial Velocities for Well-Mixed Model Solution

In the well-mixed model, mass balance consideration of the sediment requires that the suspended solids burial (or accumulation) rate be determined from the predicted sediment removal efficiency. As constructed, the design sediment removal efficiency is independent of surface impoundment depth, and therefore does not change as sediment accumulates in the surface impoundment. This will generally be true for large depths, but for shallower depths, the increased lateral flow rates tend to cause "short-circuiting" flow patterns, which decrease the sediment removal efficiency of the surface impoundment. In attempts to take this phenomenon into account, it is assumed that the sediment removal efficiency remains constant at the design efficiency (i.e., $\epsilon_{TSS} = \epsilon_{TSS,o}$) at liquid depths of 1.2 meters (4 feet) or more based on design considerations of settling chambers. As the liquid depth becomes less than 1.2 meters, it is assumed that the sediment removal efficiency will decrease as a function of the liquid retention time. A first-order sedimentation rate constant is estimated based on the "design" sediment removal rate and the surface impoundment retention time at a liquid depth of 1.2 meters. This first-order sedimentation rate constant is calculated as

$$k_{sed} = \frac{-\ln\,(1 - \epsilon_{TSS,o})}{\dfrac{(1.2\ m)\ A}{Q_{infl}}} \tag{G-124}$$

where

k_{sed} = apparent first-order sedimentation rate at a liquid depth of 1.2 meters (1/s).

For liquid depths less than 1.2 meters, the removal efficiency is estimated using this first-order sedimentation rate constant and the hydraulic retention time as

$$\epsilon_{TSS} = 1 - e^{\left(\frac{-k_{sed}\ d_1\ A}{Q_{infl}}\right)} \tag{G-125}$$

where

ϵ_{TSS} = predicted mass sediment removal efficiency of surface impoundment as sediment accumulates (mass fraction).

The predicted mass sediment removal efficiency is assumed to apply equally to influent sediment and sediment generated within the surface impoundment. The net rate of sediment transfer or burial from the liquid compartment to the sediment compartment can be calculated based on a mass balance of sediment in the liquid compartment, which can be rearranged to calculate the burial velocity (defined in terms of the sediment concentration in the sediment compartment) as follows:

$$v_b = \frac{Q_{infl}\ ([TSS]_{infl} + \lambda\ \epsilon_{BOD}\ C_{BOD})\ (1 - \epsilon_{TSS})}{A\ [TSS]_2} \tag{G-126}$$

The resuspension velocity acts on the sediment compartment, and it is assumed to effect the same upward flux of sediment as the upflow velocity. Therefore, the resuspension velocity can be calculated from the upflow velocity and the relative concentrations of particles in the liquid and sediment compartments as follows:

$$v_{res} = v_{upflow}\ \frac{[TSS_1]}{[TSS_2]} \tag{G-127}$$

The sedimentation rate is calculated from the mass balance of sediment in the sediment compartment (Equation G-4), which can be rearranged as follows:

$$v_{sed} = (v_{res} + v_b) \frac{[TSS]_2}{[TSS]_1} - \frac{Q_{leach}}{A} \quad \text{(G-128)}$$

where $[TSS]_1$ is calculated from $[TSS]_{infl}$ and $[TSS]_{out}$ using Equation G-64.

G4.4.4 Estimating Sediment Decomposition

The burial rate is the total sediment accumulation rate for the time step. To account for the reduction in solids typically associated with anaerobic digestion, a sediment decomposition rate (or sludge digestion rate) is included in the burial (accumulation) compartment. If the entire sediment compartment included this anaerobic digestion term, a more rigorous accounting of the biological (organic) versus inert solids would be required, but, ultimately, the sediment compartment will reach a steady state (i.e., biomass growth equals biomass decay). By including it only in the burial (accumulation) compartment, sediment reduction (which includes a contaminant reduction associated with the sediment) by digestion can be included without significantly complicating the module. The net accumulation of sediment over a time step is estimated as follows:

$$\Delta d_2 = v_b \, \Delta t \left[1 - k_{ba} \left(1 - e^{-k_{dec} \Delta t}\right)\right] \quad \text{(G-129)}$$

where

k_{ba} = ratio of biologically active solids to the total solids concentration - assumed to be the same ratio as present in the liquid compartment

k_{dec} = anaerobic digestion/decay rate of the organic sediment (1/sec).

Prior to the next time step calculations, Δd_2 is added to d_2 (and subtracted from d_1). Additionally, the total amount of sediment in the impoundment and the total time since the last cleaning/dredging action is compared to the input cleaning/dredging parameters (either fraction of the surface impoundment that can be filled with sediment before the surface impoundment is cleaned or dredged or a set frequency, e.g., once every 4 years). The module will also automatically run the "dredge" subroutine in the event that the sediment settling for the next time step (based on the sediment settling for the current time step) would completely fill the surface impoundment. The removed sediment and the contaminant associated with the removed sediment is recorded, but this removal acts as a sink from the overall system.

G4.5 Temperature Effects

Temperature can affect a number of the different module parameters, such as the air density and diffusivity, the biodegradation rate, liquid viscosity, and Henry's law constant. Some of the equations employed already include a temperature correction factor. For example, the liquid-phase turbulent surface mass transfer coefficient includes a temperature correction term of 1.024^{T-20}. The ambient air temperature is used to estimate the air-side properties (air diffusivity, air density, etc.). The liquid-side properties (liquid diffusivity, liquid viscosity, etc.) are evaluated at the liquid temperature within the surface impoundment.

G4.5.1 Estimating Temperature in the Surface Impoundment

A simplified energy balance is used around the surface impoundment to estimate the liquid temperature in the surface impoundment given the liquid temperature of the influent, the ambient air temperature, and the liquid residence time in the impoundment. The simplified energy balance is

$$4.18\times10^{-6}\ \rho_l\ C_{p,liq}\ Q_{infl}\ T_{infl} = 4.18\times10^{-6}\ \rho_l\ C_{p,liq}\ Q_{infl}\ T_l + h_{ave}\ A\ (T_l - T_{air}) \qquad \text{(G-130)}$$

where

ρ_l	=	liquid density (g/cm^3)
$C_{p,liq}$	=	specific heat of liquid (cal/g-°C)
T_{infl}	=	influent waste temperature (°C)
4.18×10^{-6}	=	unit conversion, 4.186 (kg-m^2/s^2)/cal × 1E6 cm^3/m^3
T_l	=	liquid waste temperature in the surface impoundment (°C)
h_{ave}	=	average overall heat transfer coefficient (W/m^2-°C = kg/s^3-°C)
T_{air}	=	ambient air temperature (°C).

The specific heat capacity of water is 1 cal/g-°C and its density is 1 g/cm^3. Kreith and Black report ranges for convective heat transfer coefficients for free and forced convection for both water and air (Kreith and Black, 1980). To estimate the average overall heat transfer coefficient, it is assumed that there is forced convection on the air side (windspeed greater than 0 m/s), free convection on the quiescent liquid side, and forced convection on the turbulent liquid side. For forced convection of air, the reported range is 10 to 200 W/m^2-°C, and a general value of 50 W/m^2-°C was selected. For free convection of water, the reported range is 20 to 100 W/m^2-°C, and a general value of 50 W/m^2-°C was selected. For forced convection of water, the reported range is 50 to 10,000 W/m^2-°C, and a general value of 1,000 W/m^2-°C was selected. Using thermal resistance theory, the overall quiescent heat transfer coefficient is estimated to be 25 W/m^2-°C, and the overall turbulent heat transfer coefficient is estimated to be 50 W/m^2-°C. Using the relative aerated and quiescent surface areas, the average overall heat transfer coefficient is estimated to be $25(1+f_{aer})$ W/m^2-°C. Therefore, assuming the liquid waste is essentially water, Equation G-130 can be rearranged to estimate the liquid temperature within the surface impoundment as follows:

$$T_l = \frac{T_{infl} + \left(\dfrac{25\ (1 + f_{aer})\ A}{4.18E6\ Q_{infl}}\right) T_{air}}{1 + \left(\dfrac{25\ (1 + f_{aer})\ A}{4.18E6\ Q_{infl}}\right)} \qquad \text{(G-131)}$$

This equation does not take into account the heat of fusion (i.e., ice formation). As such, Equation G-131 can yield liquid temperatures of less than 0°C. When this happens, the liquid temperature is set to 0.1°C and the amount of ice formed is estimated using the previous assumptions for the specific heat capacity and density of water (1 cal/g-°C and 1 g/cm^3, respectively) and using a heat of fusion of 80 cal/g and a density of ice of 0.9 g/cm^3. The additional heat loss in taking the water from 0°C to T_l (when $T_l < 0$) is translated into a mass of ice formation, and the volume or depth of ice formed is estimated using the following equation:

$$d_{ice} = \frac{A_{wmu} \times d_{wmu} \times (-T_l)}{80\ (0.9)\ A_{wmu}} \qquad \text{(G-132)}$$

where

d_{ice} = depth of ice layer formed (m).

Equation G-132 is expected to be a high estimate of ice formation because convective heat transfer from the surrounding soil was not included in the heat balance as expressed in Equation G-130. Furthermore, a small amount of ice formation will not significantly affect the emission estimates and other parameters estimated by the module. However, if a solid crust of ice develops over the entire impoundment for a prolonged period of time, the emission estimates, which do not consider volatilization through an ice layer, are expected to overstate the potential for volatile emissions. Therefore, when the depth of the ice layer, as estimated using Equation G-132, is 10 cm or more for 3 consecutive months, the module generates a warning message that significant ice formation is projected.

G4.5.2 Estimating Temperature Effects on Air-Side Properties

The air-side properties are among the most temperature sensitive of the input properties. The density at any given temperature can be estimated using the ideal gas law as

$$\rho_{air}^{Tair} = \rho_{air}^{Tr} \left(\frac{273 + T_r}{273 + T_{air}} \right) \qquad \text{(G-133)}$$

where

ρ_{air}^{Tair} = density of air at air temperature T_{air} (g/cm^3)
ρ_{air}^{Tr} = density of air at reference temperature (g/cm^3)
T_{air} = module simulation air temperature (°C)
T_r = reference temperature (°C, assumed to be 25°C).

The temperature dependence of the constituent's diffusivity in the gas phase is estimated by the chemical properties processor (Pacific Northwest National Laboratory, 1998).

The viscosity of air is only slightly influenced by temperatures in the temperature range of interest, and little error is introduced in ignoring its temperature dependency (viscosity ranges from 1.75×10^{-4} to 2.17×10^{-4} g/cm-s as temperatures range from 0°C to 100°C, Kreith and Black, 1980). Alternatively, the CHEMDAT8 Module documentation (U.S. EPA, 1994) presents the following equation that can be used for a temperature-dependent estimate of air viscosity:

$$\mu_{air}^{T2}\ (g/cm-s) = 4.568\times10^{-7}\ T_{air}(°C) + 1.7209\times10^{-4} \qquad \text{(G-134)}$$

G4.5.3 Estimating Temperature Effects on Liquid-Side Properties

The density of water is basically insensitive to temperature (no temperature adjustments are used).

The viscosity of water varies by more than a factor of 5 over the temperature range of interest (0°C to 100°C). This temperature dependency is important not only for mass transport, but also for its effect on the solids settling rate (terminal velocity) at lower Reynolds numbers. Using the data from Kreith and Black (1980), the following correlation was developed (using a log-log least squares linear regression as suggested by Liley and Gambill, 1973, p. 3-246) for the temperature-dependent viscosity of water between 0°C to 100°C:

$$\mu_{liq}^{Tl}\ (g/cm-s) = \frac{3.45\times10^{12}}{(273 + T_l)^{5.884}} \qquad \text{(G-135)}$$

The values for the viscosity of water calculated from Equation G-135 agree well with the values estimated using the figure/coordinates reported by Liley and Gambill (1973, pp. 3-212 and 3-213) for temperatures between 0°C and 100°C.

The temperature dependence of the constituent's diffusivity in the liquid phase is estimated by the chemical properties processor (Pacific Northwest National Laboratory, 1998).

G4.5.4 Estimating Temperature Effects on Vapor-Liquid Partitioning

Temperature affects both gas-phase and liquid-phase activity coefficients so that developing a temperature correction factor for Henry's law constants is not straightforward. For example, the Henry's law constant is often estimated for sparingly soluble constituents as the constituent vapor pressure divided by the solubility. Although the vapor pressure will increase with increasing temperature, the solubility of the constituent may either increase or decrease, depending on the constituent. Consequently, the combined impact of temperature on the vapor-liquid partition coefficient may be small or large depending on the constituent. The temperature dependence of the constituent's Henry's law constants is estimated by the chemical properties processors (Pacific Northwest National Laboratory, 1998).

G4.5.5 Estimating Temperature Effects on Biodegradation Rates

The temperature dependence of the constituent's aerobic and anaerobic biodegradation rates (k_{bm} and k_{bs}) is estimated by the chemical properties processors (Pacific Northwest National Laboratory, 1998). The sediment decay rate (k_{dec}) is assumed to be relatively unaffected by temperatures over a reasonably wide range of temperatures. At temperatures above 50°C and at temperatures near freezing, the sediment decay rate is assumed to drop rapidly. A simple temperature correction factor for the sediment decay rate was developed based on these assumptions and is illustrated in Figure G-4. As seen in Figure G-4, the biodegradation rate temperature correction factor is assumed to be 1 at temperatures between 7°C and 40°C. At temperatures below 3°C and above 60°C, the temperature correction factor is 0, and a linear extrapolation is used to determine the temperature correction factor between 3°C and 7°C and between 40°C and 60°C.

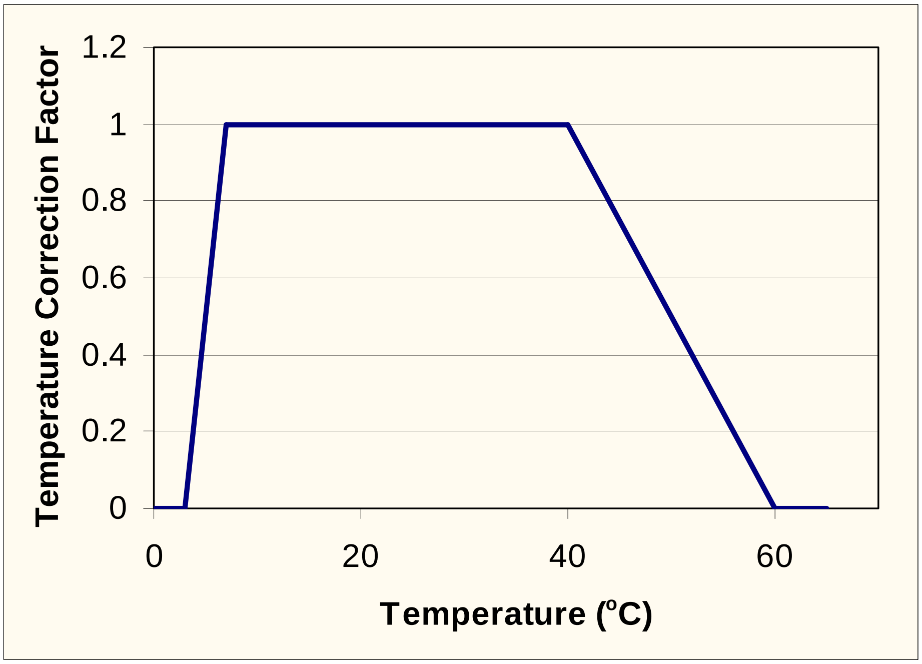

Figure G-4. Illustration of temperature correction factor used for biological rates.

G5.0 References

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Appendix G

Attachment A:
Site and Source Parameters for the Surface Impoundment Module

Appendix G

Attachment A: Site and Source Parameters for the Surface Impoundment Module

Table G-A-1 lists the SI Module input parameter values used to model emissions and leachate fluxes from sewage sludge disposal lagoons, along with a description, units, and a data source for each variable. Variables are grouped by national constants, national or site-specific distributions, and variables that are picked by RunID.

The sewage sludge lagoons modeled for the screening analysis are assumed to be unlined and quiescent (no aeration). Data from EPA's Surface Impoundment Study (SIS; U.S. EPA, 2001) survey was used to provide many of the site-specific variables needed to run the SI Module. In the probabilistic screening analysis, selection of a nonaerated SIS impoundment provides a location to be modeled for a particular RunID along with the design and operating characteristics of the impoundment to modeled. Although the SIS focused on nonhazardous industrial waste impoundments, the locations of the nonaerated units from the SIS are an adequate representation of the national distribution of sewage sludge disposal lagoons, and the characteristics of these units are reasonable with respect to sewage sludge disposal practices.

Table G-A-1. Input Parameters for the Surface Impoundment Model

Parameter	Description	Value	Reference
Constants			
C_in	Chemical concentration of the influent mg/L	0.1	Value of 0.1 used to avoid exceeding solubility in surface impoundment.
d_imp	Impeller diameter cm	0. SIS data	Quiescent impoundment (no aeration)
d_liner	Thickness of liner m	0	Assumption that the surface impoundment does not have a liner
F_aer	Fraction surface area-turbulent fraction	0	Quiescent impoundment (no aeration)
focW	Fraction organic carbon of waste solids mass fraction	0.4	Best professional judgment
hydc_liner	Saturated conductivity of liner m/s	0	Assumption that the surface impoundment does not have a liner
J	Oxygen transfer factor lb O2/h-hp	3	Best professional judgment
kba1	Biologically active solids/total solids ratio unitless	0.4	U.S. EPA, 2001
LinerALPHA	Soil retention parameter alpha of the liner 1/cm	0.008	Carsel and Parrish, 1988
LinerBETA	Soil retention parameter beta of the liner unitless	1.09	Carsel and Parrish, 1988
n_imp	Number of impellers/aerators unitless	0	Quiescent impoundment (no aeration)
NyrMax	Maximum model simulation time years	200	Ran source model for 200 years to capture maximum exposure.
Powr	Total power for impellers/aerators hp	0	Quiescent impoundment (no aeration)
Distributions			
bio_yield	Biomass yield g/g	Uniform distribution: min = 0.4 max = 0.8	Tchobanoglous et al., 1979
dmeanTSS	Particle diameter cm	Triangular distribution: min = 0.0005 max = 0.0025 mode = 0.001	Tchobanoglous et al., 1979

Table G-A-1. Input Parameters for the Surface Impoundment Model

Parameter	Description	Value	Reference
hydc_sed	Hydraulic conductivity of the sediment layer m/s	Uniform distribution: min = 0.000000001 max = 0.00000	Tchobanoglous et al., 1979
k_dec	Digestion rate of sediments 1/s	Uniform distribution: min = 0.00000046 max = 0.00000087	Tchobanoglous et al., 1979
rho_part	Solids density g/cm3	Triangular distibution: min=1 max=4 mean=2.5	Tchobanoglous et al., 1979
SrcPh	pH of the SI influent pH units	Triangular distribution: min=5 max=9 mode=7	Best professional judgment
RunID-Specific			
Infild	Infiltration rate m/d	RunID-specific. Calculated by the source model.	Calculated by the source model
VadAlpha	Soil retention parameter alpha of the vadose zone 1/cm	Source Specific. ALPHA from EPACMTP	U.S. EPA, 1996
VadBeta	Soil retention parameter beta of the vadose zone unitless	Source Specific. BETA from EPACMTP	U.S. EPA, 1996
VadSATK	Saturated hydraulic conductivity of vadose zone soil cm/h	Source Specific. SATK from EPACMTP	U.S. EPA, 1996
VadThick	Thickness of vadose zone m	Source Specific. DSOIL from EPACMTP	U.S. EPA, 1996
Site-Specific			
fwmu	Fraction waste in WMU mass fraction	1	Assumption that all waste is sewage sludge
MetSta	Meteorological station	Site-specific	U.S. EPA, 2001
SiteLatitude	Latitude of the site. degrees	Site-specific	U.S. EPA, 2001
SiteLongitude	Longitude of the site. degrees	Site-specific	U.S. EPA, 2001
TSS_in	Total suspended solids of the influent g/cm3	0.024	U.S. EPA, 2001
TSS_out	Total suspended solids of the effluent	0	U.S. EPA, 2001
w_imp	Impeller speed rad/s	0. SIS data.	Quiescent impoundment (no aeration)
Source-specific			

Table G-A-1. Input Parameters for the Surface Impoundment Model

Parameter	Description	Value	Reference
AquSATK	Saturated hydraulic conductivity of the aquifer m/yr	Source-specific. SATK from EPACMTP	U.S. EPA, 1996
AquThick	Saturated zone thickness m	Source-specific. ZB from EPACMTP	U.S. EPA, 1996
CBOD	BOD of the influent g/cm3	Source-specific. SIS data. Missing data were filled with random pick from existing data.	U.S. EPA, 2001
ClimateCenter	Index to nearest climate station to WMU n/a	Source-specific. ICLR from EPACMTP). Used to select MetSta.	U.S. EPA, 1996
d_setpt	Max fraction of SI occupied by sediments. fraction	Source-specific. Calculated based on SIS Data. If d_wmu > 5m, d_sept = 0.76 If 5 > d_wmu > 2.4, d_sept = (d_wmu -1.2)/d_wmu If d_wmu < 2.4, D_sept = 0.5.	U.S. EPA, 2001
d_wmu	Depth of the SI m	Source-specific. Step 1. Select the maximum of either the ponding depth or the (DBGS - 0.3). Step 2. If d_wmu < 0.5, set d_wmu = 0.5	Best professional judgment. Calculated based on Ponding Depth or DBGS.
DBGS	Depth below ground surface m	Source-specific. DBGS from EPACMTP	U.S. EPA, 1996
O2eff	Oxygen transfer correction factor unitless	Source-specific. SIS data. Missing data were filled with random picks from existing data	U.S. EPA, 2001
Q_wmu	Volumetric influent flow rate m3/s	Source-specific. SIS data. The hydraulic residence time was calculated as: HRT = d_wmu * SrcArea / Q_wmu / 365.25 / 86400. If the calculated HRT was > 50 or < 0.00001, a new Q_wmu was calculated as: a. Volume = SrcArea*d_wmu b. A Q_wmu is selected from a set of Q_wmu's within a range of volumes close to the one calculated until a Q_wmu is selected that generates an HRT that falls within the above specified range.	U.S. EPA, 2001
SedAlpha	Soil retention parameter alpha of the sediment 1/cm	Source-specific. ALPHA from EPACMTP	U.S. EPA, 1996

Table G-A-1. Input Parameters for the Surface Impoundment Model

Parameter	Description	Value	Reference
SedBeta	Soil retention parameter beta of the sediment unitless	Source-specific. BETA from EPACMTP	U.S. EPA, 1996
SrcLWSSubArea Area	Area of the surface impoundment m2	Source-specific	U.S. EPA, 2001
SrcTemp	Temperature of the waste deg C	Source-specific. SIS Data. Missing data were filled with random pick from existing data	U.S. EPA, 2001

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Appendix H

Source Model for Land Application Units

Appendix H

Source Model for Land Application Units

H1.0 Introduction

For the agricultural application scenario assessed in this analysis, the Land Application Unit (LAU) Module from the Multimedia, Multipathway, Multireceptor Risk Assessment (3MRA) modeling system was selected to model the environmental fate of sludge chemicals applied to a field. The following documentation details the functionality of the LAU Module in 3MRA. The specific parameter values and model modifications made for this analysis are presented in Attachment D to this appendix. Attachment E provides the LAU Module inputs used in this analysis.

As part of the 3MRA modeling system, an LAU source module was developed to estimate annual average surface soil constituent concentrations and constituent mass emission rates to air, downslope land, and groundwater. These estimates are used in an integrated, multipathway module linking source modules with environmental fate and transport and exposure/risk modules. Additionally, LAU source emission modules were combined with a local watershed module (a "local" watershed is a sheet-flow-only watershed containing the LAU) to provide estimates of constituent mass flux rates from runoff and erosion to a downslope waterbody, as well as surface soil constituent concentrations in downslope buffer areas. Because the LAU source is assumed here to interact hydrologically with the local watershed of which it is an integral part, it is termed a "land-based" unit.

A soil column model, the Generic Soil Column Module (GSCM), was developed to describe the dynamics of constituent mass fate and transport within LAUs and near-surface soils in watershed subareas. (The term "soil" is used loosely here to refer to a porous medium, whether it is waste in the LAU or near-surface soil in a watershed subarea.) Governing equations for the GSCM are similar to those used by Jury et al. (1983, 1990) and Shan and Stevens (1995). However, the analytical solution techniques used by these authors were not applicable to the source emission module developed here because they did not consider the periodic addition of constituent mass and enhanced constituent mass loss rates in the surface soil from volatilization, runoff, wind and water erosion, leaching, and mechanical processes. The GSCM provides a new solution technique that is computationally efficient and sufficiently flexible to allow consideration of the LAU. It allows

- Constituent mass balance
- Waste additions and removals to simulate active facilities
- Joint estimation of constituent mass losses due to a variety of mechanisms, including

- — Volatilization of gas-phase constituent mass from the surface to the air
- — Leaching of aqueous-phase constituent mass by advection or diffusion from the bottom of the waste management unit (WMU) or vadose zone
- — First-order losses, which can include
  - Abiotic and biodegradation
  - Suspension of constituent mass adsorbed to surface particles due to wind action and vehicular activity
  - Suspension of constituent mass adsorbed to surface particles due to water erosion
  - Surface runoff of aqueous-phase constituent mass.

Section H2 describes the GSCM assumptions, governing equations, boundary conditions, and solution technique. Section H3 describes the application of the GSCM to the land-based LAU and its integration within the holistic local watershed module, including hydrology, soil erosion, and runoff water quality. Sections H4 and H5 describe the specifics of the GSCM's application and integration for the LAU. Appendix H-A lists and defines all symbols used in Sections H2 through H6. Appendices H-B and H-C provide supplementary information on determination of H', D_a, and D_w for organic compounds and particulate emission equations.

H2.0 Generic Soil Column Module

H2.1 Assumptions

The following assumptions were made in the development of the GSCM used in the LAU:

- The contaminant partitions to three phases: adsorbed (solid), dissolved (liquid), and gaseous (as in Jury et al., 1983, 1990).

$$C_T = \rho_b C_S + \theta_w C_L + \theta_a C_G \quad \text{(H-1)}$$

where

C_T = total contaminant concentration in soil (g/m^3 of soil)
ρ_b = soil dry bulk density (kg/m^3)
C_s = adsorbed-phase contaminant concentration in soil (g/kg of dry soil)
θ_w = soil volumetric water content (m^3 soil water/m^3 soil)
C_L = aqueous-phase contaminant concentration in soil (g/m^3 of soil water)
θ_a = soil volumetric air content (m^3 soil air/m^3 soil)
C_G = gas-phase contaminant concentration in soil (g/m^3 of soil air).

- The contaminant undergoes reversible, linear equilibrium partitioning between the adsorbed and dissolved phases (as in Jury et al., 1983, 1990).

$$C_S = K_d \; C_L \tag{H-2}$$

where K_d is the linear equilibrium partitioning coefficient (m^3/kg). For organic contaminants,

$$K_d = foc \cdot K_{oc} \tag{H-3}$$

where foc is the organic carbon fraction in soil and K_{oc} is the equilibrium partition coefficient (m^3/kg), normalized to organic carbon. Alternatively, K_d can be specified as an input parameter for inorganic contaminants.[1]

$$C_G = H' \; C_L \tag{H-4}$$

- Contaminant in the dissolved and gaseous phases is assumed to be in equilibrium and to follow Henry's law (as in Jury et al., 1983, 1990).

where H´ is the dimensionless Henry's law coefficient.

- The total contaminant concentration in soil can also be expressed in units of µg of contaminant mass per g of dry soil (µg/g):

$$C_T' = \frac{C_T}{\rho_b} \tag{H-5}$$

- Using the linear equilibrium approximations in Equations H-2 through H-5, C_T can be expressed in terms of C_L, C_S, or C_G:

$$C_T = K_{TL} C_L = \frac{K_{TL}}{K_d} C_S = \frac{K_{TL}}{H'} C_G \tag{H-6}$$

where

$$K_{TL} = \rho_b K_d + \theta_w + \theta_a H' \tag{H-7}$$

[1] It is implicit in this linear equilibrium partitioning assumption that the sorptive capacity of the soil column solids is considered to be infinite with respect to the total mass of contaminant over the duration of the simulation (i.e., the soil column sorptive capacity does not become exhausted).

K_{TL} is the dimensionless equilibrium distribution coefficient between the total and aqueous-phase constituent concentrations in soil.

- The total water flux or infiltration rate (I, m/d) is constant in space and time (as in Jury et al., 1983, 1990) and greater than or equal to zero. It is specified as an annual average.

- Material in the soil column (including bulk waste) can be approximated as unconsolidated homogeneous porous media whose basic properties (ρ_b, foc, θ_w, θ_a, and η—the total soil porosity) are average annual values, constant in space.

- Contaminant mass may be lost from the soil column as a result of one or more first-order loss processes.

- The total chemical flux is the sum of the vapor flux and the flux of the dissolved solute (as in Jury et al., 1983, 1990).

- The chemical is transported in one dimension through the soil column (as in Jury et al., 1983, 1990).

- The vapor-phase and liquid-phase porosity and tortuosity factors obey the module of Millington and Quirk (1961) (as in Jury et al., 1983, 1990). (See Equation H-9 below.)

- The modeled spatial domain of the soil column remains constant in volume and fixed in space with respect to a vertical reference (e.g., the water table).

H2.2 Governing Mass Balance Equation

Under the above assumptions, the governing mass fate and transport equation can be written as follows:

$$\frac{\partial C_T}{\partial t} = D_E \frac{\partial^2 C_T}{\partial z^2} - V_E \frac{\partial C_T}{\partial z} - kC_T \qquad \text{(H-8)}$$

where k (1/d) is the total first-order loss rate and D_E (m^2/d) is the effective diffusivity in soil calculated as follows:

$$D_E = \frac{(\theta_a^{10/3} D_a\ H' + \theta_w^{10/3} D_w)\ 8.64}{\eta^2 K_{TL}} \qquad \text{(H-9)}$$

where D_a and D_w (cm^2/s) are air and water diffusivities, respectively, and 8.64 is a conversion factor (m^2-s/cm^2-d). D_E can be considered to be the sum of the effective gaseous and water diffusion coefficients in soil, $D_{E,a}$, and $D_{E,w}$, respectively, where

$$D_{E,a} = \frac{\theta_a^{10/3} D_a \, H' \, 8.64}{\eta^2 K_{TL}} \qquad \text{(H-10)}$$

and

$$D_{E,w} = \frac{\theta_w^{10/3} D_w \, 8.64}{\eta^2 K_{TL}} \qquad \text{(H-11)}$$

The effective solute convection velocity (V_E, m/d) is equal to the water flux corrected for the contaminant partitioning to the water phase as follows:

$$V_E = \frac{I}{K_{TL}} \qquad \text{(H-12)}$$

H2.3 Parameter Estimation Methodologies

- Water content (θ_w) is estimated as a function of the annual average infiltration rate (I, m/d) using (Clapp and Hornberger, 1978):

$$\theta_w = \eta \cdot \left(\frac{I}{0.24 K_{sat}} \right)^{1/(2SM_b + 3)} \qquad \text{(H-13)}$$

where K_{sat} (cm/h) is saturated hydraulic conductivity, SM_b is a unitless exponent specified by soil-type, and 0.24 (h-m/d-cm) is a unit conversion factor.

- Volumetric air content is estimated using Equation H-14.

$$\theta = \eta - \theta_w \qquad \text{(H-14)}$$

- H´, D_a, and D_w can be either estimated as a function of temperature in the soil column (T_{sc}, °C) using the methods described in Appendix H-B or specified directly as input parameters if preadjusted values are available.

H2.4 Solution Technique

H2.4.1 Background

A solution of the complete convective-diffusive-decay concentration module (Equation H-8) was undertaken to evaluate, in a soil column of depth z_{sc},

- Total contaminant concentration as a function of time, t, and depth below the surface, z, for an arbitrary chemical

- Contaminant mass fluxes across the upper (z = 0) and lower boundaries ($z = z_{sc}$) of the soil column.

A numerical solution of Equation H-8, with zero concentration boundary condition at the surface and zero gradient lower boundary condition, was first examined as a straightforward explicit finite difference method. This approach resulted in such a high numerical diffusion that made it impossible to distinguish diffusion effects. By subdividing each section into relatively thinner sections, the numerical diffusion could be reduced to more acceptable levels, but then smaller time steps were required, and the computation time became quite long. In addition, the numerical solution was not stable in the extremes (e.g., high/low V_E or D_E).

An alternative, quasi-analytical approach was developed that allows for relative computational speed and significantly reduces concern about numerical diffusion and lack of stability. The tradeoff is a loss of ability to evaluate short-term trends in concentration and diffusive flux profiles. The method was developed to allow estimation of long-term (i.e., annual average) contaminant concentration profiles and mass fluxes.

The alternative approach developed consists of a superposition of analytic solutions of the three components of the governing equation (Equation H-8) on the same grid. The solution for the simplified case where the soil column consists of one homogeneous zone whose properties are uniform in space and time is described below. Adaptations of the solution technique to account for variations from this simplified case (e.g., more than one homogeneous zone as for a landfill with cover soil zone atop the waste zone) are described in the module-specific sections.

H2.4.2 Description of Quasi-Analytical Approach

A quasi-analytical approach was developed that is a step-wise solution of the three components of the governing equation (Equation H-8) on the same grid. Boundary conditions of C_T=0 at both the upper and lower boundaries of the soil column are assumed, although some flexibility exists in specifying the lower boundary condition, as discussed below. That is, the following equations are solved individually:

$$\frac{\partial C_T}{\partial t} = D_E \frac{\partial^2 C_T}{\partial z^2} \tag{H-15}$$

$$\frac{\partial C_T}{\partial t} = - V_E \frac{\partial C_T}{\partial z} \tag{H-16}$$

$$\frac{\partial C_T}{\partial t} = - k C_T \tag{H-17}$$

Equations H-15 through H-17 each have an analytical solution that can be combined to obtain a pure diffusion solution that moves with velocity V_E through the porous medium (Jost, 1960). The solution of the general differential equation then has the form of the solution of the diffusive portion with its time dependence, translating in space with velocity V_E, and decaying exponentially with time.

The first two solutions for a point source are graphically depicted in Figures H-1 and H-2 for illustration. If it were possible to compute such point source solutions for each position in the soil column and each time of interest, then the contributions at each point could be added to obtain a global solution because the governing differential equations are linear. That is, each point in the soil column could be treated as if it were the only point for which there is a nonzero concentration.

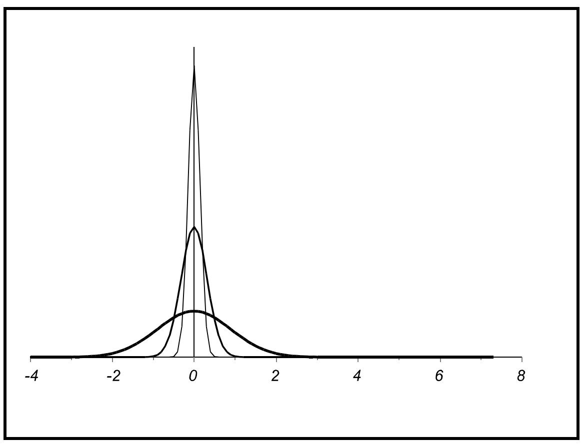

Figure H-1. Development of diffusive spreading from a point source with time, corresponding to times of 0.01, 0.05, and 0.4.

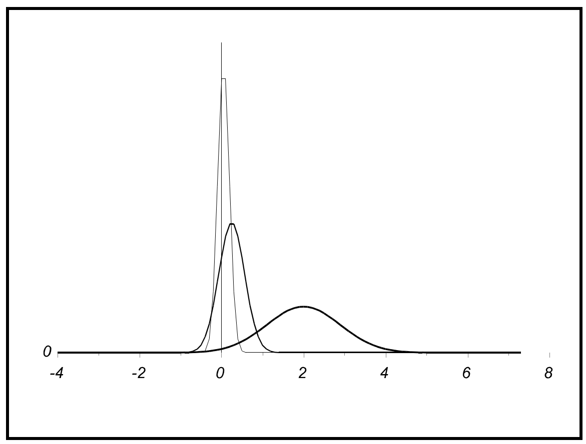

Figure H-2. Diffusive spreading from a point source with a constant velocity to the right at times of 0.01, 0.05, and 0.4.

To make the analysis tractable, instead of a point source, the soil column is divided into layer sources each of depth dz (i.e., a grid). A layer source can be thought of as multiple point sources packed closely together. In such a case, Equation H-15 has a solution for one-dimensional diffusion, with the concentration at any point and any time given by Equation H-18 for a layer of width dz centered at $z' = 0$ (Jost, 1960). The concentration profile is assumed to be initially uniform from $z' = -dz/2$ to $z' = +dz/2$ and zero everywhere else. With time, the profile spreads outward and the concentration at the origin decreases, as shown in Figure H-3 for dz=2. With a positive velocity V_E, the concentration profile also moves down the soil column as illustrated in Figure H-4. The use of layer solutions requires that we assume uniform average concentrations be assumed within each layer. Thus, the thickness of the layers determines the

$$C_T(z',t) = \frac{C_{T0}}{2}\left[erf\left(\frac{z'+dz/2}{\sqrt{4D_E t}}\right) + erf\left(\frac{dz/2-z'}{\sqrt{4D_E t}}\right)\right] \qquad \text{(H-18)}$$

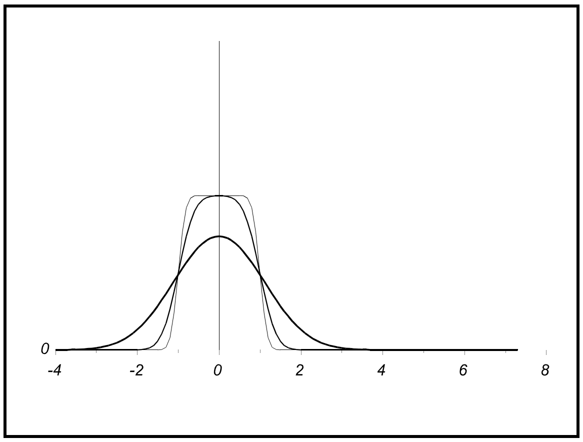

Figure H-3. Development of diffusive spreading from a layer source with time, corresponding to times of 0.01, 0.05, and 0.4.

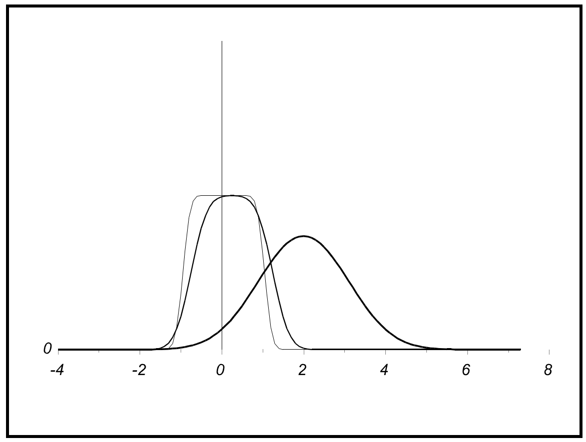

Figure H-4. Diffusive spreading from a layer source with a constant velocity to the right at times of 0.01, 0.05, and 0.4.

spatial resolution available.

The total amount of material, m, in g/m^2 that has passed any ordinate z′ after time t is given by the integral of the concentration from z′ to ∞ with one-half leaving to the left (negative z′ values) and one-half to the right (positive z′ values):

$$m(z',t) = 2\int_{z'}^{\infty} C_T(z,t)dz \qquad \text{(H-19)}$$

The integral in Equation H-19 can be derived as

$$m(z',t) = C_{T0}\sqrt{4D_E t}\left[\int_{(z'-dz/2)/\sqrt{4D_E t}}^{\infty} erfc(y)\,dy - \int_{(z'+dz/2)/\sqrt{4D_E t}}^{\infty} erfc(y)\,dy\right] \qquad \text{(H-20)}$$

which is evaluated using the relationship (Abramowitz and Stegun, 1970):

$$\int \text{erfc}(x)dx = x\,\text{erfc}(x) - \frac{1}{\sqrt{\pi}}\exp\left(-x^2\right) + \text{constant} \tag{H-21}$$

The fraction of the original mass that diffuses past a boundary at z′ in any time period 0 to t, Df(z′,t), is one-half m(z′,t) divided by the amount of mass initially present in g/m^2 in the source layer (C_{T0}·dz):

$$Df\,(z',t) = 0.5 \cdot \frac{\sqrt{4D_E t}}{dz}\left[\int_{(z'-dz/2)/\sqrt{4D_E t}}^{\infty} erfc(y)\,dy - \int_{(z'+dz/2)/\sqrt{4D_E t}}^{\infty} erfc(y)\,dy\right] \tag{H-22}$$

The fraction of mass that remains in the original layer of width dz after diffusion in the time period 0 to t, $Df_0(t)$, is

$$Df_0\,(t) = 1 - 2 \cdot Df\,(z' = 0.5dz, t) \tag{H-23}$$

By means of evaluations at all the layer boundaries (z′=0.5dz, 1.5dz, 2.5dz, ...), the amount of contaminant mass transported to any layer via diffusion after time t can be calculated as the difference between the amount outside the upstream boundary and the amount outside the downstream boundary. For example, the fraction of mass originally present in the source layer that ends up in the layer adjacent to the source layer in time t is Df(z′=0.5dz, t) -Df(z′=1.5dz, t). The integrated amounts of material that have crossed the layer boundaries and the amount that remains in the source layer after time t are given directly by Equations H-22 and H-23, respectively, and only have to be computed once for fixed time steps and layer thicknesses.

The amount of mass that diffuses from a given layer out the lower boundary of the soil column in time t can be tracked by multiplying Df(z’,t)—evaluated at the point where, for that layer, z’ is at the bottom of the soil column ($z = z_{sc}$)—by (C_{T0} ·dz) for that layer. Diffusive losses across the bottom boundary from all the soil column layers are summed to calculate the total diffusive (aqueous- and gaseous-phase) loss across the bottom boundary, $M_{lchd}(t)$ (g/m^2), in time t.

Likewise, by summing the total diffusive losses across the upper boundary from each layer, the total diffusive loss out the top of the soil column, $M_0(t)$ (g/m^2), is determined. The volatilization loss from the surface of the soil column, $M_{vol}(t)$ (g/m^2), is assumed to be due to gaseous-phase diffusion only and is determined by

$$M_{vol}(t) \;=\; M_0(t) \;\cdot\; \frac{D_{E,a}}{D_E} \tag{H-24}$$

where ($D_{E,a}/D_E$) is the fraction of the total diffusive loss from any layer that is due to diffusion in the gaseous phase in the soil.

It is assumed that mass is not lost across the top boundary due to diffusion in the aqueous phase in the soil. In order to maintain mass balance, mass calculated to be lost this way is added back into the top layer in the soil, augmenting the total contaminant concentration there by ($M_0(t) \cdot D_{E,w}/D_E$). This method of obtaining $M_{vol}(t)$ is an approximation, justified on the basis of computational efficiency. A more rigorous treatment would include a mathematical transition layer across which diffusion from the soil to the air occurs. However, use of such a transition layer would require a more computationally intensive solution technique, as well as specification of the thickness of the transition layer.

Without this approximation (i.e., if $M_{vol}(t) = M_0(t)$), $M_{vol}(t)$ could be greater than zero for nonvolatile contaminants ($D_a = H' = 0$) because of the possible contribution to M_0 from the aqueous-phase diffusive flux. It is believed that this method of estimating $M_{vol}(t)$ and augmenting the total contaminant concentration in the surface layer represents a reasonable approximation of what actually occurs. That is, contaminant mass diffuses to the surface in both the aqueous and gaseous phases. While the contaminant mass in the gas phase volatilizes out the surface of the soil column, the contaminant mass in the aqueous phase is left behind, concentrating the contaminant mass in surface soil (approximated here as the surface soil column layer).

To account for decay, Equation H-17 is solved readily by the technique of separation of variables (Jost, 1960). It has a solution of the form

$$C_T = C_{T0} \exp\left(-kt\right) \tag{H-25}$$

As Equation H-25 is applied to each layer, the amount of mass lost as a result of first-order decay in time, t, M_{loss} (g/m^2), can be tracked using

$$M_{loss}(t) = \left(1 - \exp(-kt)\right) C_{T0} \cdot dz \tag{H-26}$$

Where multiple first-order loss processes may occur (i.e., $k = \sum k_j$), the fraction of initial mass present lost as a result of each process j is determined using

$$M_{loss,j}(t) = \frac{k_j}{k} M_{loss}(t) \tag{H-27}$$

A potential difficulty with the layer solution is that the convection of material leads to an artificial numerical diffusion because the concentration within each layer can only be expressed as an average value. This component of numerical diffusion can be avoided completely if the contents of each layer are transferred completely to the next layer at the end of each time step by making the time step equal to the layer thickness divided by the effective velocity, V_E:

$$dt = \frac{dz}{V_E} \tag{H-28}$$

The contaminant mass in the bottom layer is convected out of the lower boundary. Total mass lost due to advection in dt, M_{lcha} (g/m^2), is simply C_{T0} in the lowest soil column layer times dz.

To summarize the overall solution technique, the three processes (diffusion, 1st order losses, and advective transport) are considered separately, in series, and then combined (under the justification of the superposition principle for linear differential equations) to result in the chemical concentration vertical profile at the end of a computational time step. Specifically, the chemical concentration profile after diffusion only is first simulated. Following diffusion, the chemical mass in each computational cell (the mass after diffusion) is then decreased in accordance with the first order loss model. Finally, after a sufficient time has elapsed (which may take multiple time steps) for the chemical mass in a cell to have advected (at the sorption-corrected, velocity) a distance equal to the thickness of the cell, all chemical mass in each cell is translated to the next lower cell. This completes the series solution of the overall fate and transport governing equation.

H2.4.2.1 <u>Boundary Conditions</u>. Zero concentration is assumed at the upper boundary of the soil column. This is consistent with the assumption that the air is a sink for volatilized contaminant mass, but requires the approximate method for estimating $M_{vol}(t)$ described above.

At the lower boundary of the soil column, the flexibility exists with this solution technique to specify a value between zero and 1 for the ratio (bcm) of the total contaminant concentration in the soil directly below the modeled soil column and in the soil column. A ratio of one (bcm=1) corresponds to a zero gradient boundary condition ($dC_T/dz=0$). A ratio of zero (bcm=0) corresponds to a zero concentration boundary condition ($C_T=0$).

When bcm is equal to zero, diffusive fluxes at the upper and lower boundaries of the soil column are calculated directly as described above. When bcm is greater than zero, a reflection of the soil column is created. The contaminant concentrations in the reflected soil column cells are set equal to bcm times the contaminant concentration in the soil column cell being reflected (i.e., the concentration in the first cell of the reflected soil column is set to bcm times the contaminant concentration in the lowest cell of the actual soil column). The upward diffusive flux from the reflected soil column cells (1) offsets the diffusive flux out the lower boundary of the soil column, (2) increments the contaminant concentrations in the soil column, and (3) augments the diffusive flux out the upper boundary of the soil column. Hence, when bcm is equal to 1 (the no diffusion boundary condition), the downward diffusive flux out the bottom boundary of the soil column is completely offset by the upward diffusive flux across the same boundary from the reflected soil column cells.

H2.4.2.2 <u>Algorithm</u>. The general algorithm for applying the individual solutions to Equations H-15 through H-17 is as follows for a homogeneous soil column and an averaging time period of 1 year:

1. Specify

   - Lower boundary condition multiplier (bcm)
   - Initial conditions in soil column (C_{T0})

- Soil column size (z_{sc}) and properties (ρ_b, foc, η, K_{sat}, SM_b)
- First-order loss rates (k_j)
- Chemical properties (K_{oc}, H', D_a, D_w)
- Upper and lower averaging depths (z_{ava}, z_{avb}).

2. Calculate/read K_d. K_d is internally calculated for organics ($K_d = K_{oe} \times F_{oc}$), and read as a user input for metals.

3. Subdivide the soil column into multiple layers of depth, dz, that are an integral fraction of z_{sc}. Calculate the total number of layers, $N_{dz} = z_{sc}/dz$.

4. Get annual average infiltration rate (I) for the year.

5. Calculate θ_w, θ_a, K_{TL}, D_E, V_E.

6. Calculate the time to cross a single layer at velocity V_E (Equation H-28). This is the convection-based computing time step, dt. See also note below.

7. Evaluate the fraction of mass that remains in a layer (Equation H-25) and that diffuses across layer boundaries z'= 0.5dz, 1.5dz, 2.5dz,... (Equation H-24) at t=dt. (These fractions are constant for a fixed dt.)

8. Calculate the amount of mass present in the soil column at the beginning of the year (M_{col1}, g/m^2).

9. Initialize cumulative mass loss variables (M_{vol}, M_{lchd} , M_{lcha}, $M_{loss,j}$).

10. <u>Diffusion.</u> Adjust the concentration profile to reflect diffusive fluxes for one time step. This redistributes material throughout the whole soil column. Increment M_{vol} and M_{lchd}.

11. <u>First-order losses</u>: Allow the concentration profile to decay in each layer (Equation H-27) for one time step. Increment mass lost due to all applicable first-order loss processes, j, $M_{loss,j}$ (Equation H-25).

12. <u>Convection:</u> Propagate the concentration profile one layer downstream. Increment M_{lcha}.

13. Repeat Steps 10 through 12 until it is time to add and/or remove contaminant mass (go to Step 14) or until the end of the year (go to Step 15).

14. To account for the addition of contaminant mass, update the contaminant concentrations in the affected layers. Track total mass added (M_{add}, g/m^2) and/or removed (M_{rem}, g/m^2). Begin the algorithm again at Step 10.

15. At end of the year, calculate/report

- Total mass in the soil column (M_{col2}, g/m^2)
- Mass balance error for the year (M_{err}, g/m^2):

$$M_{err} = M_{col2} - M_{col1} - M_{add} + M_{rem} + M_{vol} + M_{lcha} + M_{lchd} + \sum_j M_{loss,j} \quad \text{(H-29)}$$

- Annual average total concentration in surface layer
- Annual, depth-weighted average total concentration ($z_{ava} \leq z \leq z_{avb}$)
- Annual average volatilization flux (J_{vol}, g/m^2/d):

$$J_{vol} = \frac{M_{vol}}{365} \quad \text{(H-30)}$$

- Annual average leaching flux (J_{lch}, g/m^2/d):

$$J_{lch} = \frac{M_{lchd} + M_{lcha}}{365} \quad \text{(H-31)}$$

16. Begin the algorithm again at Step 4 until mass is no longer added to the soil column and mass has been depleted from the soil (i.e., M_{col2} =0).

Note that the convection time step cannot be any greater than the length of time between mass additions or removals (e.g., waste applications in an LAU). For example, if contaminant mass is added every 30 days, this is the maximum time step, regardless of how small the velocity is. When dt is limited in this fashion, the number of time steps required before a convective transfer can take place is determined, and the convective transfer step is performed on an "as-needed" basis. If the calculated convective time step is 60 days, in this example, the convective transfer would occur every other time step. This will result in a temporal distortion of the concentrations within the layers, but over several steps and, by the end of the year, preliminary module runs show that the effects average out.

The primary means by which the performance of the solution algorithm is checked is via the annual mass balance check (Equation H-29) to ensure that the change in mass in the system over the year is equal to the difference between mass additions and losses. If M_{err} is greater than 10^{-8} g/m^2, a message is written to the warning file.

H2.5 Limitations Related to Use of GSCM

The following limitations are noted for the GSCM:

- The GSCM was developed originally for organic contaminants and assumes that the partition efficient, K_d, is linear and is estimated as the product of K_{oc} and f_{oc}. Partitioning for metals involves complex chemistry, including the dynamic effects of aqueous-phase contaminant concentration, precipitation, dissolution, adsorption/desorption, and the geochemistry of media (e.g., oxidation-reduction conditions) on the value of K_d and the fate and transport behavior of metals in general. This complexity is not modeled by the GSCM for metals partitioning; rather, K_d is externally provided as a randomly sampled value by the chemical properties processor (CPP).

- With organic contaminants, the GSCM is not applicable if nonaqueous phase liquid (NAPL) is present. Similarly, with metals, the presence of a precipitate is not allowed. The presence of NAPL (precipitate) is determined by comparing C_T to the theoretical maximum contaminant concentration in soil without NAPL (precipitate), determined by the aqueous solubility, saturated soil-gas concentration of the contaminant, and the sorptive capacity of the soil. The limit on C_T is estimated using

$$C_T < K_{TL} C_L^{sol} \tag{H-32}$$

where C_L^{sol} (g/m^3) is the aqueous solubility. It is expected that in most circumstances exit levels will be sufficiently low that the presence of NAPL (precipitate) would be precluded.

- The algorithm is being applied to develop source release estimates on an annual average basis, to support estimation of chronic (long-term average) risk estimates. Some of the inputs used (e.g., infiltration) are long-term annual average estimates, while others are annual average. Accordingly, the outputs are not strictly applicable to individual years.

- The module allows consideration of only one contaminant at a time and does not simulate fate and transport of reaction products in its current form. With further module development, it would be possible to track the production of reaction products in each soil column layer and use basically the same algorithm that is used for the parent compound to module the fate of reaction products.

- The solution technique used, sequential solutions to the three-component differential equations of the governing differential equation, allows computational efficiency. However, systematic errors could result from the choice of the order in which these solutions are applied. The size of the error would be dependent on the relative loss rates associated with the three processes. For example, if the first- order loss rate due to degradation were high and losses due to degradation were calculated first, then less contaminant mass would be available for diffusive and advective losses. The current algorithm prioritizes diffusive losses because the diffusion equation is solved first. This is followed by first-order losses and advection, respectively.

- As discussed, a boundary condition at the soil/air interface of $C_T = 0$ was assumed in developing this solution technique. This is consistent with the assumption that the air is a sink for volatilized contaminant mass. However, as discussed in

Section H2.4.1, because the diffusion coefficient used in the governing equation (Equation H-8) includes diffusion in both the air and aqueous phases of the soil, contaminant mass that is transported upward in the soil column via diffusion can include mass in both the air and aqueous phases. Although this is appropriate within the soil where the ratio of air to water is relatively constant, the assumption breaks down at the soil/air interface itself. To account for the fact that contaminant mass in the aqueous phase should not be lost out of the surface of the soil column—which, for example, would lead to nonzero volatilization fluxes for nonvolatile contaminants (D_a = H′ =0)—the volatilization flux at the surface is assumed to include only the diffusive flux due to gas-phase diffusion. Mass estimated to be lost from the surface due to aqueous-phase diffusion is added back into the surface soil column layer, augmenting the contaminant concentration there and maintaining mass balance. This is an approximation, justified on the basis of computational efficiency; nonetheless, the approximation should be in reasonable agreement with what actually occurs in nature.

H3.0 Local Watershed/Soil Column Module

H3.1 Introduction

The LAU source emissions module is required to provide annual average contaminant mass flux rates from the surface of the LAU and its subsurface interface with the vadose zone, total contaminant concentration in the surface material, and contaminant mass emission rate due to particulate emissions. In addition, because these LAUs are on the land surface, they are integral land areas in their respective watersheds and, consequently, are not only affected by runoff and erosion from upslope land areas, but also affect downslope land areas through runoff and erosion. Indeed, after some period of time during which runoff and erosion has occurred from an LAU, the downslope land areas will have been contaminated and their surface concentrations could approach (or conceivably even exceed long after LAU operation ceases) the residual chemical concentrations in the LAU at that time. Thus, after extensive runoff and erosion from an LAU, the entire downslope surface area can be considered a “source,” and it becomes important to consider these “extended source” areas in the risk assessment. It is for this reason that a holistic modeling approach has been taken with the LAU source module to incorporate them into the watershed of which they are a part.

The watershed including an LAU is termed here the “local” watershed and is illustrated in Figure H-5. A local watershed is defined as that drainage area that just contains the LAU or a portion thereof (there can be multiple local watersheds) in the lateral (perpendicular to runoff flow) direction, and in which runoff occurs as overland flow (sheet flow) only. Thus, a local watershed extends downslope only to the point that runoff flows and eroded soil loads would enter a well-defined drainage channel, e.g., a ditch, stream, lake, or some other waterbody. The sheet-flow-only restriction is based on the assumption that any subareas downslope of the LAU subarea are subject to chemical contamination from the LAU through overland runoff and soil erosion.

Figures H-6 and H-7 illustrate how the local watershed is conceptualized for the combined Local Watershed/Soil Column Module, that is, as a two-dimensional, two-medium

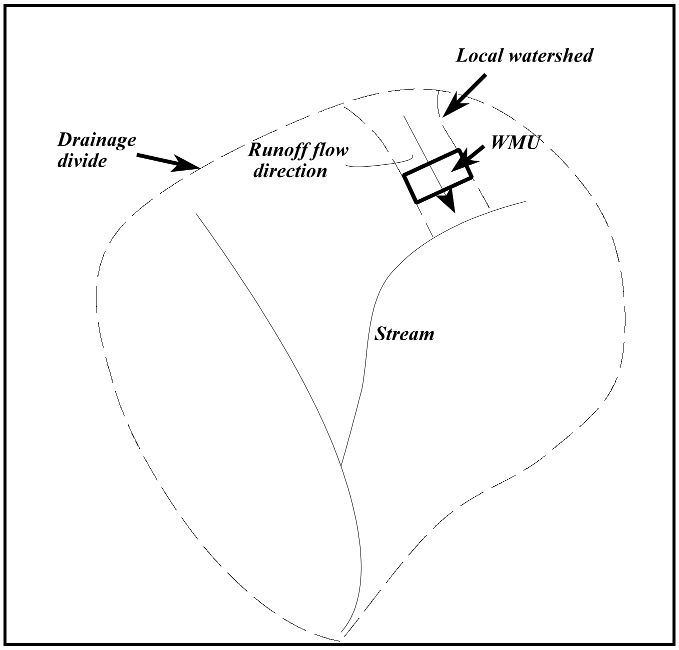

Figure H-5. Local watershed containing WMU.

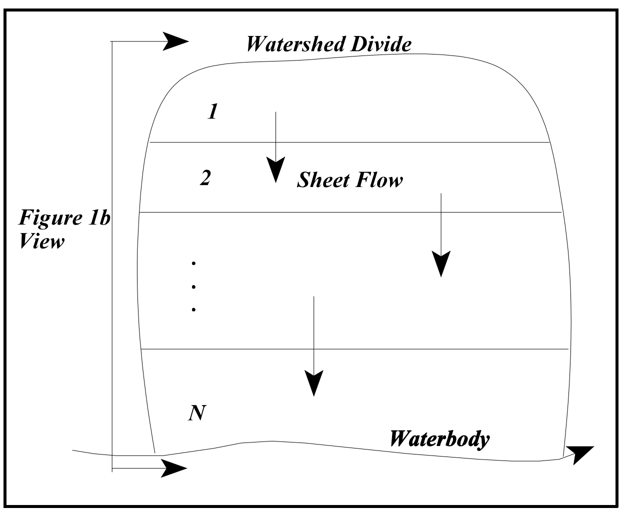

Figure H-6. Local watershed.

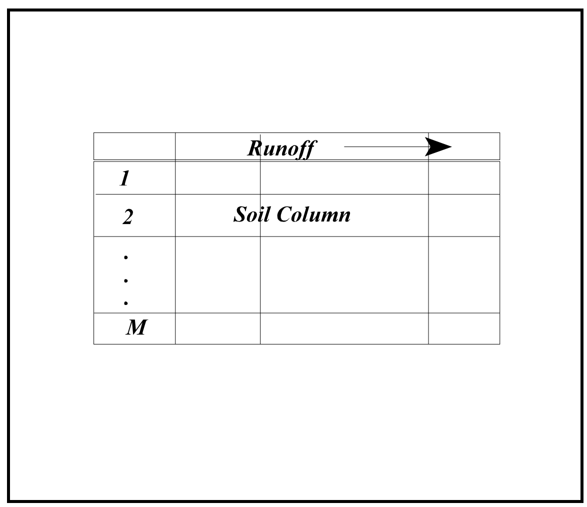

Figure H-7. Cross-section view of watershed.

system. The dimensions are longitudinal, i.e., downslope or in the direction of runoff flow, and vertical, i.e., through the soil column. The media are the soil column and, during runoff events, the overlying runoff water column. The local watershed is assumed to be made up of, in the longitudinal direction, an arbitrary number of land subareas that may have differing surface or subsurface characteristics, e.g., land uses, soil properties, and chemical concentrations. For example, subarea 2 might be an LAU, subarea 1 would then represent an upslope area, and subareas 3 through N would be downslope buffer areas extending to the waterbody.

H3.2 Hydrology

H3.2.1 Overview

Hydrologic modeling is performed to simulate watershed runoff and groundwater recharge (termed here "infiltration"). The hydrology module is based on a daily soil moisture water balance performed for the root zone of the soil column. At the end of a given day, t, the soil moisture in the root zone of an arbitrary watershed subarea, i, is updated as

$$SM_{i,t} = SM_{i,t-1} + P_t + RO_{i-1,t} - RO_{i,t} - ET_{i,t} - IN_{i,t} \quad \text{(H-33)}$$

where

$SM_{i,t}$ = soil moisture (cm) in root zone at end of day t for subarea i
$SM_{i,t-1}$ = soil moisture (cm) in root zone at end of previous day for subarea i
P_t = total precipitation (cm) on day t
$RO_{i-1,t}$ = storm runoff (cm) on day t coming onto subarea i from i-1
$RO_{i,t}$ = storm runoff (cm) on day t leaving subarea i
$ET_{i,t}$ = evapotranspiration (cm) from root zone on day t for subarea i
$IN_{i,t}$ = infiltration (groundwater recharge) on day t (cm) for subarea i.

Precipitation is undifferentiated between rainfall and frozen precipitation; that is, frozen precipitation is treated as rainfall. Runoff, evapotranspiration, and infiltration losses from the root zone are discussed in subsequent sections. The equations presented in these sections refer to "day t and subarea i" in accordance with the above water balance equation (Equation H-33).

H3.2.2 Runoff

H3.2.2.1 <u>Governing Equations.</u> Daily runoff is based on the Soil Conservation Service's (SCS's) widely used "curve number" procedure (USDA, 1986) and is a function of current and antecedent precipitation and land use. Land use is considered empirically by the curve numbers, which are catalogued by land use or cover type (e.g., woods, meadow, impervious surfaces), treatment or practice (e.g., contoured, terraced), hydrologic condition, and hydrologic soil group.

Runoff depth is calculated by the SCS procedure as

$$RO = \frac{(P - Ia)^2}{P - Ia + S} \quad for\ P \geq Ia \quad \text{(H-34)}$$

where

RO = runoff depth (cm)
P = precipitation depth (cm)
Ia = initial abstraction (threshold precipitation depth for runoff to occur) (cm)
S = watershed storage (cm).

By experimentation with over 3,000 soil types and cover crops, the SCS developed the following relationships for watershed storage as a function of CN and initial abstraction as a function of storage.

$$S = \frac{2540}{CN} - 25.4 \qquad \text{(H-35)}$$

$$Ia = 0.2S \qquad \text{(H-36)}$$

Combining Equations H-34 and H-35 results in

$$RO = \frac{(P - 0.2S)^2}{P + 0.8S} \quad for \;\; P \geq 0.2S \qquad \text{(H-37)}$$

$$RO = 0 \quad for \;\; P < 0.2S \qquad \text{(H-38)}$$

where S is given by Equation H-35. For impervious surfaces (CN = 100), it can be seen that RO = P.

Three antecedent moisture classes (AMCs) have been defined for use in adjusting the SCS curve numbers as shown in Table H-1. The growing season is assumed to be June through August (Julian Day 152 to 243) throughout the country.

Curve numbers are typically presented in the literature assuming average antecedent moisture conditions (AMC II) and can be adjusted for drier (AMC I) or wetter (AMC III) conditions as (Chow et al., 1988).

Table H-1. Antecedent Moisture Classes for SCS Curve Number Methodology

	Total 5-Day Antecedent Rainfall (cm)	
AMC Class	**Dormant Season**	**Growing Season**
I	< 1.3	< 3.6
II	1.3 to 2.8	3.6 to 5.3
III	> 2.8	> 5.3

Source: U.S. EPA (1985b).

These adjustments have the effect of increasing runoff under wet antecedent conditions and decreasing runoff under dry antecedent conditions, relative to average conditions.

H3.2.2.2 <u>Implementation</u>. Recall the conceptual module for the local watershed (Figure H-6), where the subareas may have different land uses and different curve numbers for each subarea. Equation H-37 is nonlinear in the curve number; therefore, the method by which the SCS procedure is applied to multiple subareas can make a significant difference in the resulting cumulative runoff values for downslope subareas. There are essentially two options for implementing the procedure. The first is based on runoff **routing** from each subarea to the next downslope subarea. That is, the runoff depth from subarea 1 would first be calculated from Equation H-37. The cumulative runoff depth from subareas 1 and 2 would then be calculated by applying Equation H-37 to subarea 2 and adding (routing) the runoff depth from subarea 1. This would be repeated for all subareas. This method is **not** appropriate for the sheet flow assumption of the local watershed and can give much higher cumulative runoff depths (volumes) than would actually occur under the sheet flow assumption. (The implicit assumption of the routing method is that the subareas are not hydrologically connected, e.g., runoff from subarea 1 is captured in a drainage system (non-sheet-flow) and diverted directly to the watershed outlet without passing through/over downslope subareas.)

A different, nonrouting method is appropriate for implementing the SCS procedure for the local (sheet flow) watershed. The method is based on determining composite curve numbers and is analogous to the nonsoil routing implementation of the Universal Soil Loss Equation (USLE) soil erosion module presented in Section H3.3. The methodology used for implementing this method is illustrated by the following pseudo-code:

$$CN(I) = \frac{4.2CN(II)}{10 - 0.058CN(II)} \tag{H-39}$$

$$CN(III) = \frac{23CN(II)}{10 + 0.13CN(II)} \tag{H-40}$$

FOR i = 1,...,N (subareas)

- $CNeff_i$ = area-weighted composite CN_i for all subareas j, j=1,...,i
- Calculate S_i from equation (3.2.2-2) using $CNeff_i$
- Calculate RO_i from equation (3.2.2-1) using S_i. (RO_i is the ***average*** runoff depth over all upslope subareas j, j=1,...,i).
- Calculate $Q_i = RO_i*WSA_i$ where Q_i is cumulative runoff volume and WSA_i is cumulative area.
- IF i = 1 THEN
- $H1_i = RO_i$ where $H1_i$ is subarea-specific runoff depth for subarea i, i.e. $RO_i - RO_{i-1}$
- ELSE
- $H1_i = (Q_i - Q_{i-1})/A_i$ where A_i is subarea-specific surface area
- IF $H1_i < 0$ THEN $H1_i = 0$
- END IF

NEXT i

H3.2.3 Evapotranspiration

Potential evapotranspiration (PET) is the demand for soil moisture from evaporation and plant transpiration. When soil moisture is abundant, actual evapotranspiration (ET) equals PET. When soil moisture is limiting, ET will be less than PET. The extent to which it is less under limiting conditions has been expressed as a function of PET, available soil water (AW), and available soil water capacity (AWC) as shown in Equation H-41 (Dunne and Leopold, 1978):

$$ET = PET * f(\frac{AW}{AWC}) \quad \text{(H-41)}$$

where

f = a functional relationship of the arguments.

and

$$AW = (SM - WP)\frac{DRZ}{100} \quad \text{(H-42)}$$

$$AWC = \left(FC - WP\right)\frac{DRZ}{100} \quad \text{(H-43)}$$

where

WP = soil wilting point (% volume), which is the minimum soil moisture content that is available to plants. (Plants can exert a maximum suction of approximately 15 atmospheres. The wilting point is that moisture that would not be available at 15 atmospheres.)

FC = soil field capacity (% volume), which is the maximum soil moisture content that can be held in the soil by capillary or osmotic forces. Soil moisture above the field capacity is readily drained by gravity.

DRZ = depth of the root zone (cm).

The functional relationship in Equation H-41 is assumed here to be linear, so that ET (cm) is calculated as

$$ET = \min[PET,\ PET(\frac{SM - WP}{FC - WP})] \quad \text{(H-44)}$$

PET is estimated as described below.

The more theoretically based modules for daily evapotranspiration (e.g., the Penman-Monteith equation [Monteith, 1965]) rely on the availability of significant daily meteorological data, including temperature gradient between surface and air, solar radiation, windspeed, and relative humidity. All of these variables may not be readily available for all application sites. Therefore, a less data-demanding module, the Hargreaves equation (Shuttleworth, 1993), is proposed. The Hargreaves method, which is primarily temperature-based, has been shown to provide reasonable estimates of evaporation (Jensen, 1990)—presumably because it also includes an implicit link to solar radiation through its latitude parameter (Shuttleworth, 1993).

The Hargreaves equation is

$$PET = 0.0023 S_0 \Delta_T^{0.5} (T + 17.8) * 0.1 \qquad \text{(H-45)}$$

where

PET = potential evapotranspiration (cm/d)

T = mean daily air temperature (° C)

Δ_T = difference in mean monthly maximum and mean monthly minimum air temperature

S_0 = water equivalent of extraterrestrial radiation (mm/d) and is given as (Duffie and Beckman, 1980)

$$S_0 = 15.392 d_r (\varpi_s Sin\phi Sin\theta + Cos\phi Cos\theta Sin\varpi_s) \qquad \text{(H-46)}$$

where

$$d_r = 1 + 0.033 Cos(\frac{2\pi}{365} J) \qquad \text{(H-47)}$$

and

J = Julian day
ϖ_s = sunset hour angle (radians) given by

$$\varpi_s = Arccos(-Tan\phi Tan\theta) \qquad \text{(H-48)}$$

ϕ = site latitude (positive for northern hemisphere, negative for southern)

θ = solar declination (radians) given by

$$\theta = 0.4093 Sin(\frac{2\pi}{365} J - 1.405) \tag{H-49}$$

H3.2.4 Infiltration (Recharge)

Soil moisture in excess of the soil's field capacity (FC), if not used to satisfy ET, is available for gravity drainage from the root zone as infiltration to subroot zones (Dunne and Leopold, 1978). This infiltration rate will, however, be limited by the root zone soil's saturated hydraulic conductivity. Accordingly, infiltration is calculated as

$$IN = \min[Ksat,\ (SM - FC)\frac{DRZ}{100}] \tag{H-50}$$

where

IN = infiltration rate (cm/d)
Ksat = saturated hydraulic conductivity (cm/d).

In the event that infiltration is limited by Ksat, the hydrology algorithm includes a feedback loop that increases the previously calculated runoff volume by the amount of excess soil moisture, i.e., the water above the field capacity that exceeds Ksat. This adjustment is made to preserve water balance and is based on the assumption that the runoff curve number method, which is only loosely sensitive to soil moisture (through the antecedent precipitation adjustment), has admitted more water into the soil column than can be accommodated by ET, infiltration, and/or increased soil moisture. After the runoff is increased for this excess, the ET, infiltration, and soil moisture are updated to reflect this modification and preserve the water balance.

H3.3 Soil Erosion

H3.3.1 General

The soil erosion module is based on the uniform soil loss equation (USLE), an empirical methodology (see, e.g., Wischmeier and Smith, 1978) based on measured soil losses from experimental field-scale plots in the United States for some 40,000 storms. The USLE predicts sheet and rill erosion from hillsides upslope of defined drainage channels, such as streams. It does not predict streambank erosion.

Let SL (kg/m^2-time) denote the eroded soil flux (unit load) from a hillside area over some time period. SL is predicted by the USLE as the product of six variables:

$$SL = R \times K \times C \times P \times LS \times Sd \tag{H-51}$$

These variables are discussed below.

- **R, the rainfall factor (1/time),** accounts for the erosive (kinetic) energy of falling raindrops, which is essentially controlled by rainfall intensity. The kinetic energy of an individual storm times its maximum 30-minute intensity is sometimes called the erosivity index (EI) factor. R factors are developed by cumulating these individual storm EI factors. R factors have been compiled throughout the United States on a long-term annual average basis.

- **K, the soil erodibility factor (kg/m^2),** is an experimentally determined property and is a function of soil type, including particle size distribution, organic content, structure, and profile. K values are available from soil surveys and databases such as STATSGO.

- **C, the dimensionless "cropping management" factor,** varies between 0 and 1. It accounts for the type of cover (e.g., sod, grass type, fallow) on the soil. C is used to correct the USLE prediction relative to the cover type for which the experimentally determined K values were measured (fallow or freshly plowed fields).

- **P, the dimensionless practice factor,** accounts for the effect of erosion control practices such as contouring or terracing. P is never negative, but could be greater than 1.0 if land practices actually encourage erosion relative to the original experimental plots on which K was measured.

- **LS, the length-slope factor,** accounts for the effects of the length and angle of the slope of a field on erosion losses. LS is calculated by (U.S. EPA, 1985b) as follows:

$$LS_i = (.045X_i)^b (65.41 Sin^2\theta + 4.56 Sin\theta + .065) \quad \text{(H-52)}$$

where

X_i	=	flow length (m) from the point at which sheet flow originates (the upslope drainage divide) to the point of interest on the hillside.
θ	=	slope angle (degrees), where θ may be calculated from percent slope, S, as

$$\theta = \arctan(S/100) \quad \text{(H-53)}$$

and b, the exponent, is determined as a function of S as

$b = 0.5$, if $S > .05$
$b = 0.4$, if $.035 <= S <= .045$
$b = 0.3$, if $.01 <= S < .035$
$b = 0.2$, if $S < .01$.

LS increases with increasing flow length because runoff quantity generally increases with flow length. It increases with slope because runoff velocity generally increases with slope.

- **Sd, the sediment delivery ratio,** estimates the fraction of onsite eroded soil that reaches a particular downslope or downstream location in a watershed subbasin (Shen and Julien, 1993). The sediment delivery ratio is used to account for deposition of eroded soil from the local watershed in ditches, gullies, or other depressions.

  Vanoni (1975) developed the sediment delivery ratio as a function of watershed drainage area:

$$Sd = a \times A^{-.125} \tag{H-54}$$

where

Sd	=	sediment delivery ratio (dimensionless)
A	=	subbasin area (m^2)
a	=	normalized to give Sd = 1.0 for an area of 0.001 mi^2 as per Vanoni (1975). (For area in m^2, a = 2.67.).

H3.3.2 Daily USLE Implementation

For the LAU Module, USLE is implemented on a storm event basis using a modified USLE procedure. This implementation requires determining a daily R value (R_t, with units of 1/day) that specifies the erosivity of each daily storm.

For this implementation of the LAU Module, R_t is allocated from published long-term annual total R values. Published values of long-term annual total R values, which exist in the form of isopleths across the country, are disaggregated down to a daily basis using the following method:

Given: Long-term annual total R, Rann, for a site, (obtained from the isopleths)
Given: Number of years in the simulation, NYR.
Given: Hourly time series of precipitation amounts for the complete record of NYR years.

1. Compute cumulative R over record, R_{total} = Rann x NYR

2. Compute cumulative precipitation over NYR years, PPT_{total}

3. For each hourly precipitation value in the record, allocate R_{total} to that hour based on the fraction of PPT_{total} represented by the hourly precipitation. Denote an hourly allocation as R_{hour}.

4. For each day of the record, cumulate all R_{hour} values to the daily total. The result is R_t for each day of the NYR record.

H3.3.3 Spatial Implementation

For the local watershed application, the daily USLE is applied spatially to a hillside that comprises N subareas (see Figure H-6). Pseudo-code for this application is

LET CSL_i = cumulative soil load (kg/day) for subarea i, i.e. eroded load from subarea i and all upslope subareas j, j = 1,...,i
LET WSA_i = cumulative land area (m^2) upslope of and including subarea i

FOR i=1,...,N
    $Keff_i$ = area-weighted K_i for all subareas j, j=1,...,i
    $Ceff_i$ = area-weighted C_i for all subareas j, j=1,...,i
    $Peff_i$ = area-weighted P_i for all subareas j, j=1,...,i
    $CSL_i = R*WSA_i*Keff_i*Ceff_i*Peff_i*LS_i*Sd_i$
NEXT i

H3.4 Chemical Fate and Transport

H3.4.1 Runoff Compartment

H3.4.1.1 <u>Introduction</u>. The module used to estimate chemical and suspended solids concentrations in storm event runoff is based on mass balances of solids and chemical in the runoff and the top soil column layer of thickness dz. The soil compartment is external to this module (see Section H3.4.2) and results from that compartment are called as needed by the software. A simplifying assumption is made that solids and chemical concentrations in the runoff are at instantaneous steady-state during each individual runoff event, but can vary among runoff events (i.e., a quasi-dynamic approach). The assumption of instantaneous steady-state for each storm event is appropriate for the following reasons:

- Run time considerations (i.e., maximize the numerical time step).

- Data are not available at the temporal scale to accurately track within-storm event conditions (e.g., rainfall hyetographs).

- Because of the anticipated relatively small surface areas of the watershed subareas and the associated relatively small runoff volumes, the actual time to steady-state may not differ significantly from the 1 day or less implicitly assumed here. (A sensitivity analysis was performed using a dynamic form of the runoff compartment module that suggested relatively little difference in soil concentrations as a function of the steady-state versus dynamic assumption.)

- To the extent that the actual time to steady-state would be greater than 1 day, the module is biased toward overestimating downslope concentrations and waterbody loads (i.e., it is a protective assumption from the risk standpoint).

Figure H-8 presents the conceptual runoff quality module showing the two compartments and the fate and transport processes considered. Development of mass balance equations for solids and chemical follow.[2]

H3.4.1.2 <u>Solids in Runoff Compartment</u>. A steady-state mass balance of solids in the runoff (i.e., suspended solids from erosion), written for arbitrary local watershed subarea i is given by the following equation (in the subsequent module development, units are presented in general dimensional format, i.e., M(ass)-L(ength)-T(ime), for simplicity of presentation):

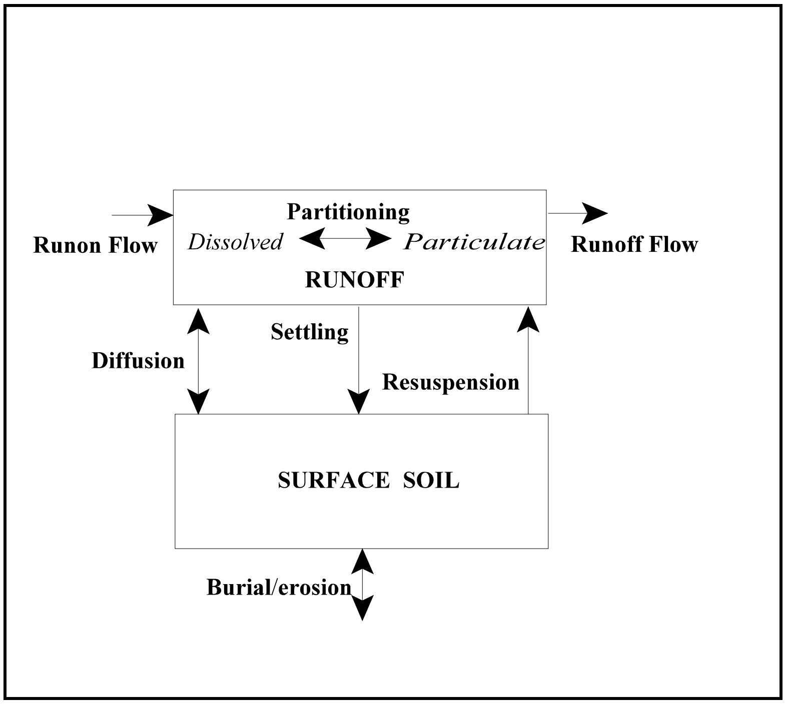

Figure H-8. Runoff quality conceptual model.

[2] Hydrolysis, volatilization, and biodegradation processes are not simulated in the runoff compartment. The percentage of time that runoff is actually occurring will be sufficiently short that any additional losses from these processes should be minimal. In addition, these processes are continuously simulated in the surface layer of the soil column. To also include them in the runoff compartment would be double-counting.

$$0 = Q'_{i-1} m_{1,i-1} - Q'_i m_{1,i} - vs_i A_i m_{1,i} + vr_i A_i m_2 \qquad \text{(H-55)}$$

$$Q'_{i-1} = Q_{i-1} + \frac{CSL_{i-1}}{\rho} \qquad \text{(H-56)}$$

$$Q'_i = Q_i + \frac{CSL_i}{\rho} \qquad \text{(H-57)}$$

where

$m_{1,i}$	=	solids concentration (M/L^3) in the subarea i runoff (suspended solids)
m_2	=	solids concentration (M/L^3) in the top soil column layer of subarea i
Q_i	=	runoff flow (L^3/T) leaving subarea i
Q_{i-1}	=	runon flow (L^3/T) from subarea i-1
A_i	=	surface area (L^2) of subarea i
vs_i	=	settling velocity (L/T)
vr_i	=	resuspension velocity (L/T)
Q'_i	=	total runoff flow volume (L^3/T) (water plus solids) leaving subarea i
CSL_i	=	cumulative soil load leaving subarea i (M/T)
ρ	=	particle density (M/L^3) (i.e., 2.65 g/m^3).

(Note: Subscript "1" denotes the runoff compartment while "2" denotes the top soil column layer compartment.) The first term in Equation H-55 a is the flux of soil across the upslope interface of subarea i. The second term is the flux of soil across the downslope interface. The third term is an internal sink of soil due to settling, and the fourth term is an internal source due to resuspension.

3.4.1.3 <u>Solids in Soil Compartment</u>. The GSCM does not consider chemical mass transport among watershed subareas due to soil erosion, because it is based on a single subarea only. Therefore, that transport is considered here. The assumption is made that solids mass transport from or to the soil compartment of any given watershed subarea occurs only in a vertical direction, i.e., no downgradient advection of the top soil column layer itself is considered. (This is analogous to the assumption of a stationary sediment bed in stream/sediment quality modules.) The downslope mass transport of soil occurs due to vertical erosion or resuspension of soil followed by advective transport of the soil in the runoff water as suspended solids. The transport is described in terms of three parameters — settling, resuspension, and burial/erosion velocities. Under the assumption of no advective transport of the soil column layer, the steady-state mass balance equation for the surficial soil layer is

$$0 = vs_i m_{1,i} A_i - vr_i m_{2,i} A_i - vb_i m_{2,i} A_i \qquad \text{(H-58)}$$

where

vb_i = burial/erosion velocity (L/T).

The first term of Equation H-58 is a source of soil mass to the surficial soil column layer due to settling from the overlying runoff water. The second term is a sink from resuspension. The third term is either a source or a sink depending on the sign of the burial/erosion velocity as described below.

Consider the solids balances in the runoff and soil compartments, Equations H-55 through H-58. These equations involve three parameters—vs, vr, and vb—and two solids concentrations—m_1 and m_2. Which of these five variables is known for arbitrary subarea i? It can be assumed that the solids concentration in the soil (m_2) is a known value—it is simply the bulk soil density. Consider now the suspended solids concentration in subarea i, $m_{1,i}$. From the soil erosion module, the total solids mass fluxes moving across both the upslope and downslope interfaces of subarea i are known, and these two fluxes are, respectively, the first two terms on the right side of Equation H-55 $m_{1,i}$ can then be determined as

$$m_{1,i} = CSL_i / Q'_i \qquad \text{(H-59)}$$

where CSL_i is the cumulative soil load leaving subarea i, as determined by the soil erosion module, and Q'_i is the cumulative runoff flow volume (including solids' volume) leaving subarea i, as determined by the runoff quantity model. Therefore, because the soil concentration (m_2) is assumed to be known and the soil erosion and runoff quantity modules can be used to determine the suspended solids concentrations (the $m_{1,i}$), Equations H-55 through H-58 can now be considered as two equations in three unknowns, vs, vr, and vb.

The settling (vs) and resuspension (vr) parameters reflect processes internal to subarea i, while the burial/erosion parameter (vb) reflects net changes across subarea i and is completely determined by the difference in the soil fluxes entering and leaving subarea i. This can be seen by adding the right-hand sides of Equations H-55 and H-58 and setting the result to zero. All terms involving vs and vr cancel, and the burial/erosion velocity is then given by

$$vb_i = \frac{CSL_{i-1} - CSL_i}{A_i m_2} \qquad \text{(H-60)}$$

where CSL_{i-1} and CSL_i denote the soil fluxes into and out of subarea i, respectively, as discussed above. From Equation H-60 it can be seen that, if the soil load entering subarea i (CSL_{i-1}) is greater than the soil load leaving (CSL_i), then the burial/erosion velocity is positive and soil is being deposited (buried). Conversely, as will typically be the case, if the load leaving is greater than the load entering, then the burial/erosion velocity will be negative and erosion is occurring in an upward direction.

Consider now vs and vr. With the net soil flux across the subarea having been determined, Equations H-55 and H-58 are in fact the same equation—the burial velocity term is explicitly shown in Equation H-58 and implicitly shown in Equation H-55. Thus, either Equation H-55 or H-58 represents one equation in two unknowns, vs and vr. If one of these is known, the other can be solved for. Of the two, the resuspension velocity would be very difficult to obtain estimates for, while the settling velocity could be assumed similar to, for example, hindered or compaction settling in sludge thickeners. Accordingly, vr as a function of vs (and vb, which is determined as per Equation H-60 is given for subarea i by

$$vr_i = vs_i \frac{m_{1,i}}{m_2} - vb_i \qquad \text{(H-61)}$$

The settling velocity, vs, is assigned values from a uniform random distribution between the range 0.05 and 1.0 m/d, based on observed settling velocities for "mineral" sludges in sludge thickening experiments.

In summary, because m_2 is assumed known and m_1 is calculated from results of the soil erosion and runoff modules, the solids mass balance equations are used to determine the burial/erosion and resuspension parameters for subsequent use in the chemical (contaminant) model.

H3.4.1.4 <u>Contaminant in Runoff Compartment</u>. As illustrated in Figure H-8, a steady-state mass balance of contaminant in the runoff results in the equation

$$0 = Q'_{i-1}c_{1,i-1} - Q'_i c_{1,i} - vs_i A_i Fp_{1,i} c_{1,i} + vr_i A_i Fp_{2,i} Er_i c_{2,i} + vd_i A_i \Phi_2 \left(\frac{Fd_{2,i}}{\Phi_2} c_{2,i} - \frac{Fd_{1,i}}{\Phi_{1,i}} c_{1,i}\right) \qquad \text{(H-62)}$$

where

$c_{1,i}$	=	total contaminant concentration (particulate + dissolved) in runoff in subarea i (M/L^3)
$c_{2,i}$	=	total contaminant concentration in soil (M/L^3)
$V_{1,i}$	=	subarea-specific (not cumulative) runoff volume for subarea i (L^3)
$Fp_{1,i}$	=	fraction particulate in runoff
$Fd_{1,i}$	=	fraction dissolved in runoff ($1-Fp_{1,i}$)
vd_i	=	diffusive exchange velocity (L/T)
Er_i	=	enrichment ratio
$\Phi_{1,i}$	=	is the porosity of the runoff, calculated as

$$\Phi_{1,i} = 1 - \frac{m_{1,i}}{\rho} \qquad \text{(H-63)}$$

where ρ is the density (M/L^3) of suspended solids (e.g., 2.65 g/cm^3).

Φ_2 = soil porosity, calculated as

$$\Phi_2 = 1 - \frac{m_2}{\rho} \qquad \text{(H-64)}$$

Note that ϕ_2 is equivalent to porosity (η) in the GSCM.

The diffusive flux term in Equation H-62 (last term) deserves some explanation regarding the porosities. Recall that the concentration is a total concentration (sorbed plus dissolved) expressed as mass of chemical per *total* volume (solids plus water) in either the soil or the runoff water. Multiplication of the total concentration by Fd converts total concentration to dissolved concentration, but still based on total volume. Thus, the runoff water and soil porosities are included in the denominators to express the dissolved concentration per volume of *water*, i.e. the actual pore water (or runoff water) concentration. Regarding the soil porosity in the $vd_i\ A_i\ \Phi_2$ term, Φ_2 is there used to account for the fact that diffusion of dissolved chemical will only occur across the interstitial area, not the entire interface area.

Equation H-62 can be used to express $c_{1,i}$ as a function of $c_{1,i-1}$ and $c_{2,i}$ as

$$c_{1,i} = \frac{Q'_{i-1} c_{1,i-1} + [vr_i A_i Fp_{2,i} Er_i + vd_i A_i Fd_{2,i}] c_{2,i}}{Q'_i + vs_i A_i Fp_{1,i} + vd_i A_i \Phi_2 (Fd_{1,i}/\Phi_{1,i})} \qquad \text{(H-65)}$$

where $c_{2,i}$ is determined by the GSCM as described in Section H2. Determination of the individual terms constituting this equation are described below.

$Fp_{1,i}$ is calculated as (Thomann and Mueller, 1987)

$$Fp_{1,i} = \frac{(k_d/\Phi_{1,i}) m_{1,i}}{1 + (k_d/\Phi_{1,i}) m_{1,i}} \qquad \text{(H-66)}$$

where

k_d = chemical-specific partition coefficient (L^3/M) (Note: k_d is divided by porosity to attain the porosity-corrected k_d with units of mass per total [liquid plus solids] volume.)

$Fp_{2,i}$ is similarly calculated as

$$Fp_{2,i} = \frac{(k_d/\Phi_2)m_2}{1 + (k_d/\Phi_2)m_2} \tag{H-67}$$

where it can be seen that Fp_2 (and Fd_2) will be constant among all subareas i.

$Fd_{1,i}$ and $Fd_{2,i}$ are then determined as

$$Fd_{1,i} = 1 - Fp_{1,i} \tag{H-68}$$

$$Fd_{2,i} = 1 - Fp_{2,i} \tag{H-69}$$

Under the assumption that resistance to vertical diffusion is much greater in the soil than in the runoff (Thomann and Mueller, 1987, p. 548), the diffusive exchange velocity, vd_i, can be expressed as

$$vd_i = \frac{Dw}{Lc} \tag{H-70}$$

where

Dw = water diffusivity (L^2/T).

Lc = characteristic mixing length (L) over which a concentration gradient exists; assumed to be the depth of the runoff volume including the solids (H1'):

$$Lc = H1'_i = \frac{Q'_i}{A_i} \tag{H-71}$$

The enrichment ratio, Er_i, is used to account for preferential erosion of finer soil particles — with higher specific surface areas and more sorbed chemical per unit area — as rainfall intensity decreases. That is, large (highly erosive) runoff events may result in average eroded soil particle sizes and associated sorbed chemical loads that do not differ much from the average sizes/loads in the surficial soil column layer. However, less intense runoff events will erode the finer materials and resulting chemical loads could be significantly higher than represented by the average soil concentration. U.S. EPA et al. (1985) give the storm event-specific enrichment ratio as a power function of sediment discharge flux (M/L^2). This formulation results in

$$Er_i = \frac{a}{(CSL_i/WSA_i)^{0.2}} \tag{H-72}$$

where a = 7.39 for CSL_i/WSA_i in kg/ha (U.S. EPA, 1985b). (CSL_i is the event soil load leaving subarea i and WSA_i is the local watershed surface area from the drainage divide down to and including subarea i.). The enrichment ratio is greater than or equal to 1.0. Should specific values of the sediment discharge (the denominator) result in an enrichment ratio less than 1.0, it is reset to 1.0 in the code.

H3.4.2 Soil Compartment

The GSCM (see Section H2.2) is coupled to the runoff compartment module (see Section H3.4.1) in this section and applied to the several subareas that constitive the sheet flow local watershed of which the LAU or wastepile is an integral part. Continuing the chemical concentration indexing scheme (i.e., subscript "1" denoting runoff compartment, and subscript "2" denoting surficial soil compartment), let the total (dissolved, particulate, and gaseous phase) chemical concentration in the surficial soil column layer of any local watershed subarea i be denoted as $C_{2,i}$. ($C_{2,i}$ is equivalent to C_T in the GSCM description.) From Section H2.2 (GSCM), the governing differential equation for the surface soil layer of subarea i is

$$\frac{\partial C_{2,i}}{\partial t} = D_E \frac{\partial^2 C_{2,i}}{\partial z^2} - V_E \frac{\partial C_{2,i}}{\partial z} - \Sigma k_j C_{2,i} + ss_i \tag{H-73}$$

where k_j represents first-order rate constant due to process j not including runoff/erosion processes, i.e., biological decay and hydrolysis and wind/mechanical action. The last term, ss_i, is a source/sink term representing the net effect of runoff and erosion processes on $C_{2,i}$ as illustrated in Figure H-8. This term is given by

$$ss_i = \frac{vs_i Fp_{1,i} C_{1,i} - vr_i Fp_{2,i} Er_i C_{2,i} - vd_i \Phi_2 \left(\frac{Fd_{2,i}}{\Phi_2} C_{2,i} - \frac{Fd_{1,i}}{\Phi_{1,i}} C_{1,i}\right) - vb_i Fp_2 C_{2,i}}{dz} \tag{H-74}$$

where vs_i, vr_i, vb_i, and vd_i denote, respectively, the settling, resuspension, burial/erosion and diffusive exchange velocities for subarea i as described in the runoff compartment model. Thus, the terms comprising ss_i are, respectively, a source of chemical due to settling from the overlying runoff water, a sink of chemical due to resuspension, and a source or sink (depending on the relative values of $C_{1,i}$ and $C_{2,i}$) due to chemical diffusion from/to the runoff.

The burial/erosion mechanism introduces a minor mass balance error into the model. The module for surface soil/runoff water fate and transport (Section H3.4.1) is based on a conceptual module originally developed for use in a stream/sediment application (e.g., Thomann and Mueller, 1987) where the sediment compartment location relative to a reference point below the surface can move vertically ("float") as burial and erosion occur. In that moving frame of reference, burial/erosion of contaminant does not introduce a mass balance error because, with respect to the modeled sediment, this sink/source of contaminant is **exogenous** to the modeled system, i.e., it is coming from/going to outside of the modeled system. There is internal (endogenous) mass balance consistency within the modeled system. However, the frame of reference is not allowed to float, but is fixed by the elevation of the lower boundary, e.g., top of the vadose zone. Thus, if sorbed chemical is eroded from the surface cell, that surface cell, which is vertically fixed, must have a "source" that is internal to the modeled soil column to compensate for this sink or its internal mass balance is not maintained. The magnitude of this mass balance error is equal to the mass of eroded soil from the surface over the duration of the simulation times its average sorbed chemical concentration. In most cases, this error as a percentage of the total chemical mass in the modeled LAU will be quite small, and that has been confirmed in multiple executions of the module. Conceptually at least, the GSCM could be designed so that, after each runoff event, the surficial soil compartment could decrease or increase in size to accommodate the event's erosion/burial magnitude, while maintaining a fixed vertical reference.

Grouping coefficients of $C_{1,i}$ and $C_{2,i}$, Equation H-74 can be rewritten as

$$ss_i = a_i C_{1,i} - b_i C_{2,i} - k_{bu,i} C_{2,i} \qquad \text{(H-75)}$$

where

$$a_i = \frac{vs_i Fp_{1,i} + vd_i \Phi_2 \dfrac{Fd_{1,i}}{\Phi_{1,i}}}{dz} \qquad \text{(H-76)}$$

$$b_i = \frac{vr_i Fp_{2,i} Er_i + vd_i Fd_{2,i}}{dz} \qquad \text{(H-77)}$$

$$k_{bu,i} = \frac{vb_i \, Fp_{2,i}}{dz} \qquad \text{(H-78)}$$

and $k_{bu,i}$ is the first-order rate constant (1/T) associated with the burial/erosion process.

Using Equation H-75, Equation H-73 can be rewritten as

$$\frac{\partial C_{2,i}}{\partial t} = D_E \frac{\partial^2 C_{2,i}}{\partial z^2} - V_E \frac{\partial C_{2,i}}{\partial z} - \Sigma k_j C_{2,i} + a_i C_{1,i} - b_i C_{2,i} - k_{bu,i} C_{2,i} \qquad \text{(H-79)}$$

From Equation H-79, it can be seen that $C_{2,i}$ is a function of $C_{1,i}$. Similarly, from Equation H-65 of the runoff compartment module, it can be seen that $C_{1,i}$ is a function of $C_{2,i}$. Thus, $C_{2,i}$ and $C_{1,i}$ are jointly determined at any time t by simultaneous solution of their two respective equations.

$C_{2,i}$ at time t can be determined by substitution for $C_{1,i}$. From the runoff compartment module (Equation H-65), $C_{1,i}$ can be expressed as

$$C_{1,i} = \frac{Q'_{i-1} C_{1,i-1}}{d_{2,i}} + \frac{d_{1,i}}{d_{2,i}} C_{2,i} \qquad \text{(H-80)}$$

where

$$d_{1,i} = vr_i A_i Fp_{2,i} Er_i + vd_i A_i Fd_{2,i} \qquad \text{(H-81)}$$

$$d_{2,i} = Q'_i + vs_i A_i Fp_{1,i} + vd_i A_i \Phi_2 \frac{Fd_{1,i}}{\Phi_{1,i}} \qquad \text{(H-82)}$$

Substituting for $C_{1,i}$ from Equation H-80 into Equation H-79, the differential equation for $C_{2,i}$ is now expressed implicitly as a function of $C_{1,i}$ as

$$\frac{\partial C_{2,i}}{\partial t} = D_E \frac{\partial^2 C_{2,i}}{\partial z^2} - V_E \frac{\partial C_{2,i}}{\partial z} - (\Sigma k_j + b_i + k_{bu,i} - \frac{a_i d_{1,i}}{d_{2,i}}) C_{2,i} + \frac{a_i Q'_{i-1} C_{1,i-1}}{d_{2,i}} \qquad \text{(H-83)}$$

Once $C_{2,i}$ at time t is determined by solution of Equation H-83, the associated value for $C_{1,i}$ can be found from Equation H-80, thus completing the simultaneous solution. (The value for $C_{1,i-1}$, i.e., the runoff concentration in the immediately upslope subarea, will have been determined previously during the simultaneous solution for the i-1 subarea at time t.)

To implement the simultaneous solution, Equation H-83 can be simplified to

$$\frac{\partial C_{2,i}}{\partial t} = D_E \frac{\partial^2 C_{2,i}}{\partial z^2} - V_E \frac{\partial C_{2,i}}{\partial z} - k_i' C_{2,i} + ld_{i-1} \qquad \text{(H-84)}$$

where

$$k'_i = \Sigma k_j + k_{ev,i} + k_{bu,i} \qquad \text{(H-85)}$$

$$k_{ev,i} = b_i - a_i \frac{d_{1,i}}{d_{2,i}} \tag{H-86}$$

$$ld_{i-1} = \frac{a_i}{d_{2,i}} Q'_{i-1} C_{1,i-1} \tag{H-87}$$

$k_{ev,i}$ is the storm event (or runoff and erosion) first-order loss rate, k'_i is the lumped first-order loss rate which includes the effects of abiotic hydrolysis (j=hy), aerobic biodegradation (j=ae), and wind/mechanical activity (j=wd), in addition to runoff and erosion. k_{hy} and k_{ae} are inputs to the module, and k_{wd} is calculated using the methodologies detailed in Appendix H-A. The last term, ld_{i-1} is the run-on load from upslope subareas in g/m^3/d.

Recall that in the GSCM, the governing equation is broken up into three component equations—diffusion, convection, and first-order losses (Equations H-15 through H-17), each solved individually on a grid. In the subsurface layers, the solution technique described in Section 2 is applied directly. However, for the surface soil column layer, the first two-component equations remain the same, while the third is revised to

$$\frac{\partial C_{2,i}}{\partial t} = -k' C_{2,i} + ld_{i-1} \tag{H-88}$$

which has the following analytical solution for $C_{2,i} = C^0_{2,i}$ at t = 0:

$$C_{2,i} = \begin{cases} C^0_{2,i} \exp(-k'_i t) + ld_{i-1}[\frac{1 - \exp(-k'_i t)}{k'_i}] & k'_i > 0 \\ C^0_{2,i} + ld_{i-1} t & k'_i = 0 \end{cases} \tag{H-89}$$

To track mass losses, the total mass added to the soil column in subarea i in any time period zero to t due to settling from runoff water, $M_{add,i}$ (M/L^2), is evaluated using

$$M_{add,i} = ld_{i-1} t \; dz \tag{H-90}$$

A mass balance on the soil column in time t gives

$$\Delta M_i = M_{add,i} - M_{loss,i} \tag{H-91}$$

where ΔM_i (M/L2) is the change in mass in the soil column in subarea i as given by $((C_{2,i} - C^\circ_{2,i})*dz)$ and $M_{loss,i}$ (M/L^2) is the total mass lost from the subarea i soil column in any time period zero to t. By substituting Equation H-49 for $C_{2,i}$ and Equation H-90 for $M_{add,i}$ and rearranging, the following equation for $M_{loss,i}$ was derived for k'_i>0. For $k'_i = 0$, $M_{loss,i} = 0$.

$$M_{loss,i} = [C^0_{2,i}(1 - \exp(-k'_i t)) + ld_{i-1}(\frac{k'_i t + \exp(-k'_i t) - 1}{k'_i})]dz \qquad \text{(H-92)}$$

The total mass lost in any time period zero to t from subarea i soil column can be attributed to specific first-order loss processes, j, $M_i(t)$ (M/L^2) using

$$M_{j,i} = M_{loss,i} \frac{k_j}{k'_i} \qquad \text{(H-93)}$$

where

j = hy for hydrolysis,
j = ae for aerobic degradation,
j = wd for losses due to wind/mechanical activity,
j = ev for runoff/erosion events, and
j = bu for burial/erosion.

Equation H-80 provides the contaminant concentration in the runoff water at time t. The average contaminant concentration in the runoff water ($\bar{C}_{1,i}$) over time 0 to t is determined using

$$\bar{C}_{1,i} = \frac{Q'_{i-1}\bar{C}_{1,i-1}}{d_{2,i}} + \frac{d_{1,i}}{d_{2,i}} \bar{C}_{2,i} \qquad \text{(H-94)}$$

where $\bar{C}_{2,i}$ is the time-weighted average contaminant concentration in the soil compartment over the same time period. Given the short time step (i.e., 1 day) used in the integration of the local watershed/soil column module, $\bar{C}_{2,i}$ is approximated using

$$\bar{C}_2,i = \frac{C^0_{2,i} + C_{2,i}}{2} \qquad \text{(H-95)}$$

where the 0 superscript denotes concentration at the beginning of the day.

H3.5 Implementation

H3.5.1 Overview

An overview of the algorithm implementing the combined local watershed/soil column modules is provided in Figures H-9 and H-10. Some additional differences from the GSCM general algorithm (Section H2.4.1) are noted. In the GSCM, it is assumed that infiltration is constant and convection events occur at regular intervals throughout the entire simulation. (With a convection event, soil column concentrations are propagated downward and M_{lcha} is incremented.) In the local watershed/soil column modules, the infiltration rate (I) is allowed to vary from year to year. As a result, convection events do not occur at regular intervals. To determine the appropriate time to initiate a convection event, at the end of every time step a variable (fadv) tracking the fraction of mass in the bottom soil column layer that would have convected is incremented by ($dt \cdot V_E/dz$). If fadv is sufficiently close to 1, a convection event is initiated and fadv is reset to zero. At the end of the simulation (year = NyrMax), if fadv is greater than zero.

M_{lcha} is incremented by fadv times dz times C_T in the lowest layer and C_T in the lowest layer is adjusted accordingly. Leachate flux for the final year is then calculated using Equation H-31.

H3.5.2 Simulation-Stopping Criterion

For a given local watershed, i, the simulation is stopped in each successive subarea when the amount of contaminant mass in local watershed i and all upslope subareas j (j < i) is determined to be insignificant. "Insignificance" is defined by the input parameter TermFrac, and this simulation criterion is implemented as follows:

1. During the years before the end of the operating life of the LAU, the year-end cumulative subarea contaminant mass in each subarea is determined. Here, cumulative subarea mass ($samass_i$) refers to the sum of the contaminant mass in subarea i and all upslope subareas j (j < i). The maximum cumulative subarea contaminant mass (max_samass_i) is stored for each subarea.

2. After LAU operation ceases, the year-end cumulative subarea contaminant mass in each subarea is compared to the stored maximum for that subarea. The simulation in subarea i is stopped when

$$samass_i \le TermFrac * maxsamass_i$$

where "TermFrac" is the user-specified fraction ranging from 0 to 1.0 (unless the NyrMax parameter is reached first, at which point the simulation is automatically stopped). The year the simulation ceases in each local watershed and subarea is stored in an internal two-dimensional array dimensioned on local watershed and subarea.

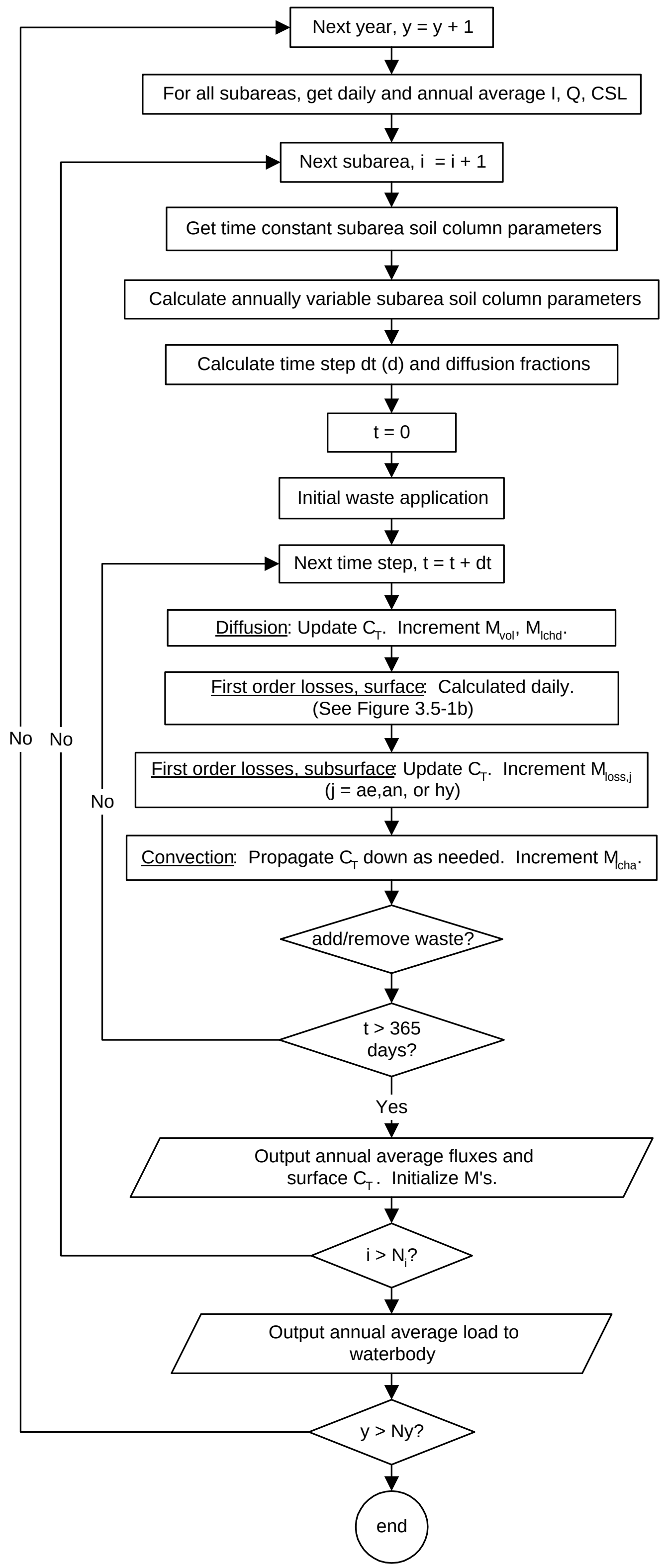

Figure H-9. Overview of algorithm for combined local watershed/soil column module.

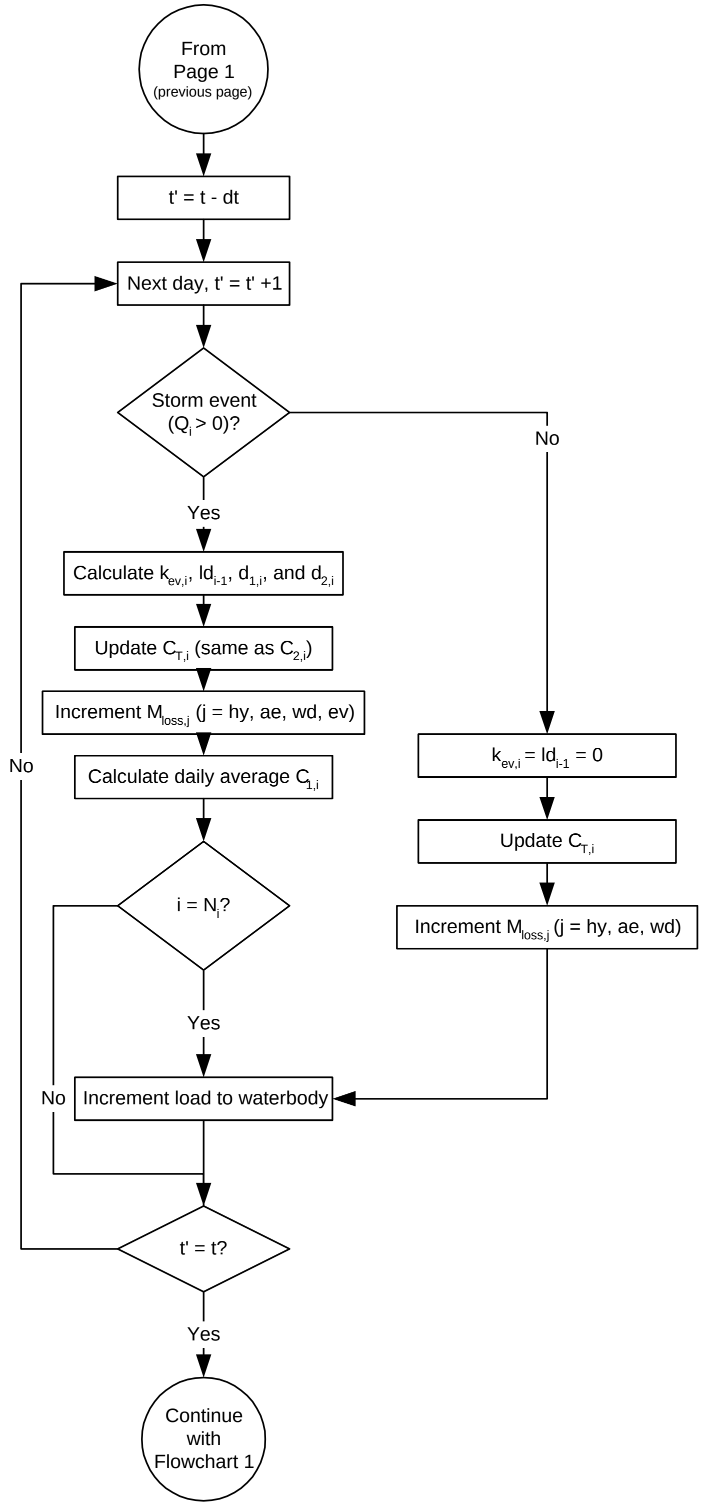

Figure H-10. Detail on calculation of first-order losses in surface layer.

(Note: As of this writing, computer memory requirements have resulted in an inability to make full use of the above-described TermFrac stopping critierion for highly persistent chemicals. Time series outputs are kept in random access memory [RAM] for postprocessing. When the length of the time series becomes excessive with respect to array sizes and available RAM, memory-cacheing occurs with a concomitant drastic slowdown in run time. To mitigate this problem, it was determined that the length of the time series would be determined by the TermFrac criterion, as described above, or 200 years, whichever comes first.)

H3.5.3 Leachate Flux Processing

Preliminary module runs indicated that there are many cases where the convective transfer step will occur less than once per year, sometimes even less than once in the entire simulation period. In these cases the leachate flux will be nonzero in the years when a convection event occurs and zero in years when it did not. This is a limitation of the solution technique. In reality, leaching occurs more or less continuously over the time between the modeled convection events. To mitigate this limitation, a leachate flux postprocessing algorithm was developed. The entire simulation ($0 < j \leq NyrMax$) is split into three time periods, where j is used here as the year index:

1. LAU operating years ($0 \leq j \leq y_{op}$)
2. Non-operating years ($y_{op} < j \leq LeachFluxNY$
3. No leachate flux years ($LeachFluxNY < j \leq NyrMax$)

where LeachFLuxNY is the last year there is a positive leachate flux. The processed leachate fluxes (J_{lchp}, g/m^2/d) in time periods 1 and 2 are calculated from J_{lch} in each year, j, using

$$J_{lchp,j} = \frac{I_j}{\bar{I}\ (b - a + 1)} \sum_{j=a}^{j=b} J_{lch,j} \qquad \text{(H-96)}$$

where, in time period 1, a = 0 and b = y_{op}. In time period 2, a = y_{op} and b = LeachFluxNY. The first term in Equation (H-96) is an infiltration-based weight where I_j is the annual average infiltration rate in year j and $\bar{I}$ is the average infiltration rate between years a and b. In time period 3, J_{lchp} is zero.

With use of Equation H-96 to estimate the leachate flux, mass is conserved. That is, the total mass lost due to leaching over the course of the simulation is the same using the processed and unprocessed leachate fluxes. However, with the processed leachate flux, a smoother function of leachate flux over time is provided.

H3.5.4 End-of-Simulation Mass Balance Check

At the end of the simulation, a system-wide mass balance check is performed in the code. The system, in the local watershed/soil column modules, includes the LAU subarea and all other subarea "soil columns." The mass balance error (fMerr) is computed as a fraction of the total contaminant mass added to the system from the mass balance equation

$$fMerr = 1 - (fMrem + fMlost) \tag{H-97}$$

where fMrem is the fraction of total contaminant mass added that remains in the system at the end of the simulation. fMlost is the fraction of the contaminant mass added that was estimated to have been lost from the system by the end of the simulation. fMlost is the sum of the variables listed and defined in Table H-2.

Table H-2. Variables Summarizing Contaminant Mass Losses

Variable	Definition: Fraction of the total mass added lost due to
fMvol_wmu	Volatilization from the LAU
fMlch_wmu	Leaching from the LAU
fMwnd_wmu	Wind/mechanical action on the LAU surface
fMdeg_wmu	Abiotic and biodegradation within the LAU
fMrmv_wmu[a]	Removal from the LAU
fMvol_sa	Volatilization from the non-LAU subarea soil columns
fMlch_sa	Leaching from the non-LAU subarea soil columns
fMdeg_sa	Abiotic and biodegradation in the non-LAU subarea soil columns
fMswl	Runoff/erosion from the most downslope subarea
fMbur[b]	Burial/erosion in all subareas (see k_{bu} in Equation H-87)

[a] Applies only to the wastepile, which is removed and refreshed regularly. See Section 3.7 for details.
[b] fMbur is the only variable listed that can be negative (indicating a mass gain). This results from the inclusion of a burial/erosion term in linking the runoff and soil compartments. See Figure H-8 and the discussion of the meaning of the burial/erosion term in Section H3.4.2.

Time series outputs are reported as follows:

- *Outputs to Air Module***.** All annnual time series outputs to ISCST3 are reported up to and including the last year that there is nonzero VE or CE. Thus, the annual time series outputs to the air model are all the same length.

- *Outputs to the Groundwater Model*. The annual time series of LeachFlux for each local watershed is reported up to and including the last year that there is a nonzero LeachFlux in any local watershed. This results in the same reported LeachFlux time series length for all local watersheds. After this, all LeachFlux values for all local watersheds will be zero and are not reported. AnnInfil is reported from year one to the last year that meteorological data are available.

H3.6 Output Summary

Table H3-3 summarizes the outputs of the combined local watershed/soil column module.

- *Outputs to Surface Water*. The annual time series of SWLoadChem are reported up to and including the last year that there is nonzero SWLoadChem in any local watershed. This results in the same reported SWLoadChem time series length for all local watersheds. SWLoadSolid and Runoff are reported for all local watersheds up to the last year that meteorological data are available.

- *Outputs to Fate and Transport Model*. The annual time series of CTda is reported to the the last year of nonzero CTda in each local watershed and subarea. Thus, the length of the reported time series for CTda in each local watershed and subarea may differ. The same is true for CTss.

Table H3-3. Output Summary for the LAU Model

Variable Name[a]			
Documentation	**Code**	**Definition**	**Units**
I	AnnInfil	Leachate infiltration rate (annual avg., WMU subarea(s) only)	m/d
J_{vol}	VE	Volatile emission rate	g/m^2/d
	VEYR	Year associated with output	Year
	VENY	Number of years in outputs	Unitless
CE30	CE	Constituent mass emission rate-PM30	g/m^2/d
	CEYR	Year associated with output	Year
	CENY	Number of years in outputs	Unitless
E30	PE30	Eroded solids mass emission rate-PM30	g/m^2/d
	PE30YR	Year associated with output	Year
	PE30NY	Number of years in outputs	Unitless
pmf	PMF	Particulate emission particle size distribution	Mass frac.
	PMFYR	Year associated with output	Year
	PMFNY	Number of years in outputs	Unitless
Q	Runoff	Runoff flow to waterbody	m3/d
J_{lch}	LeachFlux	Leachate contaminant flux	g/m^2/d
	LeachFluxYR	Year associated with output	Year

(continued)

Table 3-3. (continued)

Variable Name[a]			
Documentation	**Code**	**Definition**	**Units**
LeachFluxNY	LeachFluxNY	Number of years in outputs	Unitless
	SWLoadChem	Chemical load to waterbody	g/d
	SWLoadChemYr	Year associated with output	year
	SWLoadChemNY	Number of years in outputs	Unitless
CSL	SWLoadSolid	Total suspended solids load to waterbody	g/d
C1	SWConcTot	Total chemical concentration in surface water runoff	mg/L
	SWConcTotYR	Year associated with output	Year
	SWConcTotNY	Number of years in outputs	Unitless
C_T	CTss	Soil concentration in surface soil layer	µg/g
	CTssYR	Year associated with output	Year
	CTssNY	Number of years in outputs	Unitless
C_T	CTda	Depth-weighted average soil concentration (from zava to zavb)	µg/g
	CTdaYR	Year associated with output	Year
	CTdaNY	Number of years in outputs	Unitless
	SrcSoil	Flag for soil presence (true)	Logical
	SrcOvl	Flag for overland flow presence (true)	Logical
	SrcLeachMet	Flag for leachate presence when leachate is met-driven (true)	Logical
	SrcLeachSrc	Flag for leachate presence when leachate is not met-driven (false)	Logical
	SrcVE	Flag for volatile emissions presence (true)	Logical
	SrcCE	Flag for chemical sorbed to particulates emissions presence (true)	Logical
	SrcH2O	Flag for surface water presence for eco-exposure (false)	Logical
	NyrMet	Number of years in the available met record	Unitless

[a] Where the variable name is used in the code but not in the documentation, the first column is left blank.

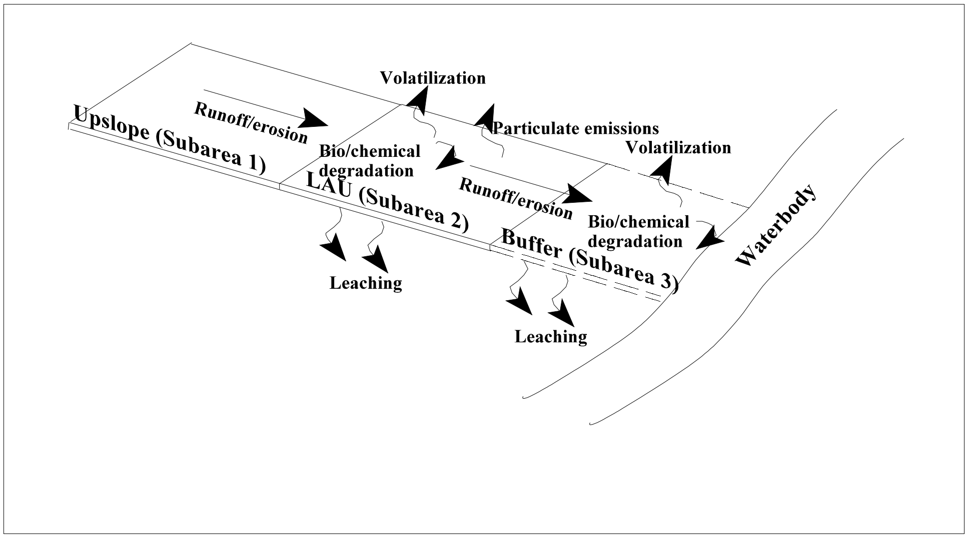

Figure H-11. Illustration of LAU in local watershed.

H3.7 Land Application Unit

H3.7.1 Introduction

Section H3.4 presented the local watershed/soil column module. This section discusses LAU-specific issues in implementation. Figure H-11 illustrates the LAU in the local watershed conceptual module.

H3.7.2 Additional Assumptions

- Waste is applied to the soil surface periodically at even intervals (e.g., quarterly) and then tilled or mixed into the top layer of soil to a depth of z_{till} (m).

- Till zone ($z = 0$ to z_{till}) is completely mixed upon each application of waste to soil.

- The modeled soil column consists of one homogeneous zone, the till zone, consisting of a soil/waste mixture. The till zone properties ($\rho_{b,till}$, $foc_{till,}$) can be estimated as the depth-weighted average of the soil ($\rho_{b,s}$, foc_s) and waste properties ($\rho_{b,w}$, foc_w) according to the depth of soil (d_s, m) and waste (d_w, m) in the till zone. To illustrate, an example using ρ_b is presented below.

$$\rho_{b,till} = \rho_{b,s} \frac{d_s}{z_{till}} + \rho_{b,w} \frac{d_w}{z_{till}} \quad \text{(H-98)}$$

$$d_s = z_{till} - d_w \quad \text{(H-99)}$$

where W is the wet waste mass loading for a single application, determined as

$$d_w = \frac{W}{\rho_{b,w}} \tag{H-100}$$

where R_{appl} is the wet waste application rate (Mg/m^2-y), sd is the weight percent solids in the waste, N_{appl} is the number of waste applications per year, ρb,s (g/cm^3) is the dry bulk density of the soil estimated from η_s using Equation H-106, and $\rho_{b,w}$ (g/cm^3) is the dry bulk density.

$$W = \frac{R_{appl} \cdot sd/100}{N_{appl}} \tag{H-101}$$

- The water added to the LAU contained in the wet waste increases the annual average infiltration rate (I) by

$$+ \frac{R_{appl}\ (1 - sd/100)}{365\, \rho_{H_2O}} \tag{H-102}$$

- The contaminant mass is concentrated in the solids portion of the waste and is re-partitioned among the solid, aqueous, and gas phases in the soil column.

- The waste added to the till zone does not significantly affect the hydraulic properties of the till zone. Thus, the hydraulic properties of the soil (K_{sat}, SM_b) are used in Equation H-13 to determine the water content if the till zone. Although the waste may affect the hydraulic properties of the till zone, there is no way of determining this effect theoretically.

- Total porosity of the till zone (η_{till}) is estimated using the following relationship for porous media (Freeze and Cherry, 1979):

$$\eta = 1 - \frac{\rho_b}{2.65} \tag{H-103}$$

- Waste applications do not result in significant buildup of the soil surface, nor does erosion significantly degrade the soil surface (i.e., the distance from the site surface (z = 0) to a fixed point below the surface is constant). As a result, there is no naturally occurring limit to the modeled C_T other than the limit for NAPLs. In other words, the modeled contaminant concentration in the till zone could exceed the contaminant concentration in the waste. Indeed, this is physically possible for highly immobile constituents if the waste matrix is organic and decomposes, leaving behind the constituent to concentrate over multiple applications.

- The LAU is operated for y_{op} years.

- The first-order chemical and biological loss processes in the till zone include aerobic biodegradation (k_{ae}, 1/d) and hydrolysis (k_{hy}, 1/d).

- The first-order loss rate due to wind erosion and other surface disturbances (k_{wd}, 1/d) is applied to the surface layer of the till zone only and is calculated each year as an annual average with consideration of losses from an active LAU due to wind erosion, vehicular activity on the surface of the LAU, and tilling operations. The particulate emission loss rate from an inactive LAU includes wind erosion only. Appendix H-A outlines the estimation procedures for k_{wd}.

- The annual average infiltration rate (I, m/d) is determined using the method described in Section H3.2.4 (I is the same as IN in Section H3.2.4) with consideration of the properties of the till zone only.

- As described in Section H3.4, the topmost soil column layer in the GSCM developed for the LAU serves as the soil compartment in the watershed/soil column algorithm (see Figure H-8). For the purposes of applying the watershed/soil column algorithm, it is assumed that the appropriate depth for the soil column surface layer (dz) is 0.01 m. In the LAU module, dz = 0.01 m is used for the entire till zone.

H3.7.3 Initial Conditions

The simulation starts immediately following the first application of waste, at which time the till zone is well-mixed. Initial conditions are

$$C_T\Big|_{z,t=0} = \frac{W \cdot C'_{T,w} \cdot f_{wmu}}{z_{till}} \qquad \text{(H-104)}$$

where $C'_{T,w}$ is the initial total contaminant concentration in the dry waste, calculated by dividing the total mass-based concentration in the wet waste (input by the user as CTPwaste in the LAU code) by sd/100.

During the operating lifetime of the LAU ($t \leq 365y_{op}$), with each application of waste the initial condition in the till zone is reset to account for the contaminant mass added as well as any contaminant mass remaining in the till zone from previous applications.

$$C_T\Big|_{z,t=j\cdot t_{bet}} = \frac{W \cdot C'_{T,w} \cdot f_{wmu}}{z_{till}} + \overline{C}_T^{\,z}(z_{till}, j \cdot t_{bet}) \qquad \text{(H-105)}$$

where j is the waste application counter index = 1,2,3..., $\bar{C}_T^z$ (z,t) (g/m^3) is the depth-weighted average total contaminant concentration at time t averaged over a depth of z, and t_{bet} is the time between applications:

$$t_{bet} = \frac{365}{N_{appl}} \qquad \text{(H-106)}$$

H4.0 References

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Appendix H

Attachment A:
Symbols, Units, and Definitions

Appendix H

Attachment A: Symbols, Units, and Definitions

(Symbols listed in tables in Appendix H-C, Particulate Emission Equations, are not repeated here.)

Table H-A-1. Symbols, Units, and Definitions

Symbol	Units	Definition
η_j	---	total porosity where j is a subscript indicating waste, w; waste/soil mixture in the till zone, till; and soil, s
η	---	total porosity
θ_a	---	soil volumetric air content
$\theta_{a,j}$	---	soil volumetric air content where j is a subscript indicating waste, w; waste/soil mixture in the till zone, till; and soil, s
θ_w	---	soil volumetric water content
$\theta_{w,j}$	---	soil volumetric water content where j is a subscript indicating waste, w; waste/soil mixture in the till zone, till; and soil, s
ρ_b	g/cm^3	soil dry bulk density. Same as m2. (Note: g/cm^3 =Mg/m^3)
$\rho_{b,j}$	g/cm^3	dry bulk density where j is a subscript indicating waste, w; waste/soil mixture in the till zone, till; and soil, s
$\rho_{b,w}^{wet}$	g/cm^3	wet bulk density of LAU waste
A	m^2	area of WMU
a_i	1/d	calculated parameter (Equation H-76) for subarea i
bcm	---	lower coil column boundary condition multiplier
b_i	1/d	calculated parameter (Equation H-77) for subarea i
C'_T	mg/g	total mass-based contaminant concentration in dry soil
$C'_{T,W}$	mg/g	total mass-based contaminant concentration in incoming dry waste
$C_{2,i}$	g/m^3	contaminant concentration in surface soil grid space in subarea i (equivalent to C_T)
C_G	g/m^3	contaminant concentration in gaseous phase in soil
C_L	g/m^3	contaminant concentration in aqueous phase in soil
C_L^{sol}	g/m^3	contaminant aqueous solubility
CN	unitless	SCS runoff module Curve Number parameter

(continued)

Table H-A-1. (continued)

Symbol	Units	Definition
C_S	mg/g	contaminant concentration in adsorbed phase in soil
$CSL_{i,t}$	kg	cumulative soil load leaving subarea i, day t
C_T	g/m^3	total volume-based contaminant concentration in soil
C_{T0}	g/m^3	initial total volume-based contaminant concentration in soil
$d_{1,i}$	m^3/d	calculated parameter (Equation H-81) for subarea i
$d_{2,i}$	m^3/d	calculated parameter (Equation H-82) for subarea i
D_a	cm^2/s	diffusivity in air
D_E	m^2/d	effective diffusivity in soil
$D_{E,a}$	m^2/d	effective diffusivity in soil air
$D_{E,w}$	m^2/d	effective diffusivity in soil water
Df	---	fraction of original mass in soil column grid space that diffuses past a boundary in time, t
Df_0	---	fraction of original mass in soil column grid space that remains after time, t
DRZ	cm	depth of the root zone
d_s	m	thickness of soil in unmixed LAU till zone
dt	d	length of time step in GSCM solution algorithm
d_w	m	thickness of waste in unmixed LAU till zone
D_w	cm^2/s	diffusivity in water
dz	m	soil column grid size in GSCM solution algorithm
ER_i	unitless	erosion chemical enrichment ratio for subarea i
$ET_{i,t}$	cm/day	evapotranspiration from root zone on day t for subarea i
FC_i	cm	soil moisture field capacity for subarea i
foc	---	organic carbon fraction in soil
foc_j	---	organic carbon fraction where j is a subscript indicating waste, w; waste/soil mixture in the till zone, till; and soil, s
h	m	height of wastepile
H'	---	dimensionless Henry’s law constant
I	m/d	average annual water infiltration rate
$IN_{i,t}$	cm/day	daily infiltration for subarea i, day t
J_{lch}	$g/m^2/d$	annual average leachate flux at lower soil column boundary
J_{vol}	$g/m^2/d$	annual average volatilization flux at upper soil column boundary
k	1/d	total first-order loss rate
$k_{bu,i}$	m/d	first order rate constant due to burial/erosion for subarea i
K_d	cm^3/g	soil-water partition coefficient

(continued)

Table H-A-1. (continued)

Symbol	Units	Definition
k_j	1/d	annual average first order loss rate due to process j, where j indicates hydrolysis, h; aerobic biodegradation, ae; anaerobic biodegradation, an; storm events in subarea i, ev,i; and wind/mechanical activity, wd
K_{oc}	cm^3/g	equilibrium partition coefficient normalized to organic carbon
K_{sat}	cm/hr	saturated hydraulic conductivity
K_{TL}	---	equilibrium distribution coefficient between the total (g/m^3) and aqueous phase (g/m^3) contaminant concentrations in soil
L	Mg/yr	bulk waste mass loading rate into WMU
ld_{i-1}	$g/m^3/d$	run-on load to subarea i from subarea i-1
L'	Mg/yr	bulk waste loading rate adjusted for mass losses due to unloading
$m1_i$	g/m3	suspended solids concentration in runoff water, subarea i
m	g/m2	total amount of material from soil column grid space that has passed a boundary at time, t
M_{col1}	g/m^2	total mass in soil column at start of year
M_{col2}	g/m^2	total mass in soil column at end of year
M_i	g/m^2	annual contaminant mass loss due to process i, where i is a subscript indicating ■ total diffusive loss at the surface, 0; ■ gas phase diffusive losses (volatilization) at the surface, vol; ■ aqueous phase leaching due to diffusion, lchd; ■ aqueous phase leaching due to advection, lcha; ■ first order loss process j where j is as defined in k_j.
M_{add}	g/m^2	annual mass added to soil column
M_{rem}	g/m^2	annual mass removed from soil column
N_{appl}	1/y	number of LAU applications per year
N_{dz}	---	total number of grid spaces of depth dz in soil column
N_{ly}	---	assumed number of waste layers in landfill cell
PET_i	cm/day	potential evapotranspiration for day t
P_t	cm	total precipitation on day t
$Q_{i,t}$	m3/day	runoff flow volume (water only) leaving subarea i, day t
$Q'_{i,t}$	m3/day	total runoff flow volume (including solids) leaving subarea i, day t
R_{appl}	Mg/m^2-y	LAU waste application rate
Sd	unitless	sediment delivery ratio for subarea/watershed i
$RO_{i,t}$	cm	stormwater runoff depth leaving subarea i, day t
sd	w/w, %	weight percent of solids in raw waste applied to LAU
SM_b	---	unitless soil-specific exponent in Equation H-13
$SM_{i,t}$	cm	soil moisture in root zone at end of day t for subarea i

(continued)

Table H-A-1. (continued)

Symbol	Units	Definition
t	d	time since start of simulation
t_{bet}	d	time between waste pile refresh or LAU waste application
vb_i	m/d	burial/erosion velocity for subarea i
vd_i	m/d	diffusive exchange velocity between runoff and surficial soil
vr_i	m/d	stormwater runoff resuspension velocity for subarea i
$\bar{C}_T^z$	g/m^3	depth-weighted average C_T at time, t
V_E	m/d	effective solute velocity in soil
W	Mg/m^2	average mass of waste added per LAU application
WP_i	cm	soil moisture wilting point for subarea i
y_{op}	yr	last year of operation of LAU or waste pile
z	m	distance down from soil surface
z_{sc}	m	total depth of soil column
z_{till}	m	distance from soil surface to bottom of LAU till (mixing) zone

Appendix H

Attachment B:
Determination H', D_a, and D_w for Organic Compounds

Appendix H

Attachment B:
Determination H′, D_a, and D_w for Organic Compounds and Outputs

H-B.1 Introduction

For organic compounds, the dimensionless Henry's law coefficent (H′) and air and water diffusivities (D_a and D_w, cm^2/s, respectively) are calculated as a function of system temperature given user-input reference values and temperatures. H′ is determined from the dimensionless Henry's law coefficient (H'^r) at temperature $T^r_{H'}$ (K). D_a and D_w are determined from air (D_a^r) and water (D_w^r) diffusivities (cm^2/s) at temperature t^r_D (°C). The methodologies used are described in this appendix. Here, T is temperature in Kelvin, and t is temperature in degrees Centigrade.

H-B.2 Air Diffusivity (D_a)

The reference air diffusivity (D_a^r) is adjusted using the following equation, which was derived from the Fuller, Schettler, and Giddings (FSG) Method for estimating air diffusivities of organic compounds in Lyman et al. (1990, Eq. 17-12):

$$D_a = D_a^r \left[\frac{T}{T_D^r} \right]^{1.75} \qquad \text{(H-B-1)}$$

In the module, D_a is converted from cm^2/s to m^2/d by multiplying by 8.64.

H-B.3 Water Diffusivity (D_w)

The reference water diffusivity (D_w^r) is adjusted using the following equation, which was derived from the Hayduk and Laudie Method for estimating water diffusivities of organic compounds in Lyman et al. (1990, Eq, 17-24):

$$D_w = \frac{\eta_w(t_D^r)}{\eta_w(t)} D_w^r \qquad \text{(H-B-2)}$$

where η_w (cp) is the viscosity of water as a function of temperature, t, in degrees centigrade; t^r is the temperature for which D_w^r was specified. Values for η_w are provided in the program and were obtained from Lyman at al. (1990, Table 17-7) for t=0 to 30°C in one-degree increments. In the module, D_w is converted from cm^2/s to m^2/d by multiplying by 8.64.

H-B.4 Dimensionless Henry's Law Coefficient (H′)

The algorithm used to adjust the dimensionless Henry's law coefficient, H′, as a function of temperature, T, is based on the Claussius-Clayperon equation and consideration of temperature effects on solubility (Dzombak et al., 1993) and is presented below:

$$H' = H'^{r} \cdot \exp\left[\frac{\Delta H_V(T_{H'}^r)}{R\ T_{H'}^r} - \frac{\Delta H_V(T)}{R\ T}\right] \qquad \text{(H-B-3)}$$

where H'^r is the dimensionless Henry's law coefficient at reference temperature $T_{H'}^r$ (K), R is the gas constant (1.9872 cal/mol-K), and $\Delta H_v(T)$ (cal/mol) is the molar heat of vaporization as a function of temperature T (K). $\Delta H_v(T)$ is estimated using Eq. 13-21 and Table 13-7 in Lyman et al. (1990):

$$\Delta H_V = \Delta H_{VB} \left[\frac{1 - T/T_c}{1 - T_b/T_c}\right]^n \qquad \text{(H-B-4)}$$

where

$$n = \begin{cases} 0.30 & \dfrac{T_b}{T_c} < 0.57 \\ 0.74\left(\dfrac{T_b}{T_c}\right) - 0.116 & 0.57 \le \dfrac{T_b}{T_c} \le 0.71 \\ 0.41 & \dfrac{T_b}{T_c} > 0.71 \end{cases} \qquad \text{(H-B-5)}$$

where T_c (K) is the critical temperature and T_b(K) is the boiling point of the compound of interest. ΔH_{VB} (cal/mol) is the molar heat of vaporization at the normal boiling point and is estimated using the method of Haggenmacher (Lyman et al., 1990, Section 13-5):

$$\Delta H_{VB} = \frac{2.303 \; B \; R \; T_b^2 \; (z_g - z_l)}{(t_b + C)^2} \qquad \text{(H-B-6)}$$

where

$$z_g - z_l = \sqrt{1 - \frac{1/P_c}{(T_b/T_c)^3}} \qquad \text{(H-B-7)}$$

where T_c (K) is the critical temperature, P_c (atm) is the critical pressure, B (˚C or K) and C (˚C). are Antoine's constants. Antoine's constants have been calculated for many compounds, especially hydrocarbons, and are tabulated in the literature (e.g., Reid et al., 1977). Some caution is required in specifying values for the Antoine's constants, because in some tabulations, the conversion factor to natural log (2.303) is included in the value of B. To check, if the value for methane is 405.42 (˚C or K) use the values for B directly. If it is about 930 (˚C or K), divide all values given for B by 2.303. Also, if Antoine's constants are presented in the literature in K, B should not be changed and C should be converted to ˚C by adding 273.2. Note that this is not the usual way to convert from K to ˚C, but is necessary to maintain the constancy of the term B/(t+C) in Antoine's relationship since temeperature, t, is assumed to be in ˚C.

In the code, if T_c is unavailable, T_c is estimated as 1.5Tb (Lyman et al., 1990, p. 14-13). If P_c is unavailable, but B and C are available, (z_g-z_l) is approximated as one (Lyman et al., 1990, Table 14-6). If B and C are unavailable, Trouton's rule is used to estimate ΔH_{VB} (Lyman et al. (1990):

$$\Delta H_{VB} = 21 \frac{cal}{mole - K} T_b \qquad \text{(H-B-8)}$$

H-B.5 References

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Appendix H

Attachment C:
Particulate Emission Equations

Appendix H

Attachment C:
Particulate Emission Equations

H-C.1 Introduction

The nonwastewater source modules have been designed to provide estimates of the annual average, area-normalized emission rate of contaminant mass adsorbed to particulate matter less than 30 µm in diameter, CE30 (g of contaminant/m^2/d), as well as annual average particle size distribution information in the form of the mass fractions of the total particulate emissions in four aerodynamic particle size categories—30 to 15 µm, 15 to 10 µm, 10 to 2.5 µm, and <2.5 µm.

Various release mechanisms are considered. The inventory of release mechanisms considered is different for each WMU, but includes, in general, wind erosion, vehicular activity, unloading operations, tilling, and spreading/compacting operations. The mechanisms considered for each WMU are summarized in Table H-C-1.

This appendix describes the algorithms and assumptions used to estimate annually for each mechanism of release:

- $E30_i$ (g of particulates $\leq$ 30 µm in diameter/m^2/d), the annual average PM_{30} emission rate due to release mechanism i, where mechanisms of release considered for each WMU are summarized in Table H-C-1
- Particle size range mass fractions, the mass fractions of $E30_i$ in the aerodynamic particle size categories identified above.

For each WMU,

- $\Sigma E30_i$ ($g/m_2/d$), the total annual average PM_{30} emission rate due to all release mechanisms
- Annual average particle size range mass fractions of the total annual average PM_{30} emission rate

Table H-C-1. Summary of Mechanisms of Release of Particulate Emissions for Each WMU

Mechanism of Release	$E30_i$ Subscript	WMU Type[a,b]						Algorithm Reference
		LAU		LF cell[c]		WP		
		Active	Inact.	Active	Inact.[d]	Active	Inact.	
Wind erosion from open area	wd	X	X	X	X			Cowherd et al. (1985)
Wind erosion from wastepile	wp					X	X	U.S. EPA (1985)
Vehicular activity	ve	X		X		X		U.S. EPA (1995)
Unloading	un			X		X		U.S. EPA (1995)
Spreading/compacting or tilling	sc	X		X		X		U.S. EPA (1985)

[a] X = Mechanism of release is considered in modeling the WMU.
[b] Active = Operating WMU.
Inact. = Inactive WMU where no additional contaminant mass is being added.
[c] For a description of how results for whole landfill are obtained from landfill cell results, see Section H-4.5.
[d] Inactive (full) and uncovered landfill cell. Assume no emissions from a covered landfill cell.

- CE30 ($g/m^2/d$), the annual average emission rate of contaminant as PM_{30}
- Annual average first-order loss rate from the soil surface due to contaminant mass losses caused by particulate emissions, k_{wd} (1/d).

H-C.2 Particulate Emission Rate ($E30_i$) Algorithms and Particle Size Range Mass Fractions

H-C.2.1 Wind Erosion from Open Fields ($E30_{wd}$)

The algorithm for the estimation of PM_{30} emissions due to wind erosion from an open field is based on the procedure developed by Cowherd et al. (1985). It was adapted for implementation in a computer code and is presented in detail here. $E30_{wd}$ is estimated in the LAU and landfill source emission modules. The user-specified input parameters are summarized in Table H-C-2.

To account for the fact that active and inactive WMUs can differ in the degree of vegetation (veg′), surface roughness height (z'_0), and frequency of disturbances per month (fd′), different values are assigned to these parameters in the equations presented below according to whether the WMU is active or inactive. The value assignments are summarized in Table H-C-3 where veg, z_0, and fd are user input values.

Table H-C-2. Input Parameter Units and Definitions for $E30_{wd}$

Symbol	Units	Definition
asdm	mm	Mode of the aggregate size distribution
Lc	---	Ratio of the silhouette area of roughness elements too large to be included in sieving to total base area
veg	---	Fraction of surface covered with vegetation (inactive WMU)
z_0	cm	Surface roughness height (inactive WMU)
S	w/w, %	Silt content of surface material
U^+	m/s	Observed or probable fastest mile of wind between disturbances
PE	---	Thornthwaite Precipitation Evaporation Index
u	m/s	Mean annual windspeed
p	d/yr	Mean number of days per year with $\geq$0.01 in precipitation
fd	1/mo	Frequency of disturbance per month where a disturbance is defined as an action that exposes fresh surface material (inactive WMU)

Table H-C-3. Active/Inactive WMU Assignments for veg′, z'_0, fd′

Symbol	Units	Active WMU	Inactive WMU
veg′	---	0.0	veg
z'_0	cm	1.0	z_0
fd′	1/mo	fd	0.0

Step 1: Calculate U_{*t}

Calculate the threshold friction velocity, U_{*t} (m/s), the threshold windspeed for the onset of wind erosion:

$$U_{*t} = 0.650 \cdot cf \cdot (asdm)^{0.425} \qquad \text{(H-C-1)}$$

where

$$cf = \begin{cases} 1.0 & Lc < 2x10^{-4} \\ 1.05 + 50.18Lc - 647.89Lc^2 + 6863.50Lc^3 & 2x10^{-4} \leq Lc \leq 1x10^{-1} \end{cases} \qquad \text{(H-C-2)}$$

Table H-C-2 provides definitions of asdm and Lc. Lc is measured by inspection of a representative 1-m^2 transect of the site surface. Lc can range from zero to 0.1. High Lc ($\geq 2x10^{-4}$) increases the threshold friction velocity, which results in a relatively low or zero particulate emission rate due to wind erosion. Low Lc ($<2x10^{-4}$) is indicative of a bare surface with homogeneous finely divided material (e.g., an agricultural field). Such surfaces have a relatively low threshold friction velocity and increased particulate emissions. Equations (H-C-1) and (H-C-2) were derived from Cowherd et al. (1985, Figures 3-4 and 3-5).

Step 2: Calculate U_t

U_t (m/s) is the threshold wind velocity at a height of 7.0 m (7.0 m is the typical weather station anemometer height). It is calculated using Cowherd et al. (1985, Equation, 4-3, with z = 700 cm):

$$U_t = \frac{U_{*t}}{0.4} \ln\left(\frac{700}{z'_0}\right) \qquad z'_0 < 700 \qquad \text{(H-C-3)}$$

where z'_0 is the roughness height in cm. Values for z'_0 for various surface conditions are provided in Cowherd et al. (1985, Figure 3-6).

Step 3: Calculate $E30_{wd}$

$E30_{wd}$ is the annual average emission rate of particulate matter less than 30 μm in diameter per unit area of the contaminated surface. Note that the methodology developed in Cowherd et al. (1985) was developed for estimation of emission rate of particulate matter less than 10 μm (or $E10_{wd}$). $E30_{wd}$ can be approximated from $E10_{wd}$ with knowledge of the ratio between PM_{30} and PM_{10} for wind erosion. Cowherd (1998) advises that a good first approximation of this ratio is provided by the particle size multiplier information presented in U.S. EPA (1995) for wind erosion from open fields where PM_{30}/PM_{10} is equal to 2. Therefore, a factor of 2 has been incorporated into Cowherd et al.'s (1985) equations for $E10_{wd}$ to allow estimation of $E30_{wd}$.

<u>For sites with limited erosion potential (U_{*t} > 0.75 m/s)</u>

The following equation was derived by using Cowherd et al. (1985, Equations 4-1 to 4-3), applying a factor of 2 as discussed above and converting units to g/m^2/d :

$$E30_{wd} = \begin{cases} \dfrac{11.12(U^{+} - U_t)(1 - veg')fd'}{(PE/50)^2} \cdot \dfrac{24}{10^3} & U^{+} \geq U_t \\ 0 & U^{+} < U_t \end{cases} \tag{H-C-4}$$

Data for mean annual U^{+} and PE for locations throughout the United States can be found in climatic atlases (e.g., U.S. Department of Commerce, 1968) and Cowherd et al. (1985, Figure 4-2), respectively. Cowherd et al. (1985) advise that, in the worst case, fd should be assumed to be 30 per month.

For sites with unlimited erosion potential ($U_{*t} \leq 0.75$ m/s)

When U_{*t} is less than 0.75 m/s, the site is considered to have unlimited erosion potential and $E30_{wd}$ is calculated using Cowherd et al. (1985, Equation 4-4) with a factor of 2 applied as discussed above.

$$E30_{wd} = 0.072\ (1 - veg')\left(\frac{u}{U_t}\right)^3 g(x) \cdot 24\ \frac{h}{d} \tag{H-C-5}$$

where

$$x = 0.886\ \frac{U_t}{u} \tag{H-C-6}$$

$$g(x) = \begin{cases} 1.91 & 0 \leq x < 0.5 \\ 2.2 - 0.6x & 0.5 \leq x \leq 1.0 \\ 2.9 - 1.3x & 1.0 < x \leq 2.0 \\ 0.18\,(8x^3 + 12x)\exp(-x^2) & x > 2.0 \end{cases} \tag{H-C-7}$$

where g(x) was derived from Cowherd et al. (1985, Figure 4-3). Data for u for locations throughout the United States can be found in climatic atlases (e.g., U.S. Department of Commerce, 1968).

Step 4: Apply Particle Size Range Mass Fractions

Particle size range mass fractions allow estimation of the fraction of the PM_{30} emitted that is in specific size fractions. As mentioned above, Cowherd (1998) suggests using the particle size multipliers provided for wind erosion from industrial fields in U.S. EPA (1995).

The U.S. EPA (1995) distribution was adapted to get the fraction of the emissions in the designated size categories as presented in Table H-C-4.

Table H-C-4. Aerodynamic Particle Size Range Mass Fractions for $E30_{wd}$ and $E30_{wp}$

30 µm -15 µm	15 µm -10 µm	10 µm -2.5 µm	≤2.5 µm
0.4	0.10	0.3	0.2

H-C2.2 Vehicular Activity ($E30_{ve}$)

To estimate $E30_{ve}$ ($g/m^2/d$), the quantity of particulate emissions from vehicular travel on the surface of the WMU, the following equation was used:

$$E30_{ve} = 1.36\left(\frac{S}{12}\right)\left(\frac{vs}{48}\right)\left(\frac{vw}{2.7}\right)^{0.7}\left(\frac{nw}{4}\right)^{0.5}\left(\frac{365-p}{365}\right)\cdot nv \cdot \left(1-eff_{dust}\right)\cdot\frac{mt}{A} \qquad \text{(H-C-8)}$$

where parameter definitions are provided in Table H-C-5. Equation H-C-8 was derived from an empirical equation presented in U.S. EPA (1995; Equation 1, p. 13.2.2-1) for the kilograms of size-specific particulate emissions emitted per vehicle kilometer traveled on unpaved roads. (In

Table H-C-5. Parameter Units and Definitions for $E30_{ve}$

Symbol	Units	Definition
S	w/w,%	Silt content of roadway (4.3-20)[a, b]
vs	km/h	Mean vehicle speed (21-64)
vw	Mg	Mean vehicle weight (2.7-142)
nw	—	Mean number of wheels per vehicle (4-13)
nv	1/d	Mean annual number of vehicles per day
eff_{dust}	—	Dust suppression control efficiency
A	m^2	Contaminated surface area
mt	m	Meters traveled per vehicle (nv) on contaminated surface
p	d/y	Mean number of days per year with ≥0.01 in precipitation

[a] Silt is defined as particles less than 75 µm in diameter. Silt content is determined by the percent of loose dry surface material that passes through a 200-mesh screen using the ASTM-C-136 method (U.S. EPA, 1985).

[b] Values in parentheses are the ranges of source conditions that were tested in developing the U.S. EPA (1995, Equation 1, p. 13.2.1-1).

this application, the EPA parameter "fraction of waste on unpaved roads" is one because travel is on the surface of the WMU.) The first six terms of Equation H-C-8 are equivalent to the U.S. EPA (1995) equation after application of the 0.80 particle size multiplier for PM_{30}. EPA's equation has been adapted here to provide emissions normalized to the contaminated surface area and to account for the control of emissions with a dust control efficiency factor of eff_{dust}.

The particle size multipliers for $E30_{ve}$ are presented in Table H-C-6. These have been adapted for the size categories of interest from the particle size multiplier information presented in U.S. EPA (1995).

Table H-C-6. Aerodynamic Particle Size Range Mass Fractions for $E30_{ve}$

30 µm -15 µm	15 µm -10 µm	10 µm -2.5 µm	≤2.5 µm
0.38	0.17	0.33	0.12

H-C.2.3 Unloading Operations ($E30_{un}$)

The equation for estimating $E30_{un}$ ($g/m^2/d$), the PM_{30} emission rate due to unloading operations at wastepiles and landfills, was adapted from U.S. EPA (1995, Equation 1, p. 13.2.4-3). The EPA equation was adapted by multiplying it by the average annual loading rate (L, Mg/yr), normalizing the emissions for the contaminated surface area, and applying the particle size multiplier for <30 µm.

$$E30_{un} = (0.0012) \cdot \frac{\left(\frac{u}{2.2}\right)^{1.3}}{\left(\frac{mcW}{2}\right)^{1.4}} \cdot \frac{L}{A} \cdot \frac{10^3\,\mathrm{g}}{\mathrm{kg}} \frac{\mathrm{yr}}{365\mathrm{d}} \qquad \text{(H-C-9)}$$

Parameter definitions are provided in Table H-C-7. The particle size range mass fractions were developed from information provided in U.S. EPA (1995) and are presented in Table H-C-8.

Table H-C-7. Parameter Units and Definitions for $E30_{un}$

Symbol	Units	Definition
u	m/s	Mean annual windspeed (0.6-6.7)
mcW	volume %	Waste moisture content (0.25-4.8)
L	Mg/yr	Annual average waste loading rate

Note: Values in parentheses are the ranges of source conditions that were tested in developing the U.S. EPA (1995) equation.

Table H-C-8. Aerodynamic Particle Size Range Mass Fractions for $E30_{un}$

30 µm -15 µm	15 µm -10 µm	10 µm -2.5 µm	≤2.5 µm
0.35	0.18	0.32	0.15

H-C.2.4 Spreading/Compacting or Tilling Operations ($E30_{sc}$)

The equation for estimating $E30_{sc}$ ($g/m^2/d$), the rate of PM_{30} emissions due to spreading and compacting or tilling operations, was adapted from an equation in U.S. EPA (1985, Equation 1, p. 11.2.2-1) that was developed for estimating emissions due to agricultural tilling in units of kilogram of particulate emissions per hectare per tilling (or spreading/ compacting) event. The first two terms in Equation H-C-10 represent the EPA equation with the particle size multiplier for <30 µm applied.

$$E30_{sc} = (1.77)\ S^{0.6} \cdot N_{op} \cdot \frac{10^3\ g}{kg} \cdot \frac{ha}{10^4\ m^2} \qquad \text{(H-C-10)}$$

Parameter definitions are provided in Table H-C-9. The particle size range mass fractions were developed from information provided in U.S. EPA (1985) and are presented in Table H-C-10.

H-C.3 Particle Size Range Mass Fractions for Total PM_{30} Emission Rate

Particle size range mass fractions characterizing the total annual average PM_{30} emission rate ($E30_i$ summed over all applicable mechanisms) is determined annually by applying the mechanism-specific mass fractions to the $E30_i$ estimates to obtain size-specific emission rate

Table H-C-9. Parameter Units and Definitions for $E30_{sc}$

Symbol	Units	Definition
S	w/w, %	Silt content of surface material (1.7-88)[a, b]
N_{op}[c]	1/d	Number of tilling (or spreading and compacting) operations per day
fcult	---	Number of cultivations per application

[a] Silt is defined as particles less than 75 µm in diameter. Silt content is determined by the percent of loose dry surface material that passes through a 200-mesh screen using the ASTM-C-136 method (U.S. EPA, 1985).

[b] Values in parentheses are the ranges of source conditions that were tested in developing the U.S. EPA (1985) equation.

[c] For the LAU, Nop = (Nappl/365 x fcult).

Table H-C-10. Aerodynamic Particle Size Range Mass Fractions for $E30_{sc}$

30 μm -15 μm	15 μm -10 μm	10 μm -2.5 μm	≤2.5 μm
0.24	0.12	0.34	0.30

estimates $E_{i,j}$ (g/m^2/d) where subscript j identifies the particle size range (j= 1 indicates 30-15 μm; 2, 15-10 μm; 3, 10-2.5 μm; and 4, <2.5 μm). The total particle size range mass fraction, pmf_j, is calculated as

$$pmf_j = \frac{\sum_i E_{i,j}}{\sum_i E30_i} \qquad \text{(H-C-11)}$$

H-C.4 Annual Average Constituent Emission Rate (CE30) Equations

The amount of mass lost due to wind and mechanical disturbances, $M_{loss,wd}$ (g/m^2), estimated using Equation H-C-26 and accumulated throughout the simulated year is used to estimate CE30 (g/m^2/d), the annual average, area-normalized emission rate of contaminant mass adsorbed to particulate matter less than 30 μm in diameter.

$$CE30 = \frac{M_{loss,wd}}{365} \qquad \text{(H-C-12)}$$

Equation H-C-10 is directly applicable to the LAU during both the inactive and active years, the wastepile during the inactive years, and the inactive (full) landfill cell. For the first year of the landfill cell and the active years of the wastepile, the raw waste losses due to particulate emissions during unloading waste are added to the CE30 estimate. The increment is equal to

$$+\ E30un \cdot C'_{T,W} \cdot fwmu \cdot 10^{-6} \frac{g}{\mu g} \qquad \text{(H-C-13)}$$

H-C.5 Estimation of First-Order Loss Rate (k_{wd})

An equation for k_{wd} was derived by performing a mass balance on the surface layer of the "soil" column to a depth of dz (the depth of the surface soil column cell) and considering losses due to wind and mechanical activity only:

$$\frac{\partial C_T}{\partial t} = -k_{wd} C_T \qquad \text{(H-C-14)}$$

where

$$k_{wd} = \frac{1}{dz} \cdot \frac{K_d}{K_{TL}} \cdot \frac{g}{10^6 \mu g} \cdot \Sigma_i E30_i \qquad i \neq un \qquad \text{(H-C-15)}$$

The processes indicated by subscript i that are included for each WMU are summarized in Table H-C-1. Only processes acting on the surface layer are included in the summation of $E30_i$. Therefore, the unloading of raw waste (i=un) is excluded.

H-C.6 References

Cowherd, C.J. 1998. Personal communication. Midwest Research Institute, Kansas City, Missouri, February 27.

Cowherd, C.J., G.E. Muleski, P.J. Englehart, and D.A. Gillette. 1985. *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites*. Office of Health and Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC.

U.S. Department of Commerce. 1968. *Climatic Atlas of the United States*. U.S. Government Printing Office, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1985. *Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, 4th Edition. AP-42.* PB86-124906. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

U.S. EPA (Environmental Protection Agency). 1995. *Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, 5th Edition. AP-42.* PB95-196028INZ, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

Appendix H

Attachment D:
Modifications to LAU Source Partition Model Programs

Appendix H

Attachment D: Modifications to LAU Source Partition Model Programs

Several coding modifications were made to the LAU source model to enable it to be used for this analysis. Those modifications are summarized below.

H-D.1 LAU Model for Crop Agricultural Field

H-D.1.1 Temperature Correction

The temperature correction routines were revised so that they were performed internal to the program. Routines for internal temperature corrections had been developed and these internal routines were re-instated for the sewage sludge application. These routines are chemical diffusivity in air (Da), chemical diffusivity in water (Dw), and Henry's law constant (H). The correction routine for Da was derived from the FSG Method (Lyman, 1990, Ch. 17, eq. 17-12), and the routine for Dw was derived from Equation 17-24 (Hayduk and Laudie) in Lyman et al. (1990). The temperature correction for H used estimates of the heat of vaporization from Lyman et al. (1990, eq. 13-21). The Haggenmacher method (Lyman et al., 1990, Sect. 13-5) is used to get the heat of vaporization at the boiling point. Temperature corrections for partitioning (Kd, Koc), hydrolysis, and solubility were not included in the sewage sludge source models.

The temperature correction routines introduced several new input variables to the model: Antoine's constants B and C, the boiling temperature of the chemical, and the critical temperature and pressure for the chemical. Changes were made to the program executables and the data dictionary files to read these data into the program.

H-D.1.2 AP-42 Changes to Vehicular Activity Particulate Emissions

One of the particulate emissions equations was modified to reflect a 1998 update by EPA (URL: www.epa.gov/ttn/chief/ap42/ch13) to the equation previously used the LAU. The equation that was updated is presented as equation H-C-9 in this appendix. That equation predicts the daily flux of particulate emissions of 30 μm of less particles resulting from vehicular traffic on the surface of the LAU, i.e. variable "E30ve." The updated equation is

E30ve = 2.819(S/12)^0.8(vw/3)^0.5((365-p)/365)nv(1-effdust)(mt/A) (H-D-1)

where the variables and units are as described in H-C-12.

H-D.2 LAU Model for Pasture Agricultural Field

H-D.2.1 Temperature Correction

Code changes to enable internal temperature corrections were identical to those described above for the crop agricultural field.

H-D.2.2 AP-42 Changes to Vehicular Activity Particulate Emissions

Code changes to update the vehicular activity particulate emissions calculations were identical to those described above for the crop agricultural field.

H-D.2.3 Changes to Include Waste Lying on Soil Surface

The most significant change to the LAU Module to configure it for the pasture agricultural field was a set of modifications that together reflect the conceptual scenario that sludge applied to the pasture is not tilled into the soil, but rather spread on the soil surface and mixed with the top 2 cm of soil through natural means. The code changes to effect this scenario performed the following steps:

1. The modeled depth of the “soil column” (variable zZ1WMU) was increased by this depth. The new “soil column” then consisted of the actual soil underneath the spread sludge (0.2 m) plus the depth of the sludge layer lying on top.

2. A sludge application now reflects an updating of the above-soil-surface model layers, rather than a “tilling” into the soil depth.

H-D.2.4 Shortcoming of the LAU Pasture Model

A shortcoming of the LAU model used to simulate the pasture scenario is that the modeled “soil column” now consists of two zones with nonhomogeneous physical properties—the sludge zone lying of top of the soil, and the underlying soil zone. The LAU model was not designed to accommodate different zones; indeed, the single zone soil column’s properties (percent silt, bulk density, and fraction organic carbon) are estimated as a weighted average of the soil properties and the waste properties, because they are mixed together. Although the pasture’s complete soil column in fact consists of these two different zones, the properties of the sludge (assumed to resemble silt) were used for the entire soil column in the simulation because of this model limitation. Thus, to the extent that the underlying soil is different from silt, some error is introduced into the results by this simplifying assumption. Despite this limitation, the LAU model was considered the most appropriate model to be used for the pasture simulation.

H-D.3 References

Lyman, W., W. Reehl, D. Rosenblatt. 1990. *Handbook of Chemical Property Estimation Methods: Environmental Behavior of Organic Compounds.* American Chemical Society, Washington, DC.

Appendix I

Air Dispersion and Deposition Data and Modeling Input Files

Appendix I

Air Dispersion and Deposition Data and Modeling Input Files

This appendix contains the unitized air concentration (UAC) data for volatile constituents used in the modeling of human health exposures in the sewage sludge lagoon (surface impoundment) scenario. Table I-1 presents the UACs of vapors for each sewage sludge lagoon (surface impoundment) modeled. Figure I-1 contains the air modeling input files used to generate the air dispersion and deposition data used in the agricultural application scenario.

Table I-1. Unitized Air Concentrations for Lagoon Scenario

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1	24233	3.12E+01	500	4.64E-04
2	14935	7.24E+02	500	6.83E-03
3	24033	1.49E+03	150	6.87E-02
4	94018	1.30E+03	500	2.32E-02
5	94018	1.30E+03	150	0.164017469
6	13968	2.60E+01	500	3.34E-04
7	24033	1.81E+03	50	0.390205085
8	13968	2.60E+01	150	2.86E-03
9	93815	1.94E+02	150	1.15E-02
10	13897	6.96E+03	150	0.642082036
11	94018	1.00E+03	150	0.12979272
12	94846	7.90E+03	500	4.94E-02
13	12839	2.02E+02	150	1.75E-02
14	14935	7.24E+02	150	5.18E-02
15	14935	1.70E+03	75	0.294345737
16	93193	1.62E+03	150	0.18215175
17	13737	2.94E+03	500	1.99E-02
18	13874	1.74E+02	500	1.38E-03
19	13963	5.57E+02	500	5.34E-03
20	12916	3.90E+02	150	0.017414141
21	24033	1.81E+03	150	8.10E-02
22	94018	1.30E+03	500	2.32E-02
23	12839	8.82E+03	150	0.458975971
24	12916	9.29E+02	150	3.83E-02
25	23234	2.36E+03	150	0.193542421
26	24011	7.28E+02	500	4.37E-03
27	13874	1.74E+02	150	1.15E-02
28	13968	5.81E+02	150	5.81E-02
29	24011	7.28E+02	150	3.47E-02
30	24033	1.81E+03	150	8.10E-02
31	13874	1.74E+02	150	1.15E-02
32	24033	1.81E+03	150	8.10E-02
33	94846	7.90E+03	500	4.94E-02
34	94846	7.90E+03	500	4.94E-02
35	94846	7.90E+03	150	0.297966719
36	13968	2.60E+01	500	3.34E-04
37	13968	2.28E+03	500	2.71E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per ug/s-m^2)
38	94846	7.90E+03	150	0.297966719
39	14935	1.03E+03	150	7.04E-02
40	24033	1.81E+03	150	8.10E-02
41	24011	1.09E+03	150	5.05E-02
42	13874	1.23E+03	500	9.39E-03
43	13968	2.60E+01	150	2.86E-03
44	94847	7.80E+02	500	6.29E-03
45	14935	1.70E+03	150	0.10937687
46	93193	1.62E+03	150	0.18215175
47	23234	2.83E+03	150	0.224960372
48	13874	1.74E+02	50	7.42E-02
49	94847	7.80E+02	500	6.29E-03
50	94018	1.30E+03	500	2.32E-02
51	13874	1.74E+02	500	1.38E-03
52	24033	1.81E+03	150	8.10E-02
53	13880	1.35E+05	150	2.245984554
54	13897	1.86E+03	500	3.61E-02
55	23234	6.48E+03	500	7.24E-02
56	24033	1.81E+03	500	1.11E-02
57	94018	1.30E+03	150	0.164017469
58	13963	2.15E+05	500	1.070623994
59	14935	7.24E+02	150	5.18E-02
60	94846	7.90E+03	150	0.297966719
61	94018	1.30E+03	150	0.164017469
62	24033	1.81E+03	150	8.10E-02
63	12842	5.20E+01	150	4.85E-03
64	24033	1.81E+03	150	8.10E-02
65	12916	3.90E+02	500	2.17E-03
66	24011	7.28E+02	150	3.47E-02
67	23234	2.36E+03	500	2.86E-02
68	12916	3.90E+02	500	2.17E-03
69	12839	8.76E+03	500	7.77E-02
70	24033	1.81E+03	150	8.10E-02
71	94018	1.30E+03	75	0.459146798
72	93193	2.91E+04	150	1.652960896
73	3937	1.30E+05	150	2.23148489

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
74	94018	1.30E+03	150	0.164017469
75	12916	3.90E+02	75	5.51E-02
76	13874	1.74E+02	500	1.38E-03
77	93193	2.91E+04	150	1.652960896
78	94018	1.30E+03	500	2.32E-02
79	94018	1.30E+03	150	0.164017469
80	24033	1.81E+03	150	8.10E-02
81	13963	1.77E+04	75	1.516706824
82	14935	7.24E+02	500	6.83E-03
83	24033	1.81E+03	75	0.228026822
84	13968	1.99E+03	500	2.38E-02
85	13737	2.94E+03	500	1.99E-02
86	13968	2.60E+01	500	3.34E-04
87	13897	6.96E+03	500	0.120370112
88	24033	1.81E+03	50	0.390205085
89	94847	1.30E+02	150	8.92E-03
90	12916	3.90E+02	150	0.017414141
91	3937	1.24E+03	150	7.23E-02
92	13897	1.16E+03	150	0.161779895
93	93193	2.91E+04	500	0.343281299
94	14740	9.14E+02	150	8.63E-02
95	24033	1.81E+03	500	1.11E-02
96	12842	5.20E+01	150	4.85E-03
97	12916	3.90E+02	150	0.017414141
98	13968	2.60E+01	150	2.86E-03
99	13968	1.52E+03	150	0.139482036
100	13968	5.81E+02	500	7.25E-03
101	93815	2.02E+04	75	1.310637474
102	93815	1.94E+02	500	1.40E-03
103	24011	1.46E+03	150	6.62E-02
104	14764	6.07E+03	500	5.75E-02
105	94846	7.90E+03	500	4.94E-02
106	13739	3.58E+03	150	0.18802318
107	94018	1.30E+03	500	2.32E-02
108	94018	1.30E+03	75	0.459146798
109	13737	2.94E+03	500	1.99E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
110	13874	1.74E+02	150	1.15E-02
111	13739	4.87E+02	500	4.04E-03
112	13968	2.60E+01	500	3.34E-04
113	94018	1.30E+03	500	2.32E-02
114	13968	2.60E+01	150	2.86E-03
115	23234	6.07E+03	500	6.83E-02
116	94847	5.30E+02	500	4.33E-03
117	14935	2.15E+04	150	0.689836383
118	93193	2.91E+04	75	3.184275866
119	23234	6.07E+03	500	6.83E-02
120	94846	7.90E+03	500	4.94E-02
121	13874	1.74E+02	150	1.15E-02
122	12842	5.20E+01	150	4.85E-03
123	13874	1.74E+02	500	1.38E-03
124	94018	1.30E+03	500	2.32E-02
125	12839	2.02E+02	150	1.75E-02
126	24033	5.55E+03	150	0.202939466
127	23234	4.86E+03	500	5.61E-02
128	24033	1.81E+03	500	1.11E-02
129	13737	2.94E+03	150	0.12866129
130	24033	1.81E+03	75	0.228026822
131	13968	2.60E+01	150	2.86E-03
132	24033	1.81E+03	150	8.10E-02
133	93815	1.30E+04	500	0.077218309
134	13963	1.77E+04	500	0.144601092
135	93815	1.94E+02	500	1.40E-03
136	14935	1.83E+04	50	1.753747344
137	23174	9.39E+03	500	0.13070333
138	94846	7.90E+03	150	0.297966719
139	94846	1.86E+04	150	0.552988529
140	13737	2.94E+03	150	0.12866129
141	24033	1.81E+03	500	1.11E-02
142	23234	2.36E+03	150	0.193542421
143	13968	2.60E+01	150	2.86E-03
144	23174	2.93E+04	500	0.356077075
145	14935	1.83E+04	150	0.626706421

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
146	93193	1.62E+03	500	2.53E-02
147	24233	3.12E+01	75	0.013633432
148	13968	2.60E+01	150	2.86E-03
149	24033	1.81E+03	150	8.10E-02
150	13968	2.60E+01	75	9.70E-03
151	94847	1.30E+02	150	8.92E-03
152	13968	2.60E+01	150	2.86E-03
153	13968	2.60E+01	500	3.34E-04
154	23234	2.36E+03	150	0.193542421
155	13874	1.74E+02	150	1.15E-02
156	13874	1.74E+02	150	1.15E-02
157	94018	1.30E+03	75	0.459146798
158	94846	5.40E+02	150	3.11E-02
159	13968	2.60E+01	500	3.34E-04
160	94846	5.40E+02	150	3.11E-02
161	24033	1.81E+03	500	1.11E-02
162	13897	1.16E+03	150	0.161779895
163	24033	1.81E+03	500	1.11E-02
164	14935	1.70E+03	150	0.10937687
165	94846	7.90E+03	500	4.94E-02
166	93815	1.30E+03	150	6.70E-02
167	94018	1.30E+03	75	0.459146798
168	13739	2.09E+03	150	0.11715059
169	13963	1.77E+04	500	0.144601092
170	12842	5.20E+01	500	5.75E-04
171	12839	8.76E+03	150	0.456498176
172	23234	4.86E+03	150	0.346287996
173	23234	2.83E+03	500	3.39E-02
174	94018	1.30E+03	500	2.32E-02
175	13874	1.74E+02	150	1.15E-02
176	23234	2.42E+03	150	0.197342426
177	13968	2.60E+01	150	2.86E-03
178	13897	2.31E+05	150	4.531942844
179	13968	2.60E+01	150	2.86E-03
180	94018	1.30E+03	500	2.32E-02
181	13739	3.58E+03	150	0.18802318

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
182	13957	8.09E+05	500	2.522666454
183	94846	7.90E+03	500	4.94E-02
184	94846	7.90E+03	500	4.94E-02
185	14935	1.83E+04	75	1.252596378
186	12839	2.02E+02	150	1.75E-02
187	94018	1.00E+03	150	0.12979272
188	93193	1.62E+03	150	0.18215175
189	13897	3.86E+03	150	0.433436334
190	14764	4.58E+04	500	0.325622469
191	93193	1.62E+03	150	0.18215175
192	13739	3.58E+03	150	0.18802318
193	93193	2.91E+04	500	0.343281299
194	13739	3.58E+03	500	2.75E-02
195	13897	1.86E+03	150	0.240401059
196	12839	8.82E+03	500	0.078199565
197	94846	5.40E+02	150	3.11E-02
198	24033	1.81E+03	150	8.10E-02
199	13968	2.60E+01	75	9.70E-03
200	94846	7.90E+03	150	0.297966719
201	94018	1.30E+03	150	0.164017469
202	12839	8.76E+03	500	7.77E-02
203	93815	2.02E+04	150	0.595363677
204	12839	8.82E+03	500	0.078199565
205	13968	2.60E+01	150	2.86E-03
206	94847	1.30E+02	150	8.92E-03
207	14935	1.70E+03	75	0.294345737
208	13874	1.74E+02	150	1.15E-02
209	13737	2.94E+03	150	0.12866129
210	12916	9.29E+02	75	0.113743268
211	23234	6.48E+03	75	0.973131061
212	14935	2.15E+04	150	0.689836383
213	13968	1.99E+03	500	2.38E-02
214	12916	3.90E+02	150	0.017414141
215	14740	9.14E+02	500	1.18E-02
216	23174	9.39E+03	500	0.13070333
217	14935	7.24E+02	50	0.263869017

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per ug/s-m^2)
218	13963	1.19E+04	150	0.591862321
219	94018	1.30E+03	500	2.32E-02
220	13897	1.86E+03	500	3.61E-02
221	24011	1.09E+03	500	6.49E-03
222	94018	1.30E+03	150	0.164017469
223	13963	1.77E+04	500	0.144601092
224	94018	1.30E+03	75	0.459146798
225	13880	1.35E+05	500	0.60772419
226	94018	1.30E+03	500	2.32E-02
227	13897	1.86E+03	150	0.240401059
228	93815	1.30E+04	500	0.077218309
229	24033	1.81E+03	150	8.10E-02
230	13968	2.60E+01	150	2.86E-03
231	13874	1.74E+02	150	1.15E-02
232	24033	1.81E+03	150	8.10E-02
233	94018	1.30E+03	150	0.164017469
234	13968	2.60E+01	500	3.34E-04
235	93193	2.91E+04	150	1.652960896
236	13957	8.09E+05	500	2.522666454
237	14935	1.70E+03	150	0.10937687
238	24033	1.81E+03	150	8.10E-02
239	94846	7.90E+03	150	0.297966719
240	13874	1.74E+02	150	1.15E-02
241	12839	8.82E+03	150	0.458975971
242	94846	7.90E+03	150	0.297966719
243	13874	1.74E+02	150	1.15E-02
244	94847	7.80E+02	150	4.66E-02
245	94018	1.30E+03	500	2.32E-02
246	23174	2.93E+04	150	1.651089549
247	94018	1.28E+03	150	0.161950201
248	14935	2.15E+04	150	0.689836383
249	12916	3.90E+02	150	0.017414141
250	13968	2.28E+03	500	2.71E-02
251	24033	1.81E+03	150	8.10E-02
252	13968	2.60E+01	500	3.34E-04
253	24033	1.81E+03	500	1.11E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
254	93193	1.62E+05	500	1.380677104
255	13897	1.86E+03	150	0.240401059
256	13968	2.60E+01	500	3.34E-04
257	12839	8.76E+03	75	1.087519169
258	24033	1.81E+03	150	8.10E-02
259	13968	2.60E+01	75	9.70E-03
260	94018	1.30E+03	500	2.32E-02
261	13968	2.60E+01	500	3.34E-04
262	13968	2.28E+03	500	2.71E-02
263	94846	5.11E+03	75	0.535634041
264	23234	2.36E+03	150	0.193542421
265	24033	1.81E+03	500	1.11E-02
266	24033	3.33E+03	150	0.13681522
267	94847	5.30E+02	500	4.33E-03
268	12916	3.90E+02	500	2.17E-03
269	94018	1.30E+03	150	0.164017469
270	14935	7.24E+02	500	6.83E-03
271	24033	1.49E+03	500	9.17E-03
272	13874	1.74E+02	150	1.15E-02
273	13968	2.60E+01	150	2.86E-03
274	24033	1.81E+03	500	1.11E-02
275	23234	2.36E+03	150	0.193542421
276	14935	2.15E+04	150	0.689836383
277	24033	1.81E+03	500	1.11E-02
278	13968	2.60E+01	50	1.94E-02
279	13963	2.15E+05	500	1.070623994
280	14935	1.03E+03	500	9.60E-03
281	24233	3.12E+01	500	4.64E-04
282	13874	4.49E+04	500	0.264645517
283	13897	6.96E+03	150	0.642082036
284	24033	1.81E+03	500	1.11E-02
285	13897	3.86E+03	500	7.21E-02
286	94018	1.30E+03	500	2.32E-02
287	24033	1.49E+03	150	6.87E-02
288	94018	1.30E+03	500	2.32E-02
289	13737	2.94E+03	500	1.99E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
290	13968	2.60E+01	75	9.70E-03
291	93815	1.94E+02	500	1.40E-03
292	24033	1.81E+03	500	1.11E-02
293	93815	1.30E+04	75	1.047177553
294	3937	7.43E+02	150	4.60E-02
295	24033	1.49E+03	150	6.87E-02
296	23234	2.36E+03	150	0.193542421
297	13968	2.60E+01	75	9.70E-03
298	12916	3.90E+02	150	0.017414141
299	23234	2.42E+03	75	0.513293624
300	13897	1.16E+03	150	0.161779895
301	14935	2.15E+04	75	1.352293134
302	94018	3.52E+03	150	0.378584981
303	13874	1.74E+02	500	1.38E-03
304	24033	1.81E+03	150	8.10E-02
305	93193	1.62E+03	150	0.18215175
306	13737	2.94E+03	150	0.12866129
307	13968	2.60E+01	75	9.70E-03
308	13874	9.29E+01	150	6.30E-03
309	14935	1.03E+03	150	7.04E-02
310	12916	3.90E+02	500	2.17E-03
311	94846	5.40E+02	500	3.94E-03
312	13737	2.94E+03	150	0.12866129
313	24033	3.33E+03	150	0.13681522
314	13874	1.74E+02	150	1.15E-02
315	94018	1.30E+03	150	0.164017469
316	24033	1.81E+03	500	1.11E-02
317	13737	2.94E+03	500	1.99E-02
318	24033	1.81E+03	500	1.11E-02
319	23234	2.42E+03	150	0.197342426
320	13739	3.58E+03	150	0.18802318
321	93815	1.30E+04	150	0.449256331
322	94018	1.30E+03	150	0.164017469
323	14935	1.83E+04	150	0.626706421
324	94018	1.30E+03	500	2.32E-02
325	23174	9.39E+03	75	1.722415924

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
326	13968	5.81E+02	150	5.81E-02
327	94846	5.11E+03	500	3.34E-02
328	23174	2.93E+04	500	0.356077075
329	13897	1.86E+03	500	3.61E-02
330	13880	4.86E+03	150	0.230076194
331	13897	6.96E+03	500	0.120370112
332	13737	2.94E+03	150	0.12866129
333	14764	4.58E+04	150	1.522423148
334	12839	8.76E+03	500	7.77E-02
335	14935	1.83E+04	150	0.626706421
336	13874	1.74E+02	500	1.38E-03
337	13968	2.60E+01	500	3.34E-04
338	13968	2.60E+01	150	2.86E-03
339	23174	2.93E+04	150	1.651089549
340	13874	1.74E+02	500	1.38E-03
341	13968	2.60E+01	150	2.86E-03
342	24011	1.46E+03	150	6.62E-02
343	94018	1.30E+03	150	0.164017469
344	13739	3.58E+03	500	2.75E-02
345	13874	1.74E+02	500	1.38E-03
346	24233	3.12E+01	150	3.99E-03
347	13874	1.74E+02	75	3.78E-02
348	24033	1.81E+03	150	8.10E-02
349	94018	1.17E+05	500	1.134759068
350	94018	1.30E+03	150	0.164017469
351	12842	5.20E+01	150	4.85E-03
352	93815	1.30E+03	75	0.194663927
353	94018	1.30E+03	150	0.164017469
354	13968	2.60E+01	75	9.70E-03
355	23234	6.07E+03	150	0.404124349
356	13874	1.74E+02	75	3.78E-02
357	94018	1.30E+03	500	2.32E-02
358	13968	2.60E+01	500	3.34E-04
359	94847	7.80E+02	500	6.29E-03
360	24011	1.46E+03	500	8.60E-03
361	23174	2.93E+04	500	0.356077075

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
362	13897	1.16E+03	150	0.161779895
363	94847	7.80E+02	150	4.66E-02
364	24033	3.33E+03	150	0.13681522
365	94846	1.86E+04	150	0.552988529
366	94846	7.90E+03	500	4.94E-02
367	13968	2.28E+03	500	2.71E-02
368	23234	2.42E+03	500	2.93E-02
369	94846	7.90E+03	75	0.70691359
370	23234	2.36E+03	150	0.193542421
371	13957	8.09E+05	500	2.522666454
372	94846	5.11E+03	500	3.34E-02
373	94846	7.90E+03	500	4.94E-02
374	94018	1.30E+03	500	2.32E-02
375	93815	1.30E+04	500	0.077218309
376	14935	1.83E+04	150	0.626706421
377	94018	1.17E+05	500	1.134759068
378	14935	2.15E+04	500	0.149872139
379	93815	1.30E+03	150	6.70E-02
380	24033	2.79E+01	150	1.53E-03
381	14764	6.07E+03	500	5.75E-02
382	93193	1.62E+03	150	0.18215175
383	94018	1.30E+03	500	2.32E-02
384	24033	1.81E+03	500	1.11E-02
385	94846	7.90E+03	150	0.297966719
386	94018	1.00E+03	500	1.80E-02
387	12916	3.90E+02	500	2.17E-03
388	13874	1.74E+02	500	1.38E-03
389	94018	1.28E+03	150	0.161950201
390	13874	1.74E+02	150	1.15E-02
391	94018	1.30E+03	150	0.164017469
392	94018	1.30E+03	150	0.164017469
393	94846	7.90E+03	500	4.94E-02
394	13968	2.28E+03	75	0.523773432
395	13968	1.99E+03	500	2.38E-02
396	93193	2.91E+04	150	1.652960896
397	94018	1.30E+03	150	0.164017469

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
398	23234	6.48E+03	150	0.423418999
399	13968	5.81E+02	500	7.25E-03
400	13968	2.60E+01	500	3.34E-04
401	94018	1.30E+03	500	2.32E-02
402	93815	2.02E+04	500	0.111287095
403	93815	1.94E+02	150	1.15E-02
404	14935	1.83E+04	150	0.626706421
405	13963	1.77E+04	150	0.74918884
406	93193	2.91E+04	150	1.652960896
407	13874	1.74E+02	500	1.38E-03
408	13897	6.69E+02	150	0.101128809
409	13874	1.74E+02	500	1.38E-03
410	13968	5.81E+02	150	5.81E-02
411	13963	5.57E+02	150	4.40E-02
412	24011	1.44E+03	500	8.51E-03
413	13968	2.60E+01	500	3.34E-04
414	13880	1.35E+05	150	2.245984554
415	13963	5.57E+02	150	4.40E-02
416	13968	1.52E+03	150	0.139482036
417	14935	2.15E+04	500	0.149872139
418	94846	7.90E+03	150	0.297966719
419	94018	1.30E+03	500	2.32E-02
420	13968	2.60E+01	500	3.34E-04
421	13880	1.04E+03	500	8.50E-03
422	23174	2.93E+04	150	1.651089549
423	23234	2.83E+03	500	3.39E-02
424	94018	1.30E+03	150	0.164017469
425	13737	2.94E+03	500	1.99E-02
426	13968	2.60E+01	500	3.34E-04
427	13739	3.58E+03	500	2.75E-02
428	13968	5.81E+02	75	0.179731175
429	94018	1.30E+03	75	0.459146798
430	13968	2.60E+01	500	3.34E-04
431	13739	3.58E+03	500	2.75E-02
432	24033	2.79E+01	150	1.53E-03
433	13874	1.74E+02	150	1.15E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
434	24011	1.44E+03	150	6.55E-02
435	14935	1.83E+04	500	0.131324604
436	24033	2.79E+01	500	1.81E-04
437	94018	2.02E+02	500	3.79E-03
438	13968	2.60E+01	150	2.86E-03
439	14935	7.24E+02	150	5.18E-02
440	3937	1.24E+03	150	7.23E-02
441	93193	2.91E+04	150	1.652960896
442	13874	1.74E+02	150	1.15E-02
443	14935	1.03E+03	150	7.04E-02
444	23234	6.07E+03	500	6.83E-02
445	24033	1.81E+03	150	8.10E-02
446	93815	1.30E+03	500	0.009018256
447	23174	9.39E+03	75	1.722415924
448	14935	7.24E+02	500	6.83E-03
449	13874	1.74E+02	500	1.38E-03
450	13897	1.16E+03	150	0.161779895
451	93815	1.30E+04	150	0.449256331
452	24033	2.79E+01	150	1.53E-03
453	24033	1.81E+03	500	1.11E-02
454	13897	1.86E+03	150	0.240401059
455	23234	2.42E+03	500	2.93E-02
456	14935	1.03E+03	150	7.04E-02
457	13968	2.60E+01	500	3.34E-04
458	13897	1.16E+03	150	0.161779895
459	13968	2.60E+01	500	3.34E-04
460	94847	5.30E+02	150	3.36E-02
461	14935	1.70E+03	75	0.294345737
462	13968	2.60E+01	500	3.34E-04
463	13968	2.60E+01	150	2.86E-03
464	13737	2.94E+03	150	0.12866129
465	94846	7.90E+03	500	4.94E-02
466	13963	5.57E+02	150	4.40E-02
467	13874	1.74E+02	500	1.38E-03
468	13968	2.60E+01	500	3.34E-04
469	14935	1.83E+04	150	0.626706421

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
470	13968	2.60E+01	150	2.86E-03
471	13874	1.74E+02	500	1.38E-03
472	13897	3.86E+03	150	0.433436334
473	14935	1.70E+03	150	0.10937687
474	94846	7.90E+03	150	0.297966719
475	23174	9.39E+03	150	0.775993705
476	23234	6.48E+03	500	7.24E-02
477	94846	7.90E+03	500	4.94E-02
478	14935	7.24E+02	150	5.18E-02
479	13897	1.16E+03	150	0.161779895
480	24033	1.81E+03	150	8.10E-02
481	13874	1.74E+02	150	1.15E-02
482	24033	1.49E+03	500	9.17E-03
483	94846	5.40E+02	150	3.11E-02
484	14764	6.07E+03	75	0.85103929
485	14935	1.68E+03	150	0.108694054
486	13963	5.57E+02	500	5.34E-03
487	13968	2.60E+01	150	2.86E-03
488	13739	4.87E+02	500	4.04E-03
489	12839	2.02E+02	500	2.16E-03
490	24033	1.81E+03	500	1.11E-02
491	13968	2.60E+01	500	3.34E-04
492	12839	8.82E+03	150	0.458975971
493	13737	2.94E+03	500	1.99E-02
494	23234	2.42E+03	500	2.93E-02
495	93193	2.91E+04	500	0.343281299
496	94018	1.30E+03	500	2.32E-02
497	13957	8.09E+05	150	6.202586651
498	14935	1.70E+03	500	1.56E-02
499	94847	7.80E+02	150	4.66E-02
500	14935	7.24E+02	150	5.18E-02
501	94018	1.30E+03	150	0.164017469
502	14935	1.83E+04	500	0.131324604
503	13968	2.60E+01	500	3.34E-04
504	24033	1.81E+03	150	8.10E-02
505	24033	2.79E+01	500	1.81E-04

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
506	24033	1.81E+03	150	8.10E-02
507	94846	7.90E+03	150	0.297966719
508	23234	6.48E+03	150	0.423418999
509	24033	1.81E+03	150	8.10E-02
510	23234	6.48E+03	50	1.495923877
511	24033	1.49E+03	150	6.87E-02
512	12839	2.02E+02	500	2.16E-03
513	13737	2.94E+03	500	1.99E-02
514	12839	8.82E+03	500	0.078199565
515	12916	3.90E+02	150	0.017414141
516	24033	1.81E+03	75	0.228026822
517	93193	2.91E+04	500	0.343281299
518	13874	1.74E+02	500	1.38E-03
519	13874	8.36E+01	500	6.70E-04
520	93193	2.91E+04	500	0.343281299
521	93193	2.91E+04	150	1.652960896
522	13874	8.36E+01	150	5.70E-03
523	13874	1.74E+02	150	1.15E-02
524	24011	1.09E+03	150	5.05E-02
525	94018	1.30E+03	150	0.164017469
526	93193	1.62E+03	500	2.53E-02
527	13874	9.29E+01	150	6.30E-03
528	93193	1.62E+03	500	2.53E-02
529	14935	7.24E+02	500	6.83E-03
530	13968	2.60E+01	500	3.34E-04
531	24033	1.81E+03	500	1.11E-02
532	94846	1.86E+04	500	0.104921967
533	24033	1.81E+03	50	0.390205085
534	24233	1.21E+04	500	0.150713742
535	94846	7.90E+03	150	0.297966719
536	14935	2.15E+04	500	0.149872139
537	94018	1.30E+03	75	0.459146798
538	94018	1.30E+03	500	2.32E-02
539	24033	2.79E+01	500	1.81E-04
540	94846	7.90E+03	150	0.297966719
541	13874	1.74E+02	150	1.15E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
542	24011	1.44E+03	150	6.55E-02
543	94846	7.90E+03	150	0.297966719
544	12839	2.02E+02	150	1.75E-02
545	13874	1.23E+03	150	0.072232224
546	94018	1.30E+03	500	2.32E-02
547	13897	6.96E+03	150	0.642082036
548	93815	1.94E+02	150	1.15E-02
549	13897	1.86E+03	150	0.240401059
550	14935	1.83E+04	150	0.626706421
551	13968	2.60E+01	500	3.34E-04
552	24033	1.49E+03	500	9.17E-03
553	93193	1.62E+03	150	0.18215175
554	23174	9.39E+03	150	0.775993705
555	13880	1.62E+03	150	9.32E-02
556	13968	2.60E+01	500	3.34E-04
557	13968	2.60E+01	500	3.34E-04
558	13874	1.74E+02	150	1.15E-02
559	13968	2.60E+01	150	2.86E-03
560	94846	7.90E+03	500	4.94E-02
561	14935	1.70E+03	150	0.10937687
562	24033	1.81E+03	50	0.390205085
563	13968	2.60E+01	150	2.86E-03
564	93815	2.02E+04	150	0.595363677
565	13968	2.28E+03	150	0.193842337
566	94847	1.30E+02	500	1.08E-03
567	13968	2.60E+01	500	3.34E-04
568	14935	1.68E+03	500	1.54E-02
569	93193	1.62E+03	150	0.18215175
570	94018	1.30E+03	500	2.32E-02
571	94018	1.28E+03	150	0.161950201
572	12916	3.90E+02	150	0.017414141
573	14935	1.70E+03	500	1.56E-02
574	94846	7.90E+03	150	0.297966719
575	23234	6.07E+03	500	6.83E-02
576	13968	2.60E+01	500	3.34E-04
577	94018	1.30E+03	75	0.459146798

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
578	14935	2.15E+04	150	0.689836383
579	93815	2.02E+04	150	0.595363677
580	24011	7.28E+02	500	4.37E-03
581	94846	7.90E+03	150	0.297966719
582	94018	1.30E+03	150	0.164017469
583	23234	4.86E+03	150	0.346287996
584	13874	1.74E+02	500	1.38E-03
585	12916	3.90E+02	150	0.017414141
586	94846	5.11E+03	500	3.34E-02
587	24233	3.12E+01	500	4.64E-04
588	14840	8.76E+03	150	0.296306461
589	13874	1.24E+03	150	7.27E-02
590	23234	2.36E+03	500	2.86E-02
591	14935	1.68E+03	500	1.54E-02
592	13739	3.58E+03	150	0.18802318
593	94846	5.11E+03	500	3.34E-02
594	23234	4.86E+03	500	5.61E-02
595	13897	1.16E+03	500	2.29E-02
596	14740	9.14E+02	500	1.18E-02
597	13737	2.94E+03	150	0.12866129
598	94847	5.30E+02	500	4.33E-03
599	13968	1.99E+03	500	2.38E-02
600	13874	1.74E+02	500	1.38E-03
601	24033	1.49E+03	500	9.17E-03
602	93815	1.94E+02	500	1.40E-03
603	94846	7.90E+03	75	0.70691359
604	14935	7.24E+02	500	6.83E-03
605	12842	5.20E+01	500	5.75E-04
606	14935	1.03E+03	150	7.04E-02
607	13968	2.60E+01	500	3.34E-04
608	24033	1.81E+03	150	8.10E-02
609	12839	2.02E+02	500	2.16E-03
610	13874	8.36E+01	150	5.70E-03
611	94018	1.30E+03	150	0.164017469
612	14935	2.15E+04	150	0.689836383
613	24033	1.81E+03	500	1.11E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
614	12916	3.90E+02	150	0.017414141
615	14935	2.15E+04	500	0.149872139
616	13874	1.74E+02	150	1.15E-02
617	13737	2.94E+03	150	0.12866129
618	94018	1.30E+03	150	0.164017469
619	13874	1.74E+02	150	1.15E-02
620	13968	1.52E+03	500	1.85E-02
621	13968	2.60E+01	150	2.86E-03
622	93193	1.62E+03	150	0.18215175
623	93193	2.91E+04	500	0.343281299
624	13897	1.86E+03	500	3.61E-02
625	93193	2.91E+04	500	0.343281299
626	3937	7.43E+02	500	6.13E-03
627	13968	2.60E+01	150	2.86E-03
628	93193	1.62E+03	150	0.18215175
629	93193	2.91E+04	150	1.652960896
630	93193	2.91E+04	500	0.343281299
631	94018	1.00E+03	150	0.12979272
632	13897	1.16E+03	150	0.161779895
633	12842	5.20E+01	500	5.75E-04
634	13968	2.60E+01	500	3.34E-04
635	13874	8.36E+01	500	6.70E-04
636	13968	5.81E+02	150	5.81E-02
637	24033	2.79E+01	500	1.81E-04
638	94018	3.52E+03	500	5.96E-02
639	14935	1.70E+03	500	1.56E-02
640	13874	1.74E+02	500	1.38E-03
641	23234	4.86E+03	150	0.346287996
642	13968	2.60E+01	500	3.34E-04
643	13874	1.74E+02	150	1.15E-02
644	94018	1.17E+05	500	1.134759068
645	14935	1.03E+03	150	7.04E-02
646	13968	2.60E+01	150	2.86E-03
647	14935	1.03E+03	150	7.04E-02
648	14935	1.68E+03	500	1.54E-02
649	24033	1.81E+03	500	1.11E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
650	23234	2.42E+03	150	0.197342426
651	13897	1.86E+03	150	0.240401059
652	13897	1.16E+03	500	2.29E-02
653	13968	2.60E+01	75	9.70E-03
654	12916	3.90E+02	500	2.17E-03
655	24033	2.79E+01	500	1.81E-04
656	24033	2.79E+01	500	1.81E-04
657	93815	1.30E+03	500	0.009018256
658	13880	2.88E+04	500	0.172440082
659	14764	6.07E+03	150	0.340731502
660	24233	3.12E+01	150	3.99E-03
661	13968	2.60E+01	500	3.34E-04
662	24011	7.28E+02	75	0.108788922
663	13874	1.74E+02	500	1.38E-03
664	12916	3.90E+02	150	0.017414141
665	13739	2.09E+03	500	1.65E-02
666	94018	1.30E+03	500	2.32E-02
667	13897	6.96E+03	150	0.642082036
668	14764	6.07E+03	500	5.75E-02
669	14935	1.03E+03	150	7.04E-02
670	94846	5.40E+02	500	3.94E-03
671	13874	9.29E+01	500	7.43E-04
672	24033	1.81E+03	150	8.10E-02
673	14935	1.68E+03	500	1.54E-02
674	13874	1.74E+02	500	1.38E-03
675	24033	1.81E+03	150	8.10E-02
676	13874	1.74E+02	500	1.38E-03
677	13874	9.29E+01	150	6.30E-03
678	13968	2.60E+01	500	3.34E-04
679	14935	1.83E+04	150	0.626706421
680	13968	2.60E+01	500	3.34E-04
681	24033	5.55E+03	150	0.202939466
682	12916	3.90E+02	500	2.17E-03
683	13968	2.60E+01	500	3.34E-04
684	14935	2.15E+04	150	0.689836383
685	13897	6.96E+03	500	0.120370112

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
686	14935	7.24E+02	500	6.83E-03
687	13897	3.86E+03	150	0.433436334
688	93193	2.91E+04	150	1.652960896
689	12916	3.90E+02	150	0.017414141
690	24033	1.49E+03	150	6.87E-02
691	94018	1.30E+03	75	0.459146798
692	13737	2.94E+03	150	0.12866129
693	13874	1.74E+02	500	1.38E-03
694	13739	3.58E+03	500	2.75E-02
695	13897	1.16E+03	500	2.29E-02
696	94018	1.30E+03	150	0.164017469
697	13968	2.60E+01	150	2.86E-03
698	14935	1.70E+03	150	0.10937687
699	13737	2.94E+03	500	1.99E-02
700	14935	1.03E+03	500	9.60E-03
701	24033	1.49E+03	150	6.87E-02
702	13897	3.86E+03	500	7.21E-02
703	13874	1.74E+02	500	1.38E-03
704	13897	6.96E+03	500	0.120370112
705	12916	3.90E+02	75	5.51E-02
706	24033	2.79E+01	500	1.81E-04
707	94846	7.90E+03	150	0.297966719
708	94018	2.02E+02	150	3.03E-02
709	14764	6.07E+03	150	0.340731502
710	14935	1.70E+03	500	1.56E-02
711	14935	7.24E+02	75	0.150180772
712	24033	1.49E+03	500	9.17E-03
713	94018	1.30E+03	150	0.164017469
714	24033	2.79E+01	150	1.53E-03
715	23234	6.07E+03	150	0.404124349
716	94846	1.86E+04	150	0.552988529
717	13874	1.74E+02	150	1.15E-02
718	12839	8.82E+03	150	0.458975971
719	14742	1.01E+03	150	5.99E-02
720	93815	1.94E+02	500	1.40E-03
721	93815	1.94E+02	500	1.40E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
722	24233	3.12E+01	150	3.99E-03
723	12839	2.02E+02	75	5.58E-02
724	14935	7.24E+02	500	6.83E-03
725	13897	1.16E+03	150	0.161779895
726	23174	9.39E+03	500	0.13070333
727	13874	1.74E+02	50	7.42E-02
728	24011	7.28E+02	150	3.47E-02
729	24033	1.81E+03	150	8.10E-02
730	13963	4.61E+03	500	4.18E-02
731	13737	2.94E+03	150	0.12866129
732	94018	1.30E+03	500	2.32E-02
733	13880	9.31E+03	500	6.54E-02
734	94846	7.90E+03	150	0.297966719
735	13968	2.60E+01	150	2.86E-03
736	14935	7.24E+02	500	6.83E-03
737	13968	2.60E+01	500	3.34E-04
738	13968	2.60E+01	500	3.34E-04
739	24033	5.55E+03	150	0.202939466
740	94018	1.28E+03	150	0.161950201
741	24033	1.81E+03	500	1.11E-02
742	13897	1.16E+03	75	0.433126569
743	94846	7.90E+03	150	0.297966719
744	23234	2.83E+03	150	0.224960372
745	13874	1.74E+02	150	1.15E-02
746	13968	2.28E+03	500	2.71E-02
747	13874	1.74E+02	150	1.15E-02
748	93815	1.30E+03	500	0.009018256
749	13968	2.60E+01	500	3.34E-04
750	14935	1.70E+03	500	1.56E-02
751	13874	1.74E+02	500	1.38E-03
752	93815	1.30E+03	500	0.009018256
753	14935	7.24E+02	500	6.83E-03
754	23234	4.86E+03	150	0.346287996
755	14935	1.70E+03	500	1.56E-02
756	13968	2.60E+01	500	3.34E-04
757	93815	1.94E+02	500	1.40E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
758	13968	2.60E+01	500	3.34E-04
759	12839	8.76E+03	150	0.456498176
760	24033	1.49E+03	500	9.17E-03
761	12916	3.90E+02	500	2.17E-03
762	24033	1.81E+03	150	8.10E-02
763	13968	2.60E+01	500	3.34E-04
764	24033	1.81E+03	150	8.10E-02
765	13880	1.35E+05	150	2.245984554
766	94018	1.30E+03	150	0.164017469
767	13739	3.58E+03	150	0.18802318
768	14935	1.03E+03	75	0.197674334
769	14935	2.15E+04	75	1.352293134
770	13874	1.74E+02	150	1.15E-02
771	12916	3.90E+02	500	2.17E-03
772	13874	1.74E+02	500	1.38E-03
773	13739	3.58E+03	500	2.75E-02
774	24011	1.09E+03	150	5.05E-02
775	94018	1.30E+03	150	0.164017469
776	12842	5.20E+01	500	5.75E-04
777	94018	1.30E+03	500	2.32E-02
778	14935	7.24E+02	150	5.18E-02
779	24033	1.81E+03	150	8.10E-02
780	13874	1.74E+02	150	1.15E-02
781	23234	2.83E+03	75	0.574242115
782	93815	1.30E+04	500	0.077218309
783	13968	2.60E+01	500	3.34E-04
784	23234	2.36E+03	500	2.86E-02
785	94018	1.30E+03	500	2.32E-02
786	13968	2.60E+01	150	2.86E-03
787	14935	1.70E+03	150	0.10937687
788	24033	1.81E+03	500	1.11E-02
789	14935	2.15E+04	150	0.689836383
790	14935	1.70E+03	500	1.56E-02
791	12916	3.90E+02	150	0.017414141
792	13897	1.86E+03	150	0.240401059
793	14935	1.83E+04	150	0.626706421

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
794	13968	1.99E+03	75	0.476182252
795	13739	4.87E+02	150	3.20E-02
796	14935	1.70E+03	150	0.10937687
797	13897	1.86E+03	150	0.240401059
798	24033	1.81E+03	500	1.11E-02
799	13739	3.58E+03	500	2.75E-02
800	24033	1.81E+03	75	0.228026822
801	13968	2.60E+01	500	3.34E-04
802	13968	2.60E+01	500	3.34E-04
803	13874	1.74E+02	150	1.15E-02
804	93815	1.94E+02	500	1.40E-03
805	23234	2.83E+03	150	0.224960372
806	23234	2.36E+03	150	0.193542421
807	14935	1.03E+03	500	9.60E-03
808	14935	7.24E+02	500	6.83E-03
809	12916	3.90E+02	500	2.17E-03
810	13880	1.62E+03	150	9.32E-02
811	13874	1.74E+02	500	1.38E-03
812	13739	3.58E+03	500	2.75E-02
813	24033	1.81E+03	500	1.11E-02
814	13968	1.99E+03	75	0.476182252
815	24033	2.79E+01	500	1.81E-04
816	94846	7.90E+03	500	4.94E-02
817	13968	2.60E+01	150	2.86E-03
818	24011	1.44E+03	150	6.55E-02
819	94846	5.40E+02	150	3.11E-02
820	24033	1.81E+03	150	8.10E-02
821	13968	2.60E+01	75	9.70E-03
822	94846	7.90E+03	150	0.297966719
823	13739	3.58E+03	500	2.75E-02
824	23234	6.07E+03	500	6.83E-02
825	14935	1.03E+03	500	9.60E-03
826	14935	2.15E+04	75	1.352293134
827	94846	5.40E+02	150	3.11E-02
828	13739	3.58E+03	150	0.18802318
829	13968	2.60E+01	150	2.86E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
830	13737	2.94E+03	150	0.12866129
831	24033	1.49E+03	150	6.87E-02
832	93193	1.62E+03	150	0.18215175
833	23174	9.39E+03	150	0.775993705
834	14935	2.15E+04	150	0.689836383
835	94847	5.30E+02	75	9.82E-02
836	14935	7.24E+02	150	5.18E-02
837	94018	1.30E+03	500	2.32E-02
838	94018	1.30E+03	500	2.32E-02
839	94846	7.90E+03	500	4.94E-02
840	24033	2.79E+01	150	1.53E-03
841	13968	2.60E+01	500	3.34E-04
842	94018	1.30E+03	500	2.32E-02
843	13897	2.31E+05	150	4.531942844
844	14935	1.83E+04	150	0.626706421
845	12916	3.90E+02	500	2.17E-03
846	24033	1.81E+03	500	1.11E-02
847	13968	5.81E+02	500	7.25E-03
848	93193	1.62E+03	500	2.53E-02
849	93193	2.91E+04	500	0.343281299
850	24033	1.49E+03	150	6.87E-02
851	93815	1.30E+03	75	0.194663927
852	14840	8.88E+03	500	4.98E-02
853	14935	1.70E+03	150	0.10937687
854	93815	1.30E+04	500	0.077218309
855	24033	2.79E+01	150	1.53E-03
856	13874	1.74E+02	150	1.15E-02
857	24233	3.12E+01	500	4.64E-04
858	13968	2.60E+01	150	2.86E-03
859	13874	1.74E+02	150	1.15E-02
860	13897	1.16E+03	500	2.29E-02
861	13739	3.58E+03	150	0.18802318
862	13874	1.74E+02	150	1.15E-02
863	13874	1.74E+02	500	1.38E-03
864	94846	5.40E+02	500	3.94E-03
865	13737	2.94E+03	500	1.99E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
866	13897	1.86E+03	500	3.61E-02
867	13968	2.60E+01	500	3.34E-04
868	94847	7.80E+02	500	6.29E-03
869	13968	2.60E+01	150	2.86E-03
870	13963	2.15E+05	75	5.074141502
871	23234	2.36E+03	500	2.86E-02
872	12916	3.90E+02	500	2.17E-03
873	23234	2.42E+03	150	0.197342426
874	94846	7.90E+03	75	0.70691359
875	94018	1.30E+03	500	2.32E-02
876	13963	5.57E+02	150	4.40E-02
877	13880	9.68E+03	150	0.396275103
878	13739	3.58E+03	500	2.75E-02
879	14935	2.15E+04	500	0.149872139
880	14935	1.83E+04	500	0.131324604
881	12916	3.90E+02	150	0.017414141
882	24033	1.81E+03	150	8.10E-02
883	13968	2.60E+01	500	3.34E-04
884	14935	2.15E+04	500	0.149872139
885	13874	1.74E+02	150	1.15E-02
886	24033	1.81E+03	75	0.228026822
887	94847	1.30E+02	500	1.08E-03
888	24033	1.81E+03	150	8.10E-02
889	13874	1.74E+02	150	1.15E-02
890	94846	7.90E+03	500	4.94E-02
891	94846	7.90E+03	500	4.94E-02
892	13968	5.81E+02	150	5.81E-02
893	24033	1.81E+03	150	8.10E-02
894	13737	2.94E+03	150	0.12866129
895	94847	7.80E+02	500	6.29E-03
896	13968	1.99E+03	150	0.172986329
897	13874	1.74E+02	150	1.15E-02
898	14740	9.14E+02	150	8.63E-02
899	14935	1.70E+03	150	0.10937687
900	14935	1.03E+03	500	9.60E-03
901	13968	2.60E+01	500	3.34E-04

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
902	94846	5.40E+02	500	3.94E-03
903	13880	1.04E+03	500	8.50E-03
904	13874	1.74E+02	150	1.15E-02
905	14935	7.24E+02	150	5.18E-02
906	12916	3.90E+02	150	0.017414141
907	94018	1.30E+03	150	0.164017469
908	13968	1.99E+03	150	0.172986329
909	14935	1.68E+03	150	0.108694054
910	94018	1.30E+03	500	2.32E-02
911	24033	1.81E+03	500	1.11E-02
912	13739	3.58E+03	150	0.18802318
913	13968	2.60E+01	500	3.34E-04
914	3937	1.30E+05	150	2.23148489
915	24033	1.81E+03	500	1.11E-02
916	94846	7.90E+03	150	0.297966719
917	12839	2.02E+02	150	1.75E-02
918	23234	6.48E+03	500	7.24E-02
919	23234	2.83E+03	150	0.224960372
920	94846	1.86E+04	150	0.552988529
921	94018	1.30E+03	500	2.32E-02
922	94846	7.90E+03	500	4.94E-02
923	13968	2.60E+01	150	2.86E-03
924	94846	7.90E+03	150	0.297966719
925	13968	2.60E+01	150	2.86E-03
926	24033	1.81E+03	150	8.10E-02
927	13874	1.74E+02	150	1.15E-02
928	13897	6.96E+03	500	0.120370112
929	12916	3.90E+02	500	2.17E-03
930	12839	8.76E+03	500	7.77E-02
931	13874	1.74E+02	150	1.15E-02
932	13874	1.74E+02	150	1.15E-02
933	24033	1.81E+03	150	8.10E-02
934	12839	8.76E+03	500	7.77E-02
935	94018	1.30E+03	150	0.164017469
936	94018	1.30E+03	150	0.164017469
937	13968	1.52E+03	500	1.85E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
938	14935	7.24E+02	500	6.83E-03
939	14935	1.70E+03	500	1.56E-02
940	24033	3.33E+03	500	1.98E-02
941	94018	3.52E+03	500	5.96E-02
942	13874	1.74E+02	500	1.38E-03
943	14935	1.83E+04	150	0.626706421
944	13874	9.29E+01	150	6.30E-03
945	24033	1.81E+03	500	1.11E-02
946	94018	1.30E+03	500	2.32E-02
947	13968	2.60E+01	500	3.34E-04
948	13968	2.60E+01	75	9.70E-03
949	14935	1.70E+03	500	1.56E-02
950	14935	2.15E+04	150	0.689836383
951	13968	2.28E+03	150	0.193842337
952	23234	2.83E+03	500	3.39E-02
953	13739	3.58E+03	500	2.75E-02
954	13968	2.60E+01	500	3.34E-04
955	23234	2.36E+03	75	0.504907608
956	24033	1.49E+03	500	9.17E-03
957	94846	5.40E+02	150	3.11E-02
958	14935	2.15E+04	150	0.689836383
959	13968	2.60E+01	500	3.34E-04
960	13897	1.16E+03	500	2.29E-02
961	24033	1.81E+03	150	8.10E-02
962	13968	1.52E+03	150	0.139482036
963	14935	7.24E+02	500	6.83E-03
964	12916	3.90E+02	150	0.017414141
965	13968	2.60E+01	500	3.34E-04
966	93193	1.62E+03	150	0.18215175
967	12839	2.02E+02	75	5.58E-02
968	13880	1.82E+04	500	0.116509967
969	12916	3.90E+02	500	2.17E-03
970	13968	2.60E+01	150	2.86E-03
971	93193	1.62E+03	150	0.18215175
972	13968	2.60E+01	150	2.86E-03
973	13874	1.24E+03	500	9.45E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
974	13968	1.99E+03	150	0.172986329
975	13897	1.16E+03	150	0.161779895
976	94846	5.40E+02	150	3.11E-02
977	24233	3.12E+01	150	3.99E-03
978	14935	7.24E+02	500	6.83E-03
979	23174	2.93E+04	150	1.651089549
980	13897	1.86E+03	150	0.240401059
981	23234	6.07E+03	150	0.404124349
982	24011	1.09E+03	150	5.05E-02
983	94846	7.90E+03	75	0.70691359
984	94847	1.30E+02	150	8.92E-03
985	94846	7.90E+03	500	4.94E-02
986	12916	3.90E+02	500	2.17E-03
987	24033	1.81E+03	500	1.11E-02
988	13874	1.74E+02	75	3.78E-02
989	24011	1.09E+03	150	5.05E-02
990	14935	1.03E+03	150	7.04E-02
991	14935	7.24E+02	500	6.83E-03
992	13897	1.86E+03	150	0.240401059
993	12842	5.20E+01	150	4.85E-03
994	13874	1.74E+02	500	1.38E-03
995	13739	4.87E+02	150	3.20E-02
996	13968	2.60E+01	500	3.34E-04
997	13963	5.57E+02	150	4.40E-02
998	13739	3.58E+03	500	2.75E-02
999	12916	3.90E+02	150	0.017414141
1000	13968	2.60E+01	150	2.86E-03
1001	94846	7.90E+03	500	4.94E-02
1002	13897	1.86E+03	500	3.61E-02
1003	24033	1.81E+03	150	8.10E-02
1004	24033	1.49E+03	150	6.87E-02
1005	24233	1.21E+04	150	0.867829859
1006	13968	5.81E+02	150	5.81E-02
1007	24033	1.81E+03	150	8.10E-02
1008	24033	1.81E+03	150	8.10E-02
1009	13739	2.09E+03	150	0.11715059

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1010	93193	2.91E+04	500	0.343281299
1011	13739	3.58E+03	150	0.18802318
1012	13968	2.60E+01	500	3.34E-04
1013	13737	2.94E+03	150	0.12866129
1014	23234	6.48E+03	500	7.24E-02
1015	13968	2.60E+01	150	2.86E-03
1016	14935	1.83E+04	500	0.131324604
1017	94018	1.30E+03	150	0.164017469
1018	23234	2.83E+03	150	0.224960372
1019	23234	4.86E+03	150	0.346287996
1020	12839	8.82E+03	500	0.078199565
1021	13968	2.60E+01	150	2.86E-03
1022	94018	1.30E+03	500	2.32E-02
1023	13897	1.16E+03	150	0.161779895
1024	94018	1.30E+03	500	2.32E-02
1025	13874	1.74E+02	500	1.38E-03
1026	24033	5.55E+03	150	0.202939466
1027	23234	2.36E+03	150	0.193542421
1028	23234	2.36E+03	500	2.86E-02
1029	13968	2.60E+01	150	2.86E-03
1030	24033	1.81E+03	75	0.228026822
1031	14935	7.24E+02	500	6.83E-03
1032	14740	9.14E+02	500	1.18E-02
1033	94847	1.30E+02	150	8.92E-03
1034	24033	1.81E+03	150	8.10E-02
1035	23234	2.36E+03	500	2.86E-02
1036	13897	1.86E+03	150	0.240401059
1037	14935	1.03E+03	150	7.04E-02
1038	94846	7.90E+03	150	0.297966719
1039	94018	1.30E+03	500	2.32E-02
1040	24033	1.81E+03	150	8.10E-02
1041	94018	1.30E+03	150	0.164017469
1042	13874	1.24E+03	150	7.27E-02
1043	94847	7.80E+02	500	6.29E-03
1044	24033	1.81E+03	150	8.10E-02
1045	94846	7.90E+03	500	4.94E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1046	14935	1.68E+03	150	0.108694054
1047	94018	1.30E+03	500	2.32E-02
1048	94847	1.30E+02	500	1.08E-03
1049	13880	1.62E+03	150	9.32E-02
1050	13880	1.04E+03	150	6.25E-02
1051	24033	1.81E+03	500	1.11E-02
1052	13897	1.16E+03	500	2.29E-02
1053	13968	2.60E+01	500	3.34E-04
1054	13968	5.81E+02	50	0.33059907
1055	13897	1.86E+03	500	3.61E-02
1056	24033	1.81E+03	150	8.10E-02
1057	12839	8.76E+03	500	7.77E-02
1058	94846	5.40E+02	500	3.94E-03
1059	13968	5.81E+02	500	7.25E-03
1060	13897	1.86E+03	500	3.61E-02
1061	13737	2.94E+03	150	0.12866129
1062	94847	7.80E+02	150	4.66E-02
1063	13968	2.60E+01	150	2.86E-03
1064	14935	7.24E+02	150	5.18E-02
1065	14935	7.24E+02	500	6.83E-03
1066	24033	1.81E+03	150	8.10E-02
1067	94018	1.30E+03	500	2.32E-02
1068	13968	2.60E+01	500	3.34E-04
1069	13968	2.60E+01	150	2.86E-03
1070	13968	2.60E+01	150	2.86E-03
1071	13968	2.60E+01	500	3.34E-04
1072	13963	5.57E+02	150	4.40E-02
1073	12839	8.82E+03	150	0.458975971
1074	13880	2.16E+05	75	4.606509686
1075	13874	1.74E+02	500	1.38E-03
1076	23174	9.39E+03	150	0.775993705
1077	94846	7.90E+03	150	0.297966719
1078	14935	1.83E+04	150	0.626706421
1079	13739	3.58E+03	150	0.18802318
1080	13874	1.74E+02	150	1.15E-02
1081	94846	7.90E+03	500	4.94E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1082	24033	1.81E+03	500	1.11E-02
1083	23234	6.48E+03	150	0.423418999
1084	24033	1.81E+03	150	8.10E-02
1085	13874	1.74E+02	150	1.15E-02
1086	13737	2.94E+03	500	1.99E-02
1087	94846	7.90E+03	150	0.297966719
1088	13963	5.57E+02	150	4.40E-02
1089	13968	2.60E+01	500	3.34E-04
1090	24033	1.81E+03	500	1.11E-02
1091	94018	1.30E+03	150	0.164017469
1092	13737	2.94E+03	150	0.12866129
1093	13968	2.60E+01	150	2.86E-03
1094	94846	7.90E+03	150	0.297966719
1095	94846	5.40E+02	50	0.176847741
1096	23234	4.86E+03	500	5.61E-02
1097	12916	3.90E+02	500	2.17E-03
1098	94018	1.30E+03	500	2.32E-02
1099	13874	1.74E+02	150	1.15E-02
1100	13968	2.60E+01	150	2.86E-03
1101	14935	1.83E+04	150	0.626706421
1102	13897	1.86E+03	500	3.61E-02
1103	13968	2.28E+03	150	0.193842337
1104	24033	1.81E+03	150	8.10E-02
1105	24033	1.81E+03	500	1.11E-02
1106	94846	5.40E+02	500	3.94E-03
1107	24033	1.81E+03	75	0.228026822
1108	12916	3.90E+02	150	0.017414141
1109	14935	7.24E+02	500	6.83E-03
1110	94846	7.90E+03	500	4.94E-02
1111	94018	1.30E+03	500	2.32E-02
1112	13968	2.60E+01	500	3.34E-04
1113	13897	1.86E+03	150	0.240401059
1114	94018	1.30E+03	150	0.164017469
1115	94847	7.80E+02	500	6.29E-03
1116	94846	7.90E+03	150	0.297966719
1117	13968	2.60E+01	150	2.86E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1118	94018	1.30E+03	500	2.32E-02
1119	24033	2.79E+01	500	1.81E-04
1120	13880	1.62E+03	150	9.32E-02
1121	24033	2.79E+01	500	1.81E-04
1122	13880	1.04E+03	500	8.50E-03
1123	13897	3.86E+03	500	7.21E-02
1124	94018	1.30E+03	500	2.32E-02
1125	13880	4.86E+03	500	3.64E-02
1126	13968	1.99E+03	500	2.38E-02
1127	13874	1.24E+03	500	9.45E-03
1128	13874	1.74E+02	500	1.38E-03
1129	12842	5.20E+01	150	4.85E-03
1130	24033	1.81E+03	150	8.10E-02
1131	14935	7.24E+02	150	5.18E-02
1132	94846	7.90E+03	150	0.297966719
1133	14935	7.24E+02	500	6.83E-03
1134	24033	5.55E+03	150	0.202939466
1135	24033	2.79E+01	150	1.53E-03
1136	13874	1.24E+03	75	0.220147952
1137	94018	1.30E+03	50	0.794203997
1138	14935	1.83E+04	150	0.626706421
1139	23234	2.36E+03	500	2.86E-02
1140	13968	2.28E+03	150	0.193842337
1141	94846	7.90E+03	150	0.297966719
1142	14935	7.24E+02	500	6.83E-03
1143	12839	8.76E+03	150	0.456498176
1144	13880	1.62E+03	150	9.32E-02
1145	24033	1.49E+03	150	6.87E-02
1146	12839	8.82E+03	150	0.458975971
1147	13968	2.60E+01	500	3.34E-04
1148	13897	1.86E+03	500	3.61E-02
1149	94018	1.30E+03	150	0.164017469
1150	13957	7.66E+02	150	0.061980415
1151	23234	2.83E+03	500	3.39E-02
1152	23234	2.36E+03	150	0.193542421
1153	94018	1.30E+03	150	0.164017469

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1154	12839	8.82E+03	150	0.458975971
1155	14935	1.83E+04	500	0.131324604
1156	14935	1.70E+03	500	1.56E-02
1157	13897	1.16E+03	150	0.161779895
1158	13880	9.68E+03	150	0.396275103
1159	13968	2.60E+01	150	2.86E-03
1160	93193	1.62E+03	150	0.18215175
1277	24033	1.49E+03	150	6.87E-02
1278	14935	2.15E+04	500	0.149872139
1279	13968	2.60E+01	500	3.34E-04
1280	94018	1.30E+03	500	2.32E-02
1281	13968	1.52E+03	150	0.139482036
1282	13968	2.60E+01	500	3.34E-04
1283	14935	2.15E+04	50	1.873957038
1284	13874	1.74E+02	500	1.38E-03
1285	14935	1.83E+04	500	0.131324604
1286	12916	3.90E+02	500	2.17E-03
1287	23234	6.07E+03	500	6.83E-02
1288	13968	2.60E+01	500	3.34E-04
1289	94018	1.30E+03	75	0.459146798
1290	13739	3.58E+03	500	2.75E-02
1291	13897	1.16E+03	500	2.29E-02
1292	94846	7.90E+03	150	0.297966719
1293	23234	2.36E+03	500	2.86E-02
1294	13968	2.60E+01	150	2.86E-03
1295	12916	3.90E+02	500	2.17E-03
1296	14935	7.24E+02	150	5.18E-02
1297	93193	2.91E+04	150	1.652960896
1298	93815	2.02E+04	500	0.111287095
1299	14935	7.24E+02	500	6.83E-03
1300	13880	1.04E+03	500	8.50E-03
1301	13874	1.74E+02	150	1.15E-02
1302	13968	2.28E+03	500	2.71E-02
1303	13897	1.16E+03	500	2.29E-02
1304	13874	1.23E+03	150	0.072232224
1305	13739	3.58E+03	500	2.75E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1306	12916	3.90E+02	150	0.017414141
1307	14935	1.70E+03	500	1.56E-02
1308	93193	1.62E+03	150	0.18215175
1309	13897	3.86E+03	150	0.433436334
1310	14935	7.24E+02	500	6.83E-03
1311	24033	1.81E+03	150	8.10E-02
1312	93815	1.30E+03	150	6.70E-02
1313	24233	3.12E+01	500	4.64E-04
1314	94018	1.30E+03	150	0.164017469
1315	93193	1.62E+03	500	2.53E-02
1316	14935	1.03E+03	150	7.04E-02
1317	94846	5.11E+03	150	0.213590831
1318	93193	2.91E+04	50	4.30161047
1319	14935	1.68E+03	500	1.54E-02
1320	94018	1.30E+03	500	2.32E-02
1321	13968	5.81E+02	500	7.25E-03
1322	13968	1.52E+03	500	1.85E-02
1323	24233	1.21E+04	75	1.797366381
1324	93193	1.62E+05	150	4.407284737
1325	13874	1.74E+02	150	1.15E-02
1326	93815	1.30E+03	500	0.009018256
1327	94847	5.30E+02	150	3.36E-02
1328	12916	3.90E+02	150	0.017414141
1329	13739	3.58E+03	500	2.75E-02
1330	94846	7.90E+03	150	0.297966719
1331	14935	1.03E+03	75	0.197674334
1332	13968	2.60E+01	150	2.86E-03
1333	13968	5.81E+02	150	5.81E-02
1334	13968	2.60E+01	500	3.34E-04
1335	23234	2.42E+03	150	0.197342426
1336	13874	1.74E+02	150	1.15E-02
1337	93815	1.30E+04	150	0.449256331
1338	23234	2.83E+03	500	3.39E-02
1339	12839	8.76E+03	500	7.77E-02
1340	94018	1.30E+03	150	0.164017469
1341	14935	2.15E+04	150	0.689836383

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1342	12916	3.90E+02	150	0.017414141
1343	94846	7.90E+03	500	4.94E-02
1344	24033	1.49E+03	150	6.87E-02
1345	13968	2.60E+01	150	2.86E-03
1346	13968	2.60E+01	500	3.34E-04
1347	94018	1.30E+03	75	0.459146798
1348	94847	7.80E+02	500	6.29E-03
1349	14935	1.70E+03	500	1.56E-02
1350	93815	2.02E+04	150	0.595363677
1351	93193	1.62E+03	500	2.53E-02
1352	94018	1.28E+03	150	0.161950201
1353	13737	2.94E+03	500	1.99E-02
1354	12839	2.02E+02	500	2.16E-03
1355	24011	1.44E+03	150	6.55E-02
1356	94018	1.28E+03	75	0.453660309
1357	14740	9.14E+02	500	1.18E-02
1358	93815	1.30E+03	150	6.70E-02
1359	24033	1.81E+03	150	8.10E-02
1360	94018	1.30E+03	500	2.32E-02
1361	13739	4.87E+02	150	3.20E-02
1362	13874	1.24E+03	500	9.45E-03
1363	13968	1.99E+03	500	2.38E-02
1364	93815	1.94E+02	150	1.15E-02
1365	14935	1.68E+03	150	0.108694054
1366	24033	1.81E+03	500	1.11E-02
1367	94018	1.30E+03	150	0.164017469
1368	12916	3.90E+02	150	0.017414141
1369	12916	3.90E+02	500	2.17E-03
1370	13737	2.94E+03	500	1.99E-02
1371	13737	2.94E+03	150	0.12866129
1372	94018	1.30E+03	150	0.164017469
1373	24033	1.81E+03	150	8.10E-02
1374	23234	6.07E+03	150	0.404124349
1375	24233	3.12E+01	150	3.99E-03
1376	12916	3.90E+02	150	0.017414141
1377	94018	1.30E+03	150	0.164017469

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1378	24033	2.79E+01	500	1.81E-04
1379	13880	2.16E+05	150	2.87854147
1380	13874	1.74E+02	150	1.15E-02
1381	14935	1.70E+03	150	0.10937687
1382	24033	1.81E+03	500	1.11E-02
1383	13874	1.23E+03	75	0.218715727
1384	14935	7.24E+02	150	5.18E-02
1385	13968	2.60E+01	150	2.86E-03
1386	94846	7.90E+03	500	4.94E-02
1387	23234	4.86E+03	500	5.61E-02
1388	23234	4.86E+03	500	5.61E-02
1389	94846	7.90E+03	150	0.297966719
1390	13968	2.60E+01	150	2.86E-03
1391	94018	1.30E+03	150	0.164017469
1392	13968	5.81E+02	150	5.81E-02
1393	13874	1.74E+02	500	1.38E-03
1394	23174	9.39E+03	75	1.722415924
1395	23234	2.36E+03	150	0.193542421
1396	13968	2.60E+01	500	3.34E-04
1397	13874	1.74E+02	150	1.15E-02
1398	14935	7.24E+02	150	5.18E-02
1399	14935	7.24E+02	500	6.83E-03
1400	13968	2.60E+01	75	9.70E-03
1401	93193	1.62E+03	150	0.18215175
1402	12916	3.90E+02	500	2.17E-03
1403	14935	1.68E+03	150	0.108694054
1404	13737	2.94E+03	500	1.99E-02
1405	13737	2.94E+03	75	0.340185344
1406	23234	4.86E+03	150	0.346287996
1407	23234	6.48E+03	75	0.973131061
1408	24033	2.79E+01	150	1.53E-03
1409	94846	7.90E+03	500	4.94E-02
1410	24033	1.81E+03	500	1.11E-02
1411	13968	1.99E+03	150	0.172986329
1412	14935	1.68E+03	500	1.54E-02
1413	94846	7.90E+03	75	0.70691359

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per ug/s-m^2)
1414	94018	1.30E+03	500	2.32E-02
1415	94018	1.00E+03	150	0.12979272
1416	93193	1.62E+03	500	2.53E-02
1417	13968	2.60E+01	150	2.86E-03
1418	94846	7.90E+03	500	4.94E-02
1419	24033	1.49E+03	150	6.87E-02
1420	14935	7.24E+02	150	5.18E-02
1421	24033	1.81E+03	150	8.10E-02
1422	24033	5.55E+03	500	3.19E-02
1423	13897	1.86E+03	150	0.240401059
1424	13880	2.67E+04	500	0.161486879
1425	24033	1.81E+03	500	1.11E-02
1426	13874	1.23E+03	150	0.072232224
1427	24033	1.81E+03	500	1.11E-02
1428	13874	1.74E+02	500	1.38E-03
1429	94846	7.90E+03	150	0.297966719
1430	94846	5.40E+02	150	3.11E-02
1431	23234	4.86E+03	500	5.61E-02
1432	94018	1.30E+03	500	2.32E-02
1433	94018	1.28E+03	500	2.29E-02
1434	24033	1.81E+03	500	1.11E-02
1435	13874	1.74E+02	150	1.15E-02
1436	94018	1.30E+03	500	2.32E-02
1437	23234	6.48E+03	75	0.973131061
1438	13963	4.61E+03	150	0.284357309
1439	94847	7.80E+02	500	6.29E-03
1440	13880	1.04E+03	500	8.50E-03
1441	94847	1.30E+02	150	8.92E-03
1442	24033	1.81E+03	500	1.11E-02
1443	12916	3.90E+02	150	0.017414141
1444	13874	1.74E+02	150	1.15E-02
1445	14935	7.24E+02	150	5.18E-02
1446	24033	1.81E+03	500	1.11E-02
1447	93193	2.91E+04	150	1.652960896
1448	93815	1.30E+04	500	0.077218309
1449	23234	6.48E+03	500	7.24E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1450	94847	5.30E+02	500	4.33E-03
1451	94846	7.90E+03	150	0.297966719
1452	13874	4.49E+04	500	0.264645517
1453	24033	1.81E+03	500	1.11E-02
1454	14935	1.68E+03	50	0.484846026
1455	14935	2.15E+04	500	0.149872139
1456	13968	2.60E+01	150	2.86E-03
1457	13874	1.74E+02	75	3.78E-02
1458	24033	1.81E+03	75	0.228026822
1459	13968	2.60E+01	500	3.34E-04
1460	13874	1.24E+03	150	7.27E-02
1461	12839	8.76E+03	500	7.77E-02
1462	24033	1.81E+03	500	1.11E-02
1463	13968	2.60E+01	500	3.34E-04
1464	14935	1.70E+03	500	1.56E-02
1465	13963	1.77E+04	500	0.144601092
1466	13874	1.23E+03	50	0.393063277
1467	12916	3.90E+02	150	0.017414141
1468	13739	3.58E+03	150	0.18802318
1469	14935	1.70E+03	150	0.10937687
1470	13880	1.04E+03	150	6.25E-02
1471	94846	7.90E+03	75	0.70691359
1472	24033	2.79E+01	75	5.24E-03
1473	13968	2.60E+01	500	3.34E-04
1474	24033	1.81E+03	150	8.10E-02
1475	13968	2.60E+01	500	3.34E-04
1476	94846	7.90E+03	500	4.94E-02
1477	24033	1.81E+03	150	8.10E-02
1478	94846	7.90E+03	150	0.297966719
1479	14935	7.24E+02	150	5.18E-02
1480	94018	1.30E+03	150	0.164017469
1481	13874	1.23E+03	500	9.39E-03
1482	14935	1.70E+03	500	1.56E-02
1483	94846	5.40E+02	500	3.94E-03
1484	12916	3.90E+02	500	2.17E-03
1485	12916	3.90E+02	500	2.17E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1486	12916	3.90E+02	150	0.017414141
1487	13874	1.74E+02	150	1.15E-02
1488	12916	9.29E+02	150	3.83E-02
1489	12839	8.82E+03	500	0.078199565
1490	13963	4.61E+03	500	4.18E-02
1491	13897	1.16E+03	500	2.29E-02
1492	13874	1.74E+02	75	3.78E-02
1493	94018	1.30E+03	500	2.32E-02
1494	12839	8.76E+03	75	1.087519169
1495	94018	1.30E+03	150	0.164017469
1496	93193	1.62E+03	500	2.53E-02
1497	13737	2.94E+03	150	0.12866129
1498	94018	1.28E+03	150	0.161950201
1499	23234	4.86E+03	500	5.61E-02
1500	23234	2.83E+03	150	0.224960372
1501	24033	1.81E+03	150	8.10E-02
1502	23234	6.07E+03	500	6.83E-02
1503	24033	1.81E+03	500	1.11E-02
1504	13968	2.60E+01	500	3.34E-04
1505	13968	2.60E+01	500	3.34E-04
1506	24033	2.79E+01	150	1.53E-03
1507	13880	1.04E+03	75	0.180395633
1508	23234	4.86E+03	150	0.346287996
1509	12839	8.76E+03	500	7.77E-02
1510	94018	1.30E+03	150	0.164017469
1511	13968	2.60E+01	75	9.70E-03
1512	93815	1.30E+04	75	1.047177553
1513	94847	1.30E+02	150	8.92E-03
1514	94847	5.30E+02	500	4.33E-03
1515	13968	2.60E+01	150	2.86E-03
1516	13994	4.80E+05	500	1.205390811
1517	13968	2.60E+01	150	2.86E-03
1518	13874	1.23E+03	150	0.072232224
1519	23174	9.39E+03	150	0.775993705
1520	12842	5.20E+01	75	1.64E-02
1521	93193	2.91E+04	150	1.652960896

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1522	14935	1.70E+03	500	1.56E-02
1523	13968	2.60E+01	150	2.86E-03
1524	13874	1.74E+02	150	1.15E-02
1525	23234	2.83E+03	150	0.224960372
1526	13897	3.86E+03	150	0.433436334
1527	14935	1.70E+03	150	0.10937687
1528	13968	2.28E+03	500	2.71E-02
1529	23234	4.86E+03	500	5.61E-02
1530	13874	1.74E+02	150	1.15E-02
1531	13968	2.60E+01	75	9.70E-03
1532	24033	1.81E+03	500	1.11E-02
1533	94846	5.40E+02	150	3.11E-02
1534	94846	5.40E+02	150	3.11E-02
1535	12916	3.90E+02	75	5.51E-02
1536	13874	1.74E+02	500	1.38E-03
1537	13968	1.99E+03	150	0.172986329
1538	13963	1.77E+04	150	0.74918884
1539	94846	7.90E+03	500	4.94E-02
1540	14935	7.24E+02	500	6.83E-03
1541	24233	3.12E+01	150	3.99E-03
1542	14935	7.24E+02	500	6.83E-03
1543	94018	1.30E+03	150	0.164017469
1544	12916	3.90E+02	150	0.017414141
1545	24033	1.81E+03	150	8.10E-02
1546	23234	6.48E+03	500	7.24E-02
1547	24033	1.81E+03	500	1.11E-02
1548	93193	2.91E+04	500	0.343281299
1549	14935	1.03E+03	500	9.60E-03
1550	13897	1.16E+03	150	0.161779895
1551	13739	3.58E+03	150	0.18802318
1552	13874	1.74E+02	500	1.38E-03
1553	13880	3.04E+04	150	0.896283686
1554	24033	1.81E+03	150	8.10E-02
1555	23234	2.36E+03	150	0.193542421
1556	14935	1.68E+03	150	0.108694054
1557	94018	1.30E+03	500	2.32E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1558	24033	2.79E+01	500	1.81E-04
1559	13874	1.23E+03	75	0.218715727
1560	24033	1.81E+03	500	1.11E-02
1561	13739	3.58E+03	150	0.18802318
1562	14935	2.15E+04	75	1.352293134
1563	13968	2.60E+01	150	2.86E-03
1564	24033	2.79E+01	150	1.53E-03
1565	14935	2.15E+04	500	0.149872139
1566	12842	5.20E+01	500	5.75E-04
1567	94018	1.30E+03	150	0.164017469
1568	13739	3.58E+03	150	0.18802318
1569	13874	1.74E+02	500	1.38E-03
1570	23234	6.48E+03	500	7.24E-02
1571	94847	5.30E+02	500	4.33E-03
1572	12916	3.90E+02	500	2.17E-03
1573	24011	1.09E+03	500	6.49E-03
1574	13739	4.87E+02	150	3.20E-02
1575	13874	1.74E+02	500	1.38E-03
1576	24033	1.81E+03	150	8.10E-02
1577	13968	5.81E+02	150	5.81E-02
1578	13968	2.60E+01	150	2.86E-03
1579	94018	1.30E+03	500	2.32E-02
1580	14935	1.03E+03	150	7.04E-02
1581	24233	3.12E+01	500	4.64E-04
1582	12842	5.20E+01	500	5.75E-04
1583	13968	2.60E+01	500	3.34E-04
1584	23234	6.07E+03	500	6.83E-02
1585	13874	1.74E+02	150	1.15E-02
1586	13968	2.28E+03	500	2.71E-02
1587	24033	1.81E+03	500	1.11E-02
1588	93193	2.91E+04	500	0.343281299
1589	13968	2.60E+01	150	2.86E-03
1590	13739	2.09E+03	500	1.65E-02
1591	13968	2.60E+01	500	3.34E-04
1592	13874	1.24E+03	500	9.45E-03
1593	94018	1.30E+03	500	2.32E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1594	24033	1.81E+03	150	8.10E-02
1595	94018	1.28E+03	500	2.29E-02
1596	13874	1.74E+02	500	1.38E-03
1597	13968	2.60E+01	75	9.70E-03
1598	24033	1.81E+03	150	8.10E-02
1599	13968	2.60E+01	500	3.34E-04
1600	93815	8.90E+03	75	0.792311549
1601	13963	4.61E+03	150	0.284357309
1602	94018	1.30E+03	150	0.164017469
1603	3937	1.24E+03	150	7.23E-02
1604	24011	1.44E+03	75	0.198902726
1605	94018	1.30E+03	150	0.164017469
1606	94018	1.30E+03	500	2.32E-02
1607	13968	1.52E+03	500	1.85E-02
1608	94846	5.40E+02	150	3.11E-02
1609	13963	5.57E+02	150	4.40E-02
1610	94018	1.30E+03	500	2.32E-02
1611	24033	5.55E+03	150	0.202939466
1612	13739	2.09E+03	150	0.11715059
1613	13880	1.04E+03	150	6.25E-02
1614	12916	3.90E+02	150	0.017414141
1615	24233	1.21E+04	500	0.150713742
1616	14935	1.70E+03	500	1.56E-02
1617	94846	7.90E+03	150	0.297966719
1618	13968	5.81E+02	500	7.25E-03
1619	12839	8.76E+03	150	0.456498176
1620	94018	1.30E+03	75	0.459146798
1621	13880	3.04E+04	500	0.180747584
1622	13897	1.16E+03	500	2.29E-02
1623	93193	2.91E+04	150	1.652960896
1624	13968	1.52E+03	500	1.85E-02
1625	14935	1.68E+03	75	0.292850286
1626	13963	4.61E+03	150	0.284357309
1627	13737	2.94E+03	500	1.99E-02
1628	24011	1.09E+03	150	5.05E-02
1629	14935	1.03E+03	150	7.04E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1630	14935	1.03E+03	500	9.60E-03
1631	93193	2.91E+04	150	1.652960896
1632	94018	1.30E+03	500	2.32E-02
1633	13874	1.74E+02	150	1.15E-02
1634	24033	1.81E+03	500	1.11E-02
1635	14935	7.24E+02	150	5.18E-02
1636	13963	1.19E+04	500	0.102946036
1637	12842	5.20E+01	150	4.85E-03
1638	14935	2.15E+04	150	0.689836383
1639	13897	1.86E+03	150	0.240401059
1640	93193	1.62E+03	500	2.53E-02
1641	13968	2.60E+01	500	3.34E-04
1642	13874	1.74E+02	500	1.38E-03
1643	13968	2.60E+01	150	2.86E-03
1644	24033	1.81E+03	500	1.11E-02
1645	13739	2.09E+03	500	1.65E-02
1646	14935	1.68E+03	150	0.108694054
1647	13897	6.96E+03	150	0.642082036
1648	94846	7.90E+03	500	4.94E-02
1649	94846	7.90E+03	75	0.70691359
1650	13897	1.16E+03	500	2.29E-02
1651	13739	3.58E+03	500	2.75E-02
1652	13874	1.74E+02	500	1.38E-03
1653	12916	3.90E+02	500	2.17E-03
1654	94846	1.86E+04	150	0.552988529
1655	24033	2.79E+01	150	1.53E-03
1656	94846	7.90E+03	150	0.297966719
1657	24033	1.49E+03	500	9.17E-03
1658	24033	2.79E+01	500	1.81E-04
1659	13968	5.81E+02	500	7.25E-03
1660	94018	1.30E+03	500	2.32E-02
1661	24033	1.81E+03	500	1.11E-02
1662	23174	2.93E+04	50	3.898567677
1663	13880	8.10E+04	150	1.71443367
1664	13874	1.74E+02	500	1.38E-03
1665	13874	1.74E+02	500	1.38E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1666	13968	2.60E+01	500	3.34E-04
1667	12916	3.90E+02	150	0.017414141
1668	13874	1.74E+02	75	3.78E-02
1669	24011	7.28E+02	150	3.47E-02
1670	14935	1.03E+03	500	9.60E-03
1671	13737	2.94E+03	150	0.12866129
1672	13739	3.58E+03	500	2.75E-02
1673	24033	1.81E+03	150	8.10E-02
1674	24033	1.81E+03	150	8.10E-02
1675	13963	5.57E+02	150	4.40E-02
1676	93815	1.94E+02	150	1.15E-02
1677	13897	1.16E+03	150	0.161779895
1678	13874	1.74E+02	150	1.15E-02
1679	14935	7.24E+02	150	5.18E-02
1680	13968	2.60E+01	500	3.34E-04
1681	13968	2.60E+01	150	2.86E-03
1682	3937	1.24E+03	500	0.010096526
1683	23174	9.39E+03	150	0.775993705
1684	13963	5.57E+02	150	4.40E-02
1685	24033	1.81E+03	500	1.11E-02
1686	13897	1.86E+03	150	0.240401059
1687	13737	2.94E+03	150	0.12866129
1688	14935	2.15E+04	500	0.149872139
1689	94018	1.30E+03	500	2.32E-02
1690	94018	1.30E+03	150	0.164017469
1691	94846	5.40E+02	150	3.11E-02
1692	12916	3.90E+02	500	2.17E-03
1693	13968	2.60E+01	150	2.86E-03
1694	13968	2.60E+01	150	2.86E-03
1695	13968	1.52E+03	150	0.139482036
1696	94018	1.30E+03	150	0.164017469
1697	13968	2.60E+01	150	2.86E-03
1698	13963	1.19E+04	150	0.591862321
1699	13968	2.28E+03	500	2.71E-02
1700	23234	6.48E+03	150	0.423418999
1701	14935	1.03E+03	150	7.04E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1702	13874	1.74E+02	150	1.15E-02
1703	94018	1.30E+03	150	0.164017469
1704	24033	1.81E+03	500	1.11E-02
1705	14935	1.68E+03	500	1.54E-02
1706	94018	1.00E+03	150	0.12979272
1707	12916	3.90E+02	75	5.51E-02
1708	94846	7.90E+03	500	4.94E-02
1709	23234	6.07E+03	75	0.937069178
1710	94846	5.11E+03	500	3.34E-02
1711	13874	1.74E+02	500	1.38E-03
1712	94846	7.90E+03	500	4.94E-02
1713	23234	2.36E+03	500	2.86E-02
1714	24033	1.81E+03	500	1.11E-02
1715	24033	1.81E+03	500	1.11E-02
1716	13968	2.60E+01	500	3.34E-04
1717	24033	2.79E+01	500	1.81E-04
1718	24033	1.81E+03	150	8.10E-02
1719	13874	1.74E+02	500	1.38E-03
1720	14764	4.58E+04	75	3.045788527
1721	14935	1.03E+03	500	9.60E-03
1722	24033	1.81E+03	150	8.10E-02
1723	13739	3.58E+03	150	0.18802318
1724	13968	2.60E+01	500	3.34E-04
1725	12916	3.90E+02	500	2.17E-03
1726	93815	1.94E+02	150	1.15E-02
1727	12916	3.90E+02	150	0.017414141
1728	94018	1.30E+03	500	2.32E-02
1729	24033	1.81E+03	150	8.10E-02
1730	94018	1.30E+03	150	0.164017469
1731	24033	1.81E+03	500	1.11E-02
1732	13897	1.16E+03	75	0.433126569
1733	13897	6.96E+03	150	0.642082036
1734	94018	1.30E+03	150	0.164017469
1735	13968	2.60E+01	150	2.86E-03
1736	13874	1.74E+02	500	1.38E-03
1737	13874	1.74E+02	150	1.15E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1738	13968	2.60E+01	500	3.34E-04
1739	13968	5.81E+02	150	5.81E-02
1740	14935	2.15E+04	500	0.149872139
1741	93815	1.30E+03	150	6.70E-02
1742	13874	1.74E+02	500	1.38E-03
1743	13737	2.94E+03	150	0.12866129
1744	13874	1.74E+02	500	1.38E-03
1745	93815	1.94E+02	150	1.15E-02
1746	93815	1.30E+03	500	0.009018256
1747	94018	1.30E+03	150	0.164017469
1748	23234	6.48E+03	150	0.423418999
1749	94846	7.90E+03	150	0.297966719
1750	13897	1.16E+03	150	0.161779895
1751	14935	7.24E+02	75	0.150180772
1752	24033	1.81E+03	500	1.11E-02
1753	14935	2.15E+04	150	0.689836383
1754	24033	1.81E+03	150	8.10E-02
1755	13874	1.74E+02	500	1.38E-03
1756	94846	7.90E+03	150	0.297966719
1757	94847	1.30E+02	150	8.92E-03
1758	12916	3.90E+02	150	0.017414141
1759	13874	1.74E+02	500	1.38E-03
1760	94846	7.90E+03	500	4.94E-02
1761	24033	1.81E+03	500	1.11E-02
1762	93815	1.30E+04	150	0.449256331
1763	94846	7.90E+03	500	4.94E-02
1764	14935	7.24E+02	150	5.18E-02
1765	13968	2.60E+01	500	3.34E-04
1766	13968	1.52E+03	150	0.139482036
1767	23234	2.36E+03	500	2.86E-02
1768	13874	1.74E+02	150	1.15E-02
1769	24033	1.81E+03	500	1.11E-02
1770	13968	2.60E+01	150	2.86E-03
1771	94846	7.90E+03	500	4.94E-02
1772	14935	7.24E+02	150	5.18E-02
1773	24033	1.81E+03	150	8.10E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1774	13897	1.86E+03	150	0.240401059
1775	24033	5.55E+03	500	3.19E-02
1776	13880	2.67E+04	150	0.814245164
1777	14764	6.07E+03	500	5.75E-02
1778	13968	2.60E+01	500	3.34E-04
1779	24033	1.81E+03	500	1.11E-02
1780	14935	1.70E+03	500	1.56E-02
1781	94846	7.90E+03	150	0.297966719
1782	13968	2.60E+01	150	2.86E-03
1783	13737	2.94E+03	150	0.12866129
1784	13968	2.60E+01	150	2.86E-03
1785	13737	2.94E+03	500	1.99E-02
1786	24033	1.81E+03	500	1.11E-02
1787	13968	2.60E+01	150	2.86E-03
1788	24033	1.81E+03	500	1.11E-02
1789	14935	1.83E+04	150	0.626706421
1790	93815	1.94E+02	500	1.40E-03
1791	24033	2.79E+01	50	1.05E-02
1792	13968	2.60E+01	150	2.86E-03
1793	13968	5.81E+02	500	7.25E-03
1794	23234	6.48E+03	150	0.423418999
1795	23234	6.07E+03	500	6.83E-02
1796	24033	1.49E+03	150	6.87E-02
1797	93193	1.62E+03	150	0.18215175
1798	13737	2.94E+03	150	0.12866129
1799	94018	1.30E+03	500	2.32E-02
1800	13874	1.74E+02	500	1.38E-03
1801	94018	1.30E+03	150	0.164017469
1802	23234	4.86E+03	150	0.346287996
1803	94018	1.30E+03	500	2.32E-02
1804	94847	5.30E+02	150	3.36E-02
1805	94846	7.90E+03	150	0.297966719
1806	94018	1.30E+03	150	0.164017469
1807	14935	1.83E+04	500	0.131324604
1808	13737	2.94E+03	150	0.12866129
1809	13968	2.60E+01	500	3.34E-04

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1810	13968	2.28E+03	500	2.71E-02
1811	13968	2.60E+01	500	3.34E-04
1812	13737	2.94E+03	150	0.12866129
1813	94018	1.30E+03	150	0.164017469
1814	93193	1.62E+03	150	0.18215175
1815	13957	7.66E+02	500	7.98E-03
1816	12916	3.90E+02	150	0.017414141
1817	14935	7.24E+02	500	6.83E-03
1818	23234	2.42E+03	150	0.197342426
1819	94847	1.30E+02	150	8.92E-03
1820	93815	1.30E+03	150	6.70E-02
1821	14935	7.24E+02	150	5.18E-02
1822	13897	1.16E+03	150	0.161779895
1823	14935	1.68E+03	150	0.108694054
1824	24033	1.81E+03	500	1.11E-02
1825	13880	1.04E+03	500	8.50E-03
1826	94846	7.90E+03	150	0.297966719
1827	24033	1.81E+03	500	1.11E-02
1828	94018	1.30E+03	500	2.32E-02
1829	94018	1.30E+03	150	0.164017469
1830	3937	1.24E+03	500	0.010096526
1831	13968	2.60E+01	150	2.86E-03
1832	94847	7.80E+02	500	6.29E-03
1833	94846	5.11E+03	150	0.213590831
1834	13968	2.60E+01	500	3.34E-04
1835	13968	2.60E+01	150	2.86E-03
1836	12839	8.76E+03	150	0.456498176
1837	13739	3.58E+03	150	0.18802318
1838	13968	2.60E+01	500	3.34E-04
1839	94018	1.28E+03	500	2.29E-02
1840	14935	1.03E+03	150	7.04E-02
1841	13968	2.60E+01	150	2.86E-03
1842	24033	2.79E+01	150	1.53E-03
1843	13897	1.16E+03	500	2.29E-02
1844	24033	1.81E+03	500	1.11E-02
1845	13968	1.52E+03	75	0.398771882

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1846	24033	1.81E+03	500	1.11E-02
1847	13968	5.81E+02	150	5.81E-02
1848	13897	1.86E+03	150	0.240401059
1849	13874	1.74E+02	500	1.38E-03
1850	12839	2.02E+02	150	1.75E-02
1851	14935	7.24E+02	500	6.83E-03
1852	24033	1.81E+03	50	0.390205085
1853	13874	8.36E+01	150	5.70E-03
1854	13897	1.16E+03	150	0.161779895
1855	13874	1.74E+02	500	1.38E-03
1856	13874	1.74E+02	150	1.15E-02
1857	24033	1.81E+03	150	8.10E-02
1858	13874	1.74E+02	150	1.15E-02
1859	13968	2.60E+01	500	3.34E-04
1860	93815	1.30E+03	150	6.70E-02
1861	13968	2.60E+01	75	9.70E-03
1862	14935	1.83E+04	500	0.131324604
1863	24033	2.79E+01	150	1.53E-03
1864	13963	5.57E+02	150	4.40E-02
1865	12916	3.90E+02	150	0.017414141
1866	24033	2.79E+01	150	1.53E-03
1867	94018	1.28E+03	500	2.29E-02
1868	13880	1.04E+03	150	6.25E-02
1869	13897	6.96E+03	150	0.642082036
1870	14935	1.03E+03	150	7.04E-02
1871	94018	1.30E+03	150	0.164017469
1872	24033	2.79E+01	150	1.53E-03
1873	13880	1.62E+03	150	9.32E-02
1874	93815	2.02E+04	75	1.310637474
1875	14935	1.68E+03	150	0.108694054
1876	13968	2.60E+01	150	2.86E-03
1877	13968	2.60E+01	150	2.86E-03
1878	24033	1.81E+03	150	8.10E-02
1879	13880	1.62E+03	150	9.32E-02
1880	24033	1.81E+03	500	1.11E-02
1881	13874	1.74E+02	150	1.15E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1882	24033	1.81E+03	500	1.11E-02
1883	12916	3.90E+02	75	5.51E-02
1884	14935	7.24E+02	500	6.83E-03
1885	14935	1.83E+04	500	0.131324604
1886	24033	5.55E+03	150	0.202939466
1887	12842	5.20E+01	500	5.75E-04
1888	94846	7.90E+03	500	4.94E-02
1889	13874	1.74E+02	500	1.38E-03
1890	14935	7.24E+02	150	5.18E-02
1891	93193	1.62E+03	150	0.18215175
1892	24033	1.81E+03	500	1.11E-02
1893	24033	1.81E+03	150	8.10E-02
1894	13874	1.74E+02	150	1.15E-02
1895	93193	1.62E+05	500	1.380677104
1896	14935	1.83E+04	500	0.131324604
1897	12842	5.20E+01	150	4.85E-03
1898	24033	1.49E+03	500	9.17E-03
1899	24033	1.49E+03	150	6.87E-02
1900	12916	3.90E+02	75	5.51E-02
1901	94018	1.00E+03	150	0.12979272
1902	13897	2.31E+05	500	1.760611653
1903	14935	1.68E+03	75	0.292850286
1904	13968	2.60E+01	75	9.70E-03
1905	12842	5.20E+01	500	5.75E-04
1906	94018	1.30E+03	150	0.164017469
1907	23174	9.39E+03	500	0.13070333
1908	24033	1.81E+03	500	1.11E-02
1909	13874	1.74E+02	500	1.38E-03
1910	13874	1.74E+02	500	1.38E-03
1911	12842	5.20E+01	150	4.85E-03
1912	93815	1.94E+02	50	0.071042426
1913	13963	5.57E+02	150	4.40E-02
1914	12916	3.90E+02	150	0.017414141
1915	24033	1.81E+03	150	8.10E-02
1916	14935	1.83E+04	500	0.131324604
1917	13897	1.86E+03	150	0.240401059

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1918	24233	3.12E+01	150	3.99E-03
1919	14935	7.24E+02	150	5.18E-02
1920	12839	8.82E+03	500	0.078199565
1921	24033	1.81E+03	150	8.10E-02
1922	94846	7.90E+03	75	0.70691359
1923	13874	1.74E+02	150	1.15E-02
1924	13897	1.16E+03	150	0.161779895
1925	14935	7.24E+02	150	5.18E-02
1926	13874	1.74E+02	500	1.38E-03
1927	13968	2.60E+01	500	3.34E-04
1928	13968	2.60E+01	150	2.86E-03
1929	93193	1.62E+03	500	2.53E-02
1930	23174	2.93E+04	500	0.356077075
1931	94018	1.30E+03	150	0.164017469
1932	13880	6.99E+03	500	5.03E-02
1933	14935	1.03E+03	500	9.60E-03
1934	24033	1.81E+03	500	1.11E-02
1935	14764	4.58E+04	500	0.325622469
1936	14935	1.68E+03	500	1.54E-02
1937	14935	1.70E+03	150	0.10937687
1938	24011	7.28E+02	500	4.37E-03
1939	13874	8.36E+01	150	5.70E-03
1940	12839	8.82E+03	75	1.092707038
1941	94846	5.40E+02	500	3.94E-03
1942	12916	3.90E+02	150	0.017414141
1943	23234	2.83E+03	500	3.39E-02
1944	13739	2.09E+03	150	0.11715059
1945	13968	2.60E+01	500	3.34E-04
1946	94846	7.90E+03	150	0.297966719
1947	14740	9.14E+02	150	8.63E-02
1948	13880	1.04E+03	500	8.50E-03
1949	24033	1.49E+03	150	6.87E-02
1950	24033	2.79E+01	500	1.81E-04
1951	24033	2.79E+01	500	1.81E-04
1952	13874	1.74E+02	500	1.38E-03
1953	94846	5.11E+03	150	0.213590831

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1954	12839	8.76E+03	150	0.456498176
1955	94018	1.30E+03	500	2.32E-02
1956	13739	3.58E+03	500	2.75E-02
1957	13874	1.74E+02	150	1.15E-02
1958	94018	1.30E+03	150	0.164017469
1959	24033	1.81E+03	500	1.11E-02
1960	94847	7.80E+02	500	6.29E-03
1961	14935	7.24E+02	500	6.83E-03
1962	24233	3.12E+01	500	4.64E-04
1963	13897	1.16E+03	500	2.29E-02
1964	12916	3.90E+02	150	0.017414141
1965	94846	7.90E+03	150	0.297966719
1966	13968	2.60E+01	150	2.86E-03
1967	23234	2.83E+03	150	0.224960372
1968	13963	1.19E+04	150	0.591862321
1969	23234	6.07E+03	150	0.404124349
1970	13739	3.58E+03	500	2.75E-02
1971	13968	2.60E+01	500	3.34E-04
1972	13897	1.86E+03	150	0.240401059
1973	13968	2.60E+01	500	3.34E-04
1974	13897	1.86E+03	150	0.240401059
1975	13968	1.99E+03	75	0.476182252
1976	13968	2.60E+01	150	2.86E-03
1977	24033	2.79E+01	500	1.81E-04
1978	23174	2.93E+04	150	1.651089549
1979	13968	2.60E+01	150	2.86E-03
1980	13968	2.60E+01	500	3.34E-04
1981	94018	1.30E+03	150	0.164017469
1982	14935	1.03E+03	75	0.197674334
1983	94846	5.40E+02	150	3.11E-02
1984	94018	1.30E+03	150	0.164017469
1985	23234	2.83E+03	150	0.224960372
1986	94018	1.30E+03	150	0.164017469
1987	13874	1.74E+02	500	1.38E-03
1988	13897	1.16E+03	150	0.161779895
1989	13874	1.74E+02	75	3.78E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1990	93815	1.94E+02	150	1.15E-02
1991	94846	5.40E+02	150	3.11E-02
1992	24033	1.81E+03	150	8.10E-02
1993	12916	3.90E+02	150	0.017414141
1994	93815	1.94E+02	500	1.40E-03
1995	94847	1.30E+02	500	1.08E-03
1996	13968	2.60E+01	150	2.86E-03
1997	94018	1.30E+03	150	0.164017469
1998	93193	1.62E+03	500	2.53E-02
1999	13737	2.94E+03	150	0.12866129
2000	13874	1.24E+03	500	9.45E-03
2001	13897	1.16E+03	150	0.161779895
2002	13874	1.23E+03	500	9.39E-03
2003	13874	1.74E+02	150	1.15E-02
2004	13880	1.04E+03	150	6.25E-02
2005	94846	7.90E+03	500	4.94E-02
2006	23234	6.07E+03	500	6.83E-02
2007	14935	1.70E+03	150	0.10937687
2008	13880	2.67E+04	500	0.161486879
2009	13897	6.96E+03	150	0.642082036
2010	13968	2.60E+01	150	2.86E-03
2011	14935	1.83E+04	150	0.626706421
2012	14764	6.07E+03	150	0.340731502
2013	12916	3.90E+02	150	0.017414141
2014	14764	6.07E+03	500	5.75E-02
2015	94018	1.30E+03	50	0.794203997
2016	12916	3.90E+02	500	2.17E-03
2017	13739	3.58E+03	500	2.75E-02
2018	13968	5.81E+02	150	5.81E-02
2019	94018	1.30E+03	75	0.459146798
2020	13968	2.60E+01	150	2.86E-03
2021	13968	2.60E+01	500	3.34E-04
2022	14935	1.03E+03	500	9.60E-03
2023	12839	8.82E+03	150	0.458975971
2024	12839	8.82E+03	500	0.078199565
2025	13739	2.09E+03	150	0.11715059

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2026	93193	1.62E+03	150	0.18215175
2027	24033	1.49E+03	150	6.87E-02
2028	94018	1.00E+03	500	1.80E-02
2029	13968	2.60E+01	150	2.86E-03
2030	13968	2.60E+01	150	2.86E-03
2031	94847	7.80E+02	500	6.29E-03
2032	93193	1.62E+03	150	0.18215175
2033	24033	1.81E+03	500	1.11E-02
2034	14935	1.03E+03	500	9.60E-03
2035	13739	3.58E+03	500	2.75E-02
2036	13874	1.74E+02	150	1.15E-02
2037	23234	2.42E+03	150	0.197342426
2038	13874	1.74E+02	500	1.38E-03
2039	93193	2.91E+04	500	0.343281299
2040	13968	2.60E+01	150	2.86E-03
2041	93815	1.30E+04	500	0.077218309
2042	93815	2.02E+04	500	0.111287095
2043	13874	1.74E+02	150	1.15E-02
2044	94847	5.30E+02	500	4.33E-03
2045	24033	1.81E+03	500	1.11E-02
2046	13963	1.77E+04	500	0.144601092
2047	12839	8.82E+03	150	0.458975971
2048	13737	2.94E+03	500	1.99E-02
2049	13968	2.60E+01	500	3.34E-04
2050	24033	1.81E+03	500	1.11E-02
2051	13880	1.04E+03	75	0.180395633
2052	13737	2.94E+03	500	1.99E-02
2053	13968	2.60E+01	500	3.34E-04
2054	14935	7.24E+02	500	6.83E-03
2055	24033	1.81E+03	500	1.11E-02
2056	14935	7.24E+02	150	5.18E-02
2057	13968	2.60E+01	500	3.34E-04
2058	94018	1.30E+03	500	2.32E-02
2059	24011	7.28E+02	150	3.47E-02
2060	12839	8.76E+03	150	0.456498176
2061	13968	2.60E+01	500	3.34E-04

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2062	12916	3.90E+02	150	0.017414141
2063	13897	6.69E+02	500	1.35E-02
2064	13963	5.57E+02	500	5.34E-03
2065	14740	9.14E+02	50	0.411008537
2066	93193	1.62E+03	500	2.53E-02
2067	14935	7.24E+02	500	6.83E-03
2068	24033	1.81E+03	75	0.228026822
2069	94018	1.30E+03	150	0.164017469
2070	93193	1.62E+03	150	0.18215175
2071	94846	7.90E+03	500	4.94E-02
2072	13737	2.94E+03	150	0.12866129
2073	14935	7.24E+02	150	5.18E-02
2074	24033	2.79E+01	500	1.81E-04
2075	13968	2.28E+03	500	2.71E-02
2076	23234	6.07E+03	500	6.83E-02
2077	14935	7.24E+02	150	5.18E-02
2078	13968	2.60E+01	150	2.86E-03
2079	13874	1.74E+02	150	1.15E-02
2080	14935	1.83E+04	500	0.131324604
2081	93815	1.30E+04	500	0.077218309
2082	24011	7.28E+02	500	4.37E-03
2083	13968	2.60E+01	500	3.34E-04
2084	14935	1.68E+03	150	0.108694054
2085	13739	2.09E+03	75	0.335079104
2086	13968	2.60E+01	500	3.34E-04
2087	13874	1.74E+02	500	1.38E-03
2088	24033	1.81E+03	500	1.11E-02
2089	24033	1.81E+03	150	8.10E-02
2090	14935	1.83E+04	150	0.626706421
2091	94018	1.30E+03	150	0.164017469
2092	24033	1.81E+03	500	1.11E-02
2093	23234	6.07E+03	500	6.83E-02
2094	24033	1.81E+03	150	8.10E-02
2095	13897	1.16E+03	150	0.161779895
2096	94846	7.90E+03	75	0.70691359
2097	13968	2.60E+01	500	3.34E-04

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2098	94018	1.30E+03	150	0.164017469
2099	14764	6.07E+03	150	0.340731502
2100	14935	1.03E+03	500	9.60E-03
2101	13880	1.04E+03	150	6.25E-02
2102	23174	9.39E+03	500	0.13070333
2103	94018	1.30E+03	500	2.32E-02
2104	93193	1.62E+03	150	0.18215175
2105	13874	4.49E+04	150	1.289641619
2106	13737	2.94E+03	500	1.99E-02
2107	93193	2.91E+04	500	0.343281299
2108	24033	1.81E+03	150	8.10E-02
2109	13968	5.81E+02	500	7.25E-03
2110	13968	5.81E+02	500	7.25E-03
2111	94846	7.90E+03	500	4.94E-02
2112	24033	1.81E+03	150	8.10E-02
2113	13963	4.61E+03	150	0.284357309
2114	13968	2.28E+03	500	2.71E-02
2115	94847	7.80E+02	150	4.66E-02
2116	13968	2.60E+01	150	2.86E-03
2117	94846	7.90E+03	500	4.94E-02
2118	13897	1.16E+03	75	0.433126569
2119	13880	8.10E+04	150	1.71443367
2120	94846	5.40E+02	500	3.94E-03
2121	13739	2.09E+03	150	0.11715059
2122	14935	1.68E+03	150	0.108694054
2123	93193	1.62E+03	500	2.53E-02
2124	24033	1.49E+03	150	6.87E-02
2125	94018	1.30E+03	150	0.164017469
2126	12916	9.29E+02	500	5.04E-03
2127	3937	1.24E+03	150	7.23E-02
2128	24033	2.79E+01	150	1.53E-03
2129	13739	2.09E+03	500	1.65E-02
2130	24011	1.46E+03	500	8.60E-03
2131	14935	7.24E+02	500	6.83E-03
2132	13963	5.57E+02	150	4.40E-02
2133	14935	7.24E+02	500	6.83E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2134	13897	1.16E+03	50	0.716510475
2135	14764	4.58E+04	500	0.325622469
2136	24033	1.81E+03	75	0.228026822
2137	14935	1.03E+03	150	7.04E-02
2138	12916	3.90E+02	500	2.17E-03
2139	93193	1.62E+05	150	4.407284737
2140	13897	3.86E+03	500	7.21E-02
2141	13968	2.60E+01	500	3.34E-04
2142	24033	2.79E+01	150	1.53E-03
2143	24033	1.81E+03	150	8.10E-02
2144	13968	2.60E+01	500	3.34E-04
2145	94847	7.80E+02	150	4.66E-02
2146	93815	1.94E+02	150	1.15E-02
2147	94846	7.90E+03	500	4.94E-02
2148	13874	9.29E+01	150	6.30E-03
2149	94846	5.11E+03	500	3.34E-02
2150	94846	7.90E+03	500	4.94E-02
2151	13874	1.74E+02	500	1.38E-03
2152	93815	1.30E+03	150	6.70E-02
2153	12842	5.20E+01	75	1.64E-02
2154	14935	7.24E+02	500	6.83E-03
2155	94846	7.90E+03	500	4.94E-02
2156	23234	4.86E+03	150	0.346287996
2157	24033	1.81E+03	500	1.11E-02
2158	94846	7.90E+03	150	0.297966719
2159	94846	7.90E+03	150	0.297966719
2160	13897	1.86E+03	500	3.61E-02
2161	93815	1.94E+02	500	1.40E-03
2162	14935	1.70E+03	150	0.10937687
2163	13968	2.60E+01	150	2.86E-03
2164	12842	5.20E+01	500	5.75E-04
2165	93193	2.91E+04	50	4.30161047
2166	93815	1.30E+03	150	6.70E-02
2167	13968	2.60E+01	500	3.34E-04
2168	14840	8.88E+03	150	0.299487591
2169	23234	6.07E+03	75	0.937069178

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2170	13968	2.60E+01	150	2.86E-03
2171	13874	1.74E+02	500	1.38E-03
2172	94846	7.90E+03	500	4.94E-02
2173	24033	1.81E+03	150	8.10E-02
2174	94847	7.80E+02	500	6.29E-03
2175	13968	2.60E+01	150	2.86E-03
2176	94018	3.52E+03	500	5.96E-02
2177	14935	7.24E+02	75	0.150180772
2178	13739	3.58E+03	500	2.75E-02
2179	13897	1.16E+03	150	0.161779895
2180	13897	3.86E+03	500	7.21E-02
2181	13968	2.60E+01	500	3.34E-04
2182	93815	1.30E+04	500	0.077218309
2183	94846	7.90E+03	150	0.297966719
2184	13968	2.60E+01	150	2.86E-03
2185	24033	1.81E+03	75	0.228026822
2186	94846	7.90E+03	150	0.297966719
2187	23234	4.86E+03	75	0.828972638
2188	13880	1.62E+03	150	9.32E-02
2189	24033	1.49E+03	150	6.87E-02
2190	14935	1.83E+04	500	0.131324604
2191	12839	8.82E+03	150	0.458975971
2192	94018	1.28E+03	500	2.29E-02
2193	13737	2.94E+03	150	0.12866129
2194	13739	2.09E+03	500	1.65E-02
2195	93193	1.62E+03	150	0.18215175
2196	13880	2.16E+05	150	2.87854147
2197	94018	1.00E+03	150	0.12979272
2198	14935	1.03E+03	150	7.04E-02
2199	94018	1.30E+03	500	2.32E-02
2200	13968	2.60E+01	150	2.86E-03
2201	13968	2.60E+01	500	3.34E-04
2202	14764	6.07E+03	500	5.75E-02
2203	94846	7.90E+03	500	4.94E-02
2204	13897	1.86E+03	150	0.240401059
1161	14935	1.03E+03	75	0.197674334

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1162	13737	2.94E+03	500	1.99E-02
1163	23234	2.83E+03	500	3.39E-02
1164	94846	5.11E+03	150	0.213590831
1165	13968	2.60E+01	500	3.34E-04
1166	93815	1.30E+04	75	1.047177553
1167	14935	1.68E+03	150	0.108694054
1168	94018	1.30E+03	150	0.164017469
1169	13897	1.86E+03	500	3.61E-02
1170	13968	2.60E+01	500	3.34E-04
1171	23234	2.42E+03	150	0.197342426
1172	13897	1.86E+03	150	0.240401059
1173	24033	1.81E+03	500	1.11E-02
1174	94847	5.30E+02	500	4.33E-03
1175	94018	1.30E+03	150	0.164017469
1176	94018	1.30E+03	150	0.164017469
1177	24033	1.81E+03	150	8.10E-02
1178	13874	1.74E+02	150	1.15E-02
1179	94018	1.00E+03	500	1.80E-02
1180	24011	1.44E+03	500	8.51E-03
1181	23234	2.36E+03	500	2.86E-02
1182	94018	1.30E+03	150	0.164017469
1183	94018	1.17E+05	500	1.134759068
1184	24033	1.81E+03	150	8.10E-02
1185	24033	1.81E+03	500	1.11E-02
1186	24033	5.55E+03	500	3.19E-02
1187	12842	5.20E+01	150	4.85E-03
1188	13874	1.74E+02	150	1.15E-02
1189	13897	3.86E+03	500	7.21E-02
1190	13739	4.87E+02	150	3.20E-02
1191	94018	1.00E+03	150	0.12979272
1192	24033	1.81E+03	500	1.11E-02
1193	24033	1.81E+03	150	8.10E-02
1194	13897	1.16E+03	150	0.161779895
1195	94847	5.30E+02	500	4.33E-03
1196	23174	2.93E+04	500	0.356077075
1197	13874	1.74E+02	150	1.15E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
1198	13874	1.74E+02	150	1.15E-02
1199	94846	7.90E+03	150	0.297966719
1200	13968	2.60E+01	500	3.34E-04
1201	13880	4.05E+03	150	0.202204108
1202	13737	2.94E+03	500	1.99E-02
1203	13737	2.94E+03	150	0.12866129
1204	13897	1.86E+03	500	3.61E-02
1205	14935	7.24E+02	150	5.18E-02
1206	93815	1.30E+04	150	0.449256331
1207	13968	2.60E+01	500	3.34E-04
1208	14935	1.03E+03	75	0.197674334
1209	24033	2.79E+01	500	1.81E-04
1210	13968	2.60E+01	150	2.86E-03
1211	24033	2.79E+01	150	1.53E-03
1212	14764	6.07E+03	150	0.340731502
1213	13897	1.86E+03	150	0.240401059
1214	24033	1.49E+03	150	6.87E-02
1215	94846	7.90E+03	500	4.94E-02
1216	24033	1.81E+03	150	8.10E-02
1217	13968	2.60E+01	150	2.86E-03
1218	13897	1.86E+03	500	3.61E-02
1219	93193	2.91E+04	500	0.343281299
1220	24033	1.81E+03	500	1.11E-02
1221	12842	5.20E+01	500	5.75E-04
1222	13874	8.36E+01	150	5.70E-03
1223	12916	3.90E+02	500	2.17E-03
1224	94846	7.90E+03	150	0.297966719
1225	13968	5.81E+02	150	5.81E-02
1226	23234	6.07E+03	150	0.404124349
1227	13874	1.74E+02	150	1.15E-02
1228	93815	8.90E+03	500	5.43E-02
1229	14740	9.14E+02	150	8.63E-02
1230	24033	1.49E+03	500	9.17E-03
1231	13968	2.60E+01	150	2.86E-03
1232	94018	1.30E+03	150	0.164017469
1233	13897	1.86E+03	500	3.61E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1234	14935	7.24E+02	500	6.83E-03
1235	93193	1.62E+03	150	0.18215175
1236	23234	2.36E+03	500	2.86E-02
1237	94018	3.52E+03	150	0.378584981
1238	13897	1.16E+03	500	2.29E-02
1239	24033	1.81E+03	500	1.11E-02
1240	13874	1.74E+02	150	1.15E-02
1241	13968	2.60E+01	500	3.34E-04
1242	14740	9.14E+02	500	1.18E-02
1243	13897	1.86E+03	150	0.240401059
1244	13880	1.04E+03	150	6.25E-02
1245	13874	1.74E+02	500	1.38E-03
1246	94018	1.30E+03	500	2.32E-02
1247	12842	5.20E+01	500	5.75E-04
1248	13739	3.58E+03	150	0.18802318
1249	13968	5.81E+02	500	7.25E-03
1250	3937	7.43E+02	150	4.60E-02
1251	13968	2.28E+03	500	2.71E-02
1252	14935	7.24E+02	150	5.18E-02
1253	94018	1.17E+05	75	6.157810688
1254	13968	2.60E+01	150	2.86E-03
1255	24033	1.81E+03	150	8.10E-02
1256	94018	1.30E+03	500	2.32E-02
1257	13874	8.36E+01	150	5.70E-03
1258	13739	3.58E+03	150	0.18802318
1259	94018	1.30E+03	500	2.32E-02
1260	13737	2.94E+03	150	0.12866129
1261	24233	3.12E+01	150	3.99E-03
1262	14935	7.24E+02	150	5.18E-02
1263	13880	1.04E+03	500	8.50E-03
1264	14935	1.83E+04	75	1.252596378
1265	13874	1.74E+02	150	1.15E-02
1266	13968	2.60E+01	75	9.70E-03
1267	23234	2.83E+03	150	0.224960372
1268	14935	1.03E+03	500	9.60E-03
1269	13968	2.60E+01	500	3.34E-04

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
1270	12842	5.20E+01	500	5.75E-04
1271	23234	6.07E+03	150	0.404124349
1272	13968	2.60E+01	150	2.86E-03
1273	94018	1.30E+03	50	0.794203997
1274	23234	2.36E+03	150	0.193542421
1275	24033	1.81E+03	150	8.10E-02
1276	24033	1.81E+03	150	8.10E-02
2205	24033	1.81E+03	500	1.11E-02
2206	94846	7.90E+03	500	4.94E-02
2207	13897	6.69E+02	150	0.101128809
2208	13737	2.94E+03	500	1.99E-02
2209	13739	2.09E+03	500	1.65E-02
2210	94018	1.30E+03	500	2.32E-02
2211	13968	1.99E+03	150	0.172986329
2212	14935	1.03E+03	150	7.04E-02
2213	94846	7.90E+03	500	4.94E-02
2214	13968	5.81E+02	500	7.25E-03
2215	13968	2.60E+01	150	2.86E-03
2216	13874	1.74E+02	150	1.15E-02
2217	13968	2.60E+01	150	2.86E-03
2218	93815	1.30E+03	150	6.70E-02
2219	94846	7.90E+03	500	4.94E-02
2220	93815	1.94E+02	500	1.40E-03
2221	24033	1.81E+03	500	1.11E-02
2222	13897	1.16E+03	150	0.161779895
2223	13968	2.60E+01	150	2.86E-03
2224	13968	2.60E+01	150	2.86E-03
2225	14935	1.70E+03	75	0.294345737
2226	13968	1.52E+03	150	0.139482036
2227	94846	5.40E+02	500	3.94E-03
2228	13874	1.74E+02	500	1.38E-03
2229	93193	1.62E+03	150	0.18215175
2230	13897	1.16E+03	500	2.29E-02
2231	13963	2.15E+05	150	3.048651695
2232	13874	1.74E+02	50	7.42E-02
2233	24033	1.81E+03	500	1.11E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2234	24033	2.79E+01	500	1.81E-04
2235	12916	3.90E+02	500	2.17E-03
2236	24033	1.81E+03	500	1.11E-02
2237	12916	3.90E+02	500	2.17E-03
2238	94846	7.90E+03	150	0.297966719
2239	13874	1.74E+02	150	1.15E-02
2240	13897	1.16E+03	500	2.29E-02
2241	24233	3.12E+01	150	3.99E-03
2242	23234	2.36E+03	500	2.86E-02
2243	94847	7.80E+02	150	4.66E-02
2244	94846	7.90E+03	150	0.297966719
2245	13968	2.60E+01	500	3.34E-04
2246	13874	1.74E+02	500	1.38E-03
2247	13739	3.58E+03	500	2.75E-02
2248	93815	2.02E+04	150	0.595363677
2249	14764	6.07E+03	500	5.75E-02
2250	13968	2.60E+01	150	2.86E-03
2251	13897	2.31E+05	500	1.760611653
2252	13874	1.74E+02	150	1.15E-02
2253	14935	1.70E+03	500	1.56E-02
2254	94847	7.80E+02	75	0.130357772
2255	13968	2.28E+03	150	0.193842337
2256	13874	1.74E+02	150	1.15E-02
2257	24033	1.81E+03	500	1.11E-02
2258	94846	7.90E+03	150	0.297966719
2259	24033	3.33E+03	150	0.13681522
2260	13874	1.74E+02	150	1.15E-02
2261	24033	1.81E+03	150	8.10E-02
2262	13737	2.94E+03	150	0.12866129
2263	94846	5.40E+02	150	3.11E-02
2264	14935	1.83E+04	500	0.131324604
2265	13739	3.58E+03	150	0.18802318
2266	13963	1.19E+04	500	0.102946036
2267	3937	1.24E+03	150	7.23E-02
2268	24033	1.81E+03	500	1.11E-02
2269	13968	2.60E+01	75	9.70E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2270	12916	3.90E+02	500	2.17E-03
2271	94018	2.02E+02	150	3.03E-02
2272	14935	1.83E+04	500	0.131324604
2273	13897	1.86E+03	75	0.613451004
2274	93815	1.30E+03	150	6.70E-02
2275	94846	5.40E+02	150	3.11E-02
2276	13963	5.57E+02	500	5.34E-03
2277	94018	1.30E+03	75	0.459146798
2278	23234	4.86E+03	500	5.61E-02
2279	24033	1.81E+03	75	0.228026822
2280	24033	1.81E+03	500	1.11E-02
2281	93193	1.62E+03	500	2.53E-02
2282	13968	2.60E+01	500	3.34E-04
2283	14935	7.24E+02	500	6.83E-03
2284	93815	1.30E+04	500	0.077218309
2285	94018	1.30E+03	500	2.32E-02
2286	13874	1.74E+02	150	1.15E-02
2287	14764	4.58E+04	150	1.522423148
2288	14935	1.83E+04	150	0.626706421
2289	23234	6.07E+03	150	0.404124349
2290	24011	1.46E+03	500	8.60E-03
2291	13968	5.81E+02	150	5.81E-02
2292	94846	7.90E+03	500	4.94E-02
2293	14935	1.03E+03	150	7.04E-02
2294	13739	2.09E+03	150	0.11715059
2295	3937	1.30E+05	50	5.351579189
2296	94018	1.30E+03	150	0.164017469
2297	13968	2.60E+01	75	9.70E-03
2298	24033	1.81E+03	150	8.10E-02
2299	13874	1.74E+02	150	1.15E-02
2300	24033	1.81E+03	500	1.11E-02
2301	23234	2.42E+03	150	0.197342426
2302	12916	3.90E+02	500	2.17E-03
2303	94018	1.30E+03	500	2.32E-02
2304	13874	9.29E+01	500	7.43E-04
2305	13737	2.94E+03	500	1.99E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2306	13968	2.60E+01	150	2.86E-03
2307	94846	7.90E+03	150	0.297966719
2308	13968	2.28E+03	500	2.71E-02
2309	93193	1.62E+03	50	0.900720894
2310	23174	9.39E+03	500	0.13070333
2311	14935	7.24E+02	150	5.18E-02
2312	13874	1.74E+02	500	1.38E-03
2313	12916	3.90E+02	150	0.017414141
2314	24033	1.81E+03	75	0.228026822
2315	24033	1.81E+03	150	8.10E-02
2316	13968	2.60E+01	75	9.70E-03
2317	94846	7.90E+03	500	4.94E-02
2318	14935	7.24E+02	150	5.18E-02
2319	24033	3.33E+03	75	0.356505185
2320	14935	7.24E+02	500	6.83E-03
2321	13897	1.86E+03	500	3.61E-02
2322	12842	5.20E+01	150	4.85E-03
2323	12916	3.90E+02	150	0.017414141
2324	13874	1.74E+02	500	1.38E-03
2325	13880	1.04E+03	500	8.50E-03
2326	13874	1.74E+02	150	1.15E-02
2327	13874	1.74E+02	150	1.15E-02
2328	94018	1.00E+03	150	0.12979272
2329	13968	2.60E+01	500	3.34E-04
2330	94847	1.30E+02	150	8.92E-03
2331	94018	3.52E+03	500	5.96E-02
2332	24033	1.49E+03	75	0.198487192
2333	13897	1.16E+03	500	2.29E-02
2334	93815	1.30E+04	150	0.449256331
2335	94018	1.00E+03	500	1.80E-02
2336	23234	4.86E+03	500	5.61E-02
2337	94847	5.30E+02	150	3.36E-02
2338	13874	1.74E+02	500	1.38E-03
2339	94018	1.00E+03	150	0.12979272
2340	94018	3.52E+03	150	0.378584981
2341	14935	1.83E+04	500	0.131324604

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2342	13739	3.58E+03	150	0.18802318
2343	93193	1.62E+03	500	2.53E-02
2344	13874	1.74E+02	500	1.38E-03
2345	93815	2.02E+04	150	0.595363677
2346	13968	2.60E+01	500	3.34E-04
2347	13968	1.99E+03	150	0.172986329
2348	13897	1.16E+03	500	2.29E-02
2349	24033	2.79E+01	500	1.81E-04
2350	24033	1.81E+03	500	1.11E-02
2351	13968	2.60E+01	500	3.34E-04
2352	13968	2.60E+01	500	3.34E-04
2353	14935	1.70E+03	50	0.48696509
2354	3937	1.30E+05	150	2.23148489
2355	93193	1.62E+03	500	2.53E-02
2356	13968	2.60E+01	500	3.34E-04
2357	93193	2.91E+04	500	0.343281299
2358	23174	2.93E+04	150	1.651089549
2359	14935	2.15E+04	150	0.689836383
2360	13968	2.60E+01	150	2.86E-03
2361	94018	1.30E+03	500	2.32E-02
2362	13968	2.28E+03	150	0.193842337
2363	24033	1.81E+03	150	8.10E-02
2364	24033	1.81E+03	500	1.11E-02
2365	24033	1.81E+03	150	8.10E-02
2366	14935	7.24E+02	150	5.18E-02
2367	94846	7.90E+03	500	4.94E-02
2368	13897	1.16E+03	150	0.161779895
2369	94846	7.90E+03	500	4.94E-02
2370	14935	7.24E+02	150	5.18E-02
2371	12916	3.90E+02	150	0.017414141
2372	94018	1.30E+03	150	0.164017469
2373	93815	1.30E+03	500	0.009018256
2374	13874	1.74E+02	150	1.15E-02
2375	23234	4.86E+03	500	5.61E-02
2376	24033	1.81E+03	75	0.228026822
2377	13874	1.74E+02	150	1.15E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2378	13874	1.74E+02	500	1.38E-03
2379	23174	2.93E+04	150	1.651089549
2380	14935	1.68E+03	500	1.54E-02
2381	94018	1.30E+03	150	0.164017469
2382	94018	1.30E+03	500	2.32E-02
2383	24033	5.55E+03	150	0.202939466
2384	12916	3.90E+02	500	2.17E-03
2385	24033	1.81E+03	150	8.10E-02
2386	24033	1.49E+03	500	9.17E-03
2387	24033	1.49E+03	150	6.87E-02
2388	94018	1.30E+03	500	2.32E-02
2389	13897	6.69E+02	50	0.493969887
2390	13968	2.60E+01	500	3.34E-04
2391	24033	1.81E+03	75	0.228026822
2392	23234	2.83E+03	500	3.39E-02
2393	24233	3.12E+01	500	4.64E-04
2394	94018	1.30E+03	150	0.164017469
2395	93193	1.62E+03	150	0.18215175
2396	12916	3.90E+02	150	0.017414141
2397	13968	2.60E+01	150	2.86E-03
2398	94018	1.30E+03	500	2.32E-02
2399	13968	2.60E+01	150	2.86E-03
2400	13874	1.74E+02	500	1.38E-03
2401	12916	3.90E+02	500	2.17E-03
2402	94018	1.30E+03	150	0.164017469
2403	94018	1.30E+03	150	0.164017469
2404	13968	2.60E+01	500	3.34E-04
2405	12916	3.90E+02	150	0.017414141
2406	24033	1.49E+03	500	9.17E-03
2407	13968	2.60E+01	500	3.34E-04
2408	12916	3.90E+02	150	0.017414141
2409	12916	3.90E+02	150	0.017414141
2410	13897	1.16E+03	150	0.161779895
2411	13968	5.81E+02	500	7.25E-03
2412	13897	1.16E+03	500	2.29E-02
2413	94846	7.90E+03	150	0.297966719

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2414	13963	5.57E+02	150	4.40E-02
2415	13737	2.94E+03	75	0.340185344
2416	14935	1.03E+03	500	9.60E-03
2417	13874	1.74E+02	150	1.15E-02
2418	24011	7.28E+02	150	3.47E-02
2419	24033	1.81E+03	75	0.228026822
2420	13874	1.74E+02	500	1.38E-03
2421	94018	1.30E+03	150	0.164017469
2422	94018	1.30E+03	500	2.32E-02
2423	13897	1.16E+03	500	2.29E-02
2424	13874	1.74E+02	500	1.38E-03
2425	23174	2.93E+04	150	1.651089549
2426	13897	6.96E+03	150	0.642082036
2427	14935	1.70E+03	150	0.10937687
2428	94018	1.30E+03	150	0.164017469
2429	94846	5.40E+02	500	3.94E-03
2430	13968	2.60E+01	500	3.34E-04
2431	24033	1.81E+03	150	8.10E-02
2432	24033	1.81E+03	500	1.11E-02
2433	13739	2.09E+03	150	0.11715059
2434	93815	1.30E+03	150	6.70E-02
2435	13968	2.60E+01	500	3.34E-04
2436	12916	3.90E+02	150	0.017414141
2437	14935	7.24E+02	150	5.18E-02
2438	13968	2.60E+01	150	2.86E-03
2439	94846	7.90E+03	150	0.297966719
2440	12916	3.90E+02	500	2.17E-03
2441	13874	8.36E+01	150	5.70E-03
2442	94846	7.90E+03	500	4.94E-02
2443	94846	5.40E+02	150	3.11E-02
2444	14935	1.68E+03	500	1.54E-02
2445	93815	2.02E+04	500	0.111287095
2446	23174	9.39E+03	150	0.775993705
2447	12839	8.82E+03	150	0.458975971
2448	94018	1.30E+03	150	0.164017469
2449	13897	1.86E+03	500	3.61E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2450	24011	1.44E+03	150	6.55E-02
2451	13874	1.74E+02	500	1.38E-03
2452	24033	2.79E+01	500	1.81E-04
2453	24033	1.81E+03	150	8.10E-02
2454	13897	6.96E+03	500	0.120370112
2455	13968	2.60E+01	150	2.86E-03
2456	13874	1.74E+02	150	1.15E-02
2457	14742	1.01E+03	500	7.64E-03
2458	94846	7.90E+03	150	0.297966719
2459	94846	7.90E+03	150	0.297966719
2460	13963	5.57E+02	500	5.34E-03
2461	14935	7.24E+02	150	5.18E-02
2462	14764	4.58E+04	500	0.325622469
2463	93815	1.94E+02	150	1.15E-02
2464	13739	4.87E+02	500	4.04E-03
2465	12842	5.20E+01	500	5.75E-04
2466	13874	1.24E+03	500	9.45E-03
2467	13874	1.74E+02	150	1.15E-02
2468	23234	2.83E+03	500	3.39E-02
2469	13968	5.81E+02	150	5.81E-02
2470	94846	7.90E+03	150	0.297966719
2471	14935	1.68E+03	150	0.108694054
2472	14935	1.68E+03	50	0.484846026
2473	93815	1.30E+04	500	0.077218309
2474	12916	3.90E+02	150	0.017414141
2475	94018	1.30E+03	500	2.32E-02
2476	93193	1.62E+03	150	0.18215175
2477	14935	1.03E+03	150	7.04E-02
2478	24233	3.12E+01	150	3.99E-03
2479	13874	1.74E+02	500	1.38E-03
2480	14935	1.83E+04	500	0.131324604
2481	13968	2.60E+01	500	3.34E-04
2482	13968	2.60E+01	150	2.86E-03
2483	94018	1.30E+03	500	2.32E-02
2484	14935	1.03E+03	150	7.04E-02
2485	13739	3.58E+03	500	2.75E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2486	13874	1.74E+02	150	1.15E-02
2487	13874	1.74E+02	150	1.15E-02
2488	13968	2.60E+01	500	3.34E-04
2489	14935	1.83E+04	150	0.626706421
2490	13739	4.87E+02	500	4.04E-03
2491	94018	1.30E+03	150	0.164017469
2492	14935	1.03E+03	150	7.04E-02
2493	94847	7.80E+02	150	4.66E-02
2494	13968	2.60E+01	150	2.86E-03
2495	14935	1.83E+04	500	0.131324604
2496	12842	5.20E+01	500	5.75E-04
2497	14935	2.15E+04	150	0.689836383
2498	14935	2.15E+04	150	0.689836383
2499	13968	2.60E+01	150	2.86E-03
2500	24033	1.81E+03	500	1.11E-02
2501	13963	5.57E+02	150	4.40E-02
2502	13897	1.86E+03	150	0.240401059
2503	94018	1.30E+03	150	0.164017469
2504	94018	1.30E+03	500	2.32E-02
2505	13880	8.10E+04	150	1.71443367
2506	13737	2.94E+03	150	0.12866129
2507	13897	6.96E+03	500	0.120370112
2508	23234	2.83E+03	150	0.224960372
2509	14935	1.70E+03	500	1.56E-02
2510	24033	1.81E+03	150	8.10E-02
2511	13968	2.60E+01	75	9.70E-03
2512	24033	1.49E+03	500	9.17E-03
2513	94018	1.30E+03	150	0.164017469
2514	12842	5.20E+01	150	4.85E-03
2515	13874	1.74E+02	150	1.15E-02
2516	13968	2.60E+01	500	3.34E-04
2517	12916	3.90E+02	150	0.017414141
2518	13968	2.60E+01	50	1.94E-02
2519	12916	3.90E+02	150	0.017414141
2520	24033	1.81E+03	500	1.11E-02
2521	93815	1.94E+02	500	1.40E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2522	13737	2.94E+03	50	0.573708653
2523	13874	1.74E+02	500	1.38E-03
2524	13968	2.60E+01	500	3.34E-04
2525	23234	4.86E+03	150	0.346287996
2526	13880	4.86E+03	500	3.64E-02
2527	12916	3.90E+02	500	2.17E-03
2528	13968	2.28E+03	150	0.193842337
2529	94846	7.90E+03	500	4.94E-02
2530	13874	1.74E+02	150	1.15E-02
2531	13739	4.87E+02	150	3.20E-02
2532	13897	1.86E+03	500	3.61E-02
2533	94846	7.90E+03	150	0.297966719
2534	13737	2.94E+03	500	1.99E-02
2535	13968	1.99E+03	500	2.38E-02
2536	24033	1.81E+03	150	8.10E-02
2537	23234	6.48E+03	150	0.423418999
2538	13874	9.29E+01	150	6.30E-03
2539	23174	2.93E+04	150	1.651089549
2540	13968	2.60E+01	75	9.70E-03
2541	93193	2.91E+04	500	0.343281299
2542	94018	1.30E+03	150	0.164017469
2543	13968	2.60E+01	150	2.86E-03
2544	13897	1.86E+03	150	0.240401059
2545	94846	7.90E+03	150	0.297966719
2546	13897	1.16E+03	150	0.161779895
2547	94018	1.30E+03	150	0.164017469
2548	13897	1.16E+03	500	2.29E-02
2549	13897	1.16E+03	150	0.161779895
2550	94018	1.30E+03	150	0.164017469
2551	13737	2.94E+03	150	0.12866129
2552	13968	2.60E+01	500	3.34E-04
2553	14840	8.88E+03	150	0.299487591
2554	13874	1.74E+02	150	1.15E-02
2555	94018	1.30E+03	150	0.164017469
2556	13880	6.99E+03	500	5.03E-02
2557	24033	1.49E+03	150	6.87E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2558	23234	6.48E+03	500	7.24E-02
2559	94018	1.30E+03	500	2.32E-02
2560	93815	1.94E+02	150	1.15E-02
2561	94018	1.30E+03	500	2.32E-02
2562	13874	1.74E+02	75	3.78E-02
2563	94846	7.90E+03	500	4.94E-02
2564	94846	5.40E+02	500	3.94E-03
2565	24033	1.81E+03	500	1.11E-02
2566	13739	3.58E+03	500	2.75E-02
2567	13897	1.16E+03	150	0.161779895
2568	13739	2.09E+03	500	1.65E-02
2569	13968	2.60E+01	150	2.86E-03
2570	13874	1.74E+02	150	1.15E-02
2571	94847	7.80E+02	150	4.66E-02
2572	13968	2.60E+01	150	2.86E-03
2573	14935	1.70E+03	75	0.294345737
2574	13874	8.36E+01	150	5.70E-03
2575	14935	7.24E+02	500	6.83E-03
2576	94018	1.30E+03	500	2.32E-02
2577	94846	7.90E+03	500	4.94E-02
2578	24033	1.49E+03	150	6.87E-02
2579	13968	2.60E+01	500	3.34E-04
2580	13737	2.94E+03	150	0.12866129
2581	13897	2.31E+05	150	4.531942844
2582	13739	3.58E+03	500	2.75E-02
2583	24033	1.49E+03	500	9.17E-03
2584	94847	5.30E+02	500	4.33E-03
2585	94018	1.30E+03	500	2.32E-02
2586	24033	1.81E+03	500	1.11E-02
2587	13874	8.36E+01	150	5.70E-03
2588	14935	1.68E+03	500	1.54E-02
2589	13739	3.58E+03	500	2.75E-02
2590	94018	1.30E+03	150	0.164017469
2591	13874	1.74E+02	150	1.15E-02
2592	14935	7.24E+02	500	6.83E-03
2593	13874	1.74E+02	150	1.15E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2594	14764	6.07E+03	500	5.75E-02
2595	13968	2.28E+03	150	0.193842337
2596	24033	1.81E+03	500	1.11E-02
2597	13963	5.57E+02	500	5.34E-03
2598	24033	1.49E+03	150	6.87E-02
2599	13874	1.74E+02	500	1.38E-03
2600	13737	2.94E+03	150	0.12866129
2601	24033	2.79E+01	50	1.05E-02
2602	24233	3.12E+01	500	4.64E-04
2603	14935	7.24E+02	150	5.18E-02
2604	23234	2.83E+03	500	3.39E-02
2605	13874	1.74E+02	500	1.38E-03
2606	93815	1.30E+03	150	6.70E-02
2607	13874	1.74E+02	150	1.15E-02
2608	24033	2.79E+01	150	1.53E-03
2609	13739	2.09E+03	150	0.11715059
2610	93193	2.91E+04	500	0.343281299
2611	12916	9.29E+02	150	3.83E-02
2612	94846	7.90E+03	50	1.10594821
2613	93193	2.91E+04	150	1.652960896
2614	94018	1.30E+03	500	2.32E-02
2615	13968	2.60E+01	150	2.86E-03
2616	13968	2.60E+01	75	9.70E-03
2617	13897	1.86E+03	500	3.61E-02
2618	24011	1.44E+03	150	6.55E-02
2619	24033	1.81E+03	150	8.10E-02
2620	13874	1.74E+02	500	1.38E-03
2621	94018	1.30E+03	500	2.32E-02
2622	24033	1.81E+03	500	1.11E-02
2623	23234	6.07E+03	150	0.404124349
2624	13874	1.74E+02	150	1.15E-02
2625	94018	1.30E+03	150	0.164017469
2626	13968	5.81E+02	500	7.25E-03
2627	3937	7.43E+02	150	4.60E-02
2628	13737	2.94E+03	500	1.99E-02
2629	24033	1.81E+03	500	1.11E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2630	13874	1.74E+02	500	1.38E-03
2631	14935	1.83E+04	150	0.626706421
2632	13739	2.09E+03	150	0.11715059
2633	13874	1.74E+02	150	1.15E-02
2634	94018	1.00E+03	500	1.80E-02
2635	14935	1.03E+03	150	7.04E-02
2636	14935	7.24E+02	500	6.83E-03
2637	14935	7.24E+02	150	5.18E-02
2638	24033	1.81E+03	500	1.11E-02
2639	94018	1.28E+03	75	0.453660309
2640	23234	6.07E+03	150	0.404124349
2641	13874	1.74E+02	500	1.38E-03
2642	13874	1.74E+02	75	3.78E-02
2643	14935	1.03E+03	150	7.04E-02
2644	93815	1.30E+03	500	0.009018256
2645	13963	2.15E+05	75	5.074141502
2646	94018	1.30E+03	150	0.164017469
2647	93815	1.30E+04	150	0.449256331
2648	24033	1.81E+03	75	0.228026822
2649	13739	4.87E+02	500	4.04E-03
2650	13874	1.23E+03	500	9.39E-03
2651	24033	1.81E+03	150	8.10E-02
2652	14935	1.70E+03	500	1.56E-02
2653	94018	1.28E+03	150	0.161950201
2654	12916	3.90E+02	150	0.017414141
2655	13968	2.60E+01	500	3.34E-04
2656	94018	1.30E+03	500	2.32E-02
2657	94847	1.30E+02	150	8.92E-03
2658	24033	1.49E+03	150	6.87E-02
2659	94018	1.30E+03	500	2.32E-02
2660	13968	2.60E+01	150	2.86E-03
2661	14742	1.01E+03	150	5.99E-02
2662	13874	9.29E+01	75	2.13E-02
2663	93815	1.94E+02	150	1.15E-02
2664	13874	1.24E+03	500	9.45E-03
2665	13737	2.94E+03	150	0.12866129

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2666	24033	1.81E+03	500	1.11E-02
2667	94018	1.30E+03	150	0.164017469
2668	13739	4.87E+02	150	3.20E-02
2669	94018	1.30E+03	150	0.164017469
2670	13874	1.74E+02	150	1.15E-02
2671	13874	1.74E+02	75	3.78E-02
2672	13737	2.94E+03	150	0.12866129
2673	24033	1.81E+03	500	1.11E-02
2674	94846	7.90E+03	500	4.94E-02
2675	94846	7.90E+03	500	4.94E-02
2676	13963	5.57E+02	150	4.40E-02
2677	13737	2.94E+03	150	0.12866129
2678	23174	2.93E+04	150	1.651089549
2679	94018	1.30E+03	150	0.164017469
2680	23174	2.93E+04	150	1.651089549
2681	14935	1.03E+03	500	9.60E-03
2682	93815	1.94E+02	150	1.15E-02
2683	24033	1.81E+03	500	1.11E-02
2684	94846	7.90E+03	150	0.297966719
2685	93193	2.91E+04	500	0.343281299
2686	94847	1.30E+02	500	1.08E-03
2687	23234	2.42E+03	150	0.197342426
2688	12916	3.90E+02	150	0.017414141
2689	14935	1.83E+04	150	0.626706421
2690	94018	1.30E+03	150	0.164017469
2691	94018	1.30E+03	150	0.164017469
2692	24033	2.79E+01	150	1.53E-03
2693	93815	1.30E+04	150	0.449256331
2694	24011	1.09E+03	150	5.05E-02
2695	24033	1.81E+03	500	1.11E-02
2696	14935	1.68E+03	50	0.484846026
2697	12839	8.76E+03	150	0.456498176
2698	93815	1.94E+02	150	1.15E-02
2699	94846	7.90E+03	500	4.94E-02
2700	12842	5.20E+01	150	4.85E-03
2701	14935	7.24E+02	500	6.83E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2702	94018	1.30E+03	150	0.164017469
2703	23234	6.07E+03	500	6.83E-02
2704	14935	1.70E+03	150	0.10937687
2705	24033	1.81E+03	150	8.10E-02
2706	94846	7.90E+03	150	0.297966719
2707	14935	7.24E+02	150	5.18E-02
2708	24033	2.79E+01	150	1.53E-03
2709	13897	6.96E+03	150	0.642082036
2710	24033	2.79E+01	500	1.81E-04
2711	13968	2.60E+01	150	2.86E-03
2712	3937	7.43E+02	500	6.13E-03
2713	13968	2.28E+03	500	2.71E-02
2714	94846	7.90E+03	150	0.297966719
2715	13968	2.60E+01	150	2.86E-03
2716	94846	7.90E+03	500	4.94E-02
2717	23234	6.07E+03	150	0.404124349
2718	94018	1.30E+03	150	0.164017469
2719	13874	1.24E+03	150	7.27E-02
2720	13739	2.09E+03	150	0.11715059
2721	14935	1.70E+03	500	1.56E-02
2722	24033	1.81E+03	150	8.10E-02
2723	94846	7.90E+03	500	4.94E-02
2724	94018	1.30E+03	500	2.32E-02
2725	13737	2.94E+03	500	1.99E-02
2726	13897	1.16E+03	150	0.161779895
2727	94018	1.30E+03	150	0.164017469
2728	14935	1.68E+03	150	0.108694054
2729	13963	1.77E+04	150	0.74918884
2730	94018	1.30E+03	150	0.164017469
2731	12839	8.82E+03	150	0.458975971
2732	24033	1.81E+03	500	1.11E-02
2733	94018	1.30E+03	500	2.32E-02
2734	14935	1.03E+03	500	9.60E-03
2735	14935	1.83E+04	500	0.131324604
2736	14764	6.07E+03	150	0.340731502
2737	13963	1.19E+04	150	0.591862321

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2738	14935	2.15E+04	150	0.689836383
2739	14935	2.15E+04	500	0.149872139
2740	23234	2.36E+03	150	0.193542421
2741	24033	1.81E+03	150	8.10E-02
2742	14764	6.07E+03	150	0.340731502
2743	24033	2.79E+01	75	5.24E-03
2744	14935	1.83E+04	500	0.131324604
2745	24033	1.81E+03	500	1.11E-02
2746	94846	7.90E+03	500	4.94E-02
2747	24033	1.49E+03	150	6.87E-02
2748	14935	1.70E+03	150	0.10937687
2749	13968	2.60E+01	75	9.70E-03
2750	12916	3.90E+02	500	2.17E-03
2751	13968	2.60E+01	500	3.34E-04
2752	94018	1.17E+05	150	3.857833147
2753	13874	1.74E+02	150	1.15E-02
2754	24033	1.49E+03	150	6.87E-02
2755	13968	2.60E+01	150	2.86E-03
2756	13874	1.74E+02	500	1.38E-03
2757	13968	2.60E+01	150	2.86E-03
2758	94846	7.90E+03	500	4.94E-02
2759	93815	1.30E+03	500	0.009018256
2760	14740	9.14E+02	500	1.18E-02
2761	13739	3.58E+03	150	0.18802318
2762	24033	2.79E+01	500	1.81E-04
2763	13968	2.60E+01	150	2.86E-03
2764	13897	1.86E+03	150	0.240401059
2765	14764	6.07E+03	150	0.340731502
2766	14935	7.24E+02	500	6.83E-03
2767	24033	1.81E+03	150	8.10E-02
2768	24033	1.81E+03	500	1.11E-02
2769	13968	2.60E+01	150	2.86E-03
2770	13737	2.94E+03	500	1.99E-02
2771	24033	1.81E+03	150	8.10E-02
2772	13968	2.60E+01	500	3.34E-04
2773	14935	7.24E+02	500	6.83E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2774	13968	2.60E+01	150	2.86E-03
2775	94018	1.30E+03	500	2.32E-02
2776	93193	1.62E+03	150	0.18215175
2777	94018	1.30E+03	150	0.164017469
2778	13874	1.23E+03	150	0.072232224
2779	14935	1.83E+04	500	0.131324604
2780	13968	2.60E+01	500	3.34E-04
2781	13874	9.29E+01	75	2.13E-02
2782	13968	1.99E+03	500	2.38E-02
2783	24033	1.81E+03	500	1.11E-02
2784	13968	2.60E+01	150	2.86E-03
2785	23234	2.83E+03	500	3.39E-02
2786	94018	1.30E+03	150	0.164017469
2787	94018	1.30E+03	75	0.459146798
2788	13874	1.74E+02	500	1.38E-03
2789	13880	4.86E+03	150	0.230076194
2790	13874	1.74E+02	500	1.38E-03
2791	13874	1.74E+02	500	1.38E-03
2792	13968	2.60E+01	75	9.70E-03
2793	13897	3.86E+03	75	1.014361978
2794	14935	2.15E+04	500	0.149872139
2795	13968	5.81E+02	150	5.81E-02
2796	24233	3.12E+01	500	4.64E-04
2797	12839	8.76E+03	500	7.77E-02
2798	13874	9.29E+01	150	6.30E-03
2799	24033	1.81E+03	500	1.11E-02
2800	13737	2.94E+03	500	1.99E-02
2801	24033	1.81E+03	500	1.11E-02
2802	13739	2.09E+03	500	1.65E-02
2803	13963	4.61E+03	500	4.18E-02
2804	94018	1.00E+03	500	1.80E-02
2805	24033	1.81E+03	150	8.10E-02
2806	13874	1.74E+02	150	1.15E-02
2807	23174	2.93E+04	150	1.651089549
2808	13737	2.94E+03	150	0.12866129
2809	94018	1.30E+03	500	2.32E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2810	12842	5.20E+01	500	5.75E-04
2811	24033	1.81E+03	50	0.390205085
2812	94018	1.30E+03	500	2.32E-02
2813	13968	2.60E+01	500	3.34E-04
2814	24011	7.28E+02	150	3.47E-02
2815	13874	1.74E+02	150	1.15E-02
2816	13968	2.60E+01	150	2.86E-03
2817	24033	1.81E+03	500	1.11E-02
2818	12839	8.82E+03	150	0.458975971
2819	13968	2.60E+01	150	2.86E-03
2820	24033	1.81E+03	500	1.11E-02
2821	14935	7.24E+02	150	5.18E-02
2822	94847	1.30E+02	150	8.92E-03
2823	13897	1.86E+03	150	0.240401059
2824	24033	1.81E+03	150	8.10E-02
2825	13737	2.94E+03	75	0.340185344
2826	23234	6.07E+03	150	0.404124349
2827	23234	4.86E+03	150	0.346287996
2828	14935	1.03E+03	150	7.04E-02
2829	13968	1.52E+03	500	1.85E-02
2830	24033	1.81E+03	500	1.11E-02
2831	94846	7.90E+03	150	0.297966719
2832	24033	1.49E+03	500	9.17E-03
2833	24033	2.79E+01	500	1.81E-04
2834	13968	2.60E+01	150	2.86E-03
2835	23174	2.93E+04	500	0.356077075
2836	13874	1.23E+03	150	0.072232224
2837	24033	1.81E+03	150	8.10E-02
2838	93193	2.91E+04	150	1.652960896
2839	23174	2.93E+04	150	1.651089549
2840	13968	2.60E+01	150	2.86E-03
2841	13968	2.60E+01	500	3.34E-04
2842	94018	1.28E+03	500	2.29E-02
2843	13897	1.86E+03	500	3.61E-02
2844	13968	2.60E+01	150	2.86E-03
2845	13874	9.29E+01	150	6.30E-03

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2846	13963	5.57E+02	500	5.34E-03
2847	94846	5.11E+03	150	0.213590831
2848	24033	5.55E+03	500	3.19E-02
2849	14935	1.03E+03	150	7.04E-02
2850	13968	2.60E+01	150	2.86E-03
2851	14935	1.03E+03	500	9.60E-03
2852	13874	1.74E+02	150	1.15E-02
2853	24033	1.49E+03	500	9.17E-03
2854	13968	2.60E+01	75	9.70E-03
2855	13968	2.60E+01	150	2.86E-03
2856	13963	1.77E+04	500	0.144601092
2857	13874	1.74E+02	150	1.15E-02
2858	13874	1.74E+02	500	1.38E-03
2859	13897	1.16E+03	150	0.161779895
2860	13968	2.28E+03	150	0.193842337
2861	13968	2.60E+01	75	9.70E-03
2862	13880	4.86E+03	500	3.64E-02
2863	12842	5.20E+01	500	5.75E-04
2864	13874	8.36E+01	500	6.70E-04
2865	13739	3.58E+03	150	0.18802318
2866	23174	9.39E+03	150	0.775993705
2867	94846	7.90E+03	150	0.297966719
2868	93815	1.30E+03	150	6.70E-02
2869	24033	1.81E+03	150	8.10E-02
2870	13968	5.81E+02	150	5.81E-02
2871	94847	5.30E+02	500	4.33E-03
2872	14840	8.76E+03	150	0.296306461
2873	93193	1.62E+05	150	4.407284737
2874	93815	1.94E+02	500	1.40E-03
2875	14935	1.68E+03	500	1.54E-02
2876	13874	1.74E+02	150	1.15E-02
2877	94847	7.80E+02	150	4.66E-02
2878	13968	2.60E+01	500	3.34E-04
2879	93815	1.30E+03	150	6.70E-02
2880	12839	2.02E+02	500	2.16E-03
2881	93193	2.91E+04	500	0.343281299

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2882	24033	1.81E+03	500	1.11E-02
2883	13874	8.36E+01	500	6.70E-04
2884	24033	1.49E+03	500	9.17E-03
2885	13963	5.57E+02	500	5.34E-03
2886	13968	2.60E+01	50	1.94E-02
2887	94018	1.30E+03	500	2.32E-02
2888	94846	7.90E+03	150	0.297966719
2889	93815	1.30E+03	150	6.70E-02
2890	93193	1.62E+03	500	2.53E-02
2891	13968	2.60E+01	150	2.86E-03
2892	24033	1.81E+03	500	1.11E-02
2893	13874	1.74E+02	500	1.38E-03
2894	14935	1.03E+03	75	0.197674334
2895	13897	1.86E+03	500	3.61E-02
2896	13963	1.19E+04	500	0.102946036
2897	24011	7.28E+02	500	4.37E-03
2898	14740	9.14E+02	150	8.63E-02
2899	13968	2.60E+01	500	3.34E-04
2900	13897	1.16E+03	500	2.29E-02
2901	93193	2.91E+04	150	1.652960896
2902	13874	8.36E+01	150	5.70E-03
2903	24033	2.79E+01	150	1.53E-03
2904	13963	1.77E+04	500	0.144601092
2905	13880	1.04E+03	500	8.50E-03
2906	23234	4.86E+03	150	0.346287996
2907	24033	1.81E+03	150	8.10E-02
2908	13968	2.60E+01	150	2.86E-03
2909	94846	7.90E+03	75	0.70691359
2910	13968	2.60E+01	500	3.34E-04
2911	94846	7.90E+03	150	0.297966719
2912	12916	3.90E+02	500	2.17E-03
2913	14935	2.15E+04	150	0.689836383
2914	13874	1.23E+03	150	0.072232224
2915	13968	2.60E+01	500	3.34E-04
2916	94018	1.30E+03	500	2.32E-02
2917	94846	7.90E+03	150	0.297966719

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s-m^2$)
2918	94847	7.80E+02	75	0.130357772
2919	94847	7.80E+02	150	4.66E-02
2920	94018	1.30E+03	150	0.164017469
2921	13897	1.86E+03	500	3.61E-02
2922	24033	1.81E+03	75	0.228026822
2923	13968	2.60E+01	150	2.86E-03
2924	13874	1.74E+02	500	1.38E-03
2925	14935	1.83E+04	500	0.131324604
2926	13874	1.74E+02	75	3.78E-02
2927	13874	1.74E+02	500	1.38E-03
2928	14935	1.70E+03	150	0.10937687
2929	13880	1.04E+03	75	0.180395633
2930	12916	9.29E+02	150	3.83E-02
2931	93815	2.02E+04	500	0.111287095
2932	94846	7.90E+03	75	0.70691359
2933	14935	1.03E+03	500	9.60E-03
2934	13963	5.57E+02	500	5.34E-03
2935	24033	1.81E+03	150	8.10E-02
2936	94018	1.30E+03	150	0.164017469
2937	13874	9.29E+01	150	6.30E-03
2938	23234	2.36E+03	150	0.193542421
2939	14935	7.24E+02	150	5.18E-02
2940	94846	7.90E+03	150	0.297966719
2941	13874	1.74E+02	500	1.38E-03
2942	13968	2.60E+01	150	2.86E-03
2943	13880	4.86E+03	150	0.230076194
2944	94846	5.40E+02	500	3.94E-03
2945	14935	7.24E+02	150	5.18E-02
2946	93815	1.30E+04	75	1.047177553
2947	13968	1.52E+03	500	1.85E-02
2948	13897	1.16E+03	150	0.161779895
2949	94018	1.30E+03	75	0.459146798
2950	14935	2.15E+04	500	0.149872139
2951	94018	1.30E+03	500	2.32E-02
2952	24033	1.81E+03	500	1.11E-02
2953	93193	1.62E+05	500	1.380677104

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per ug/s-m^2)
2954	13963	1.77E+04	500	0.144601092
2955	94847	7.80E+02	150	4.66E-02
2956	93815	1.30E+03	150	6.70E-02
2957	94018	1.30E+03	150	0.164017469
2958	93815	1.30E+04	500	0.077218309
2959	23234	6.07E+03	150	0.404124349
2960	13968	5.81E+02	500	7.25E-03
2961	13874	1.74E+02	500	1.38E-03
2962	12842	5.20E+01	150	4.85E-03
2963	13874	1.74E+02	500	1.38E-03
2964	14935	2.15E+04	150	0.689836383
2965	13897	1.86E+03	150	0.240401059
2966	14935	1.03E+03	150	7.04E-02
2967	13880	1.04E+03	150	6.25E-02
2968	94846	7.90E+03	500	4.94E-02
2969	93815	1.94E+02	75	3.70E-02
2970	13968	2.60E+01	150	2.86E-03
2971	13968	5.81E+02	500	7.25E-03
2972	93815	1.30E+03	150	6.70E-02
2973	94847	7.80E+02	500	6.29E-03
2974	94846	7.90E+03	150	0.297966719
2975	13874	1.74E+02	500	1.38E-03
2976	94018	1.30E+03	500	2.32E-02
2977	24033	1.81E+03	500	1.11E-02
2978	12916	3.90E+02	500	2.17E-03
2979	13897	1.16E+03	150	0.161779895
2980	13874	1.74E+02	500	1.38E-03
2981	13880	4.86E+03	150	0.230076194
2982	94018	1.30E+03	150	0.164017469
2983	23234	2.36E+03	150	0.193542421
2984	12839	8.76E+03	500	7.77E-02
2985	24011	7.28E+02	500	4.37E-03
2986	93193	2.91E+04	500	0.343281299
2987	13968	2.60E+01	150	2.86E-03
2988	24011	7.28E+02	150	3.47E-02
2989	93815	1.30E+03	150	6.70E-02

(continued)

Table I-1. (continued)

RunID	Site ID	Source Area (m^2)	Distance (m)	Unitized Air Concentration (ug/m^3 per $ug/s\text{-}m^2$)
2990	24033	1.81E+03	150	8.10E-02
2991	94018	1.30E+03	500	2.32E-02
2992	94018	1.30E+03	500	2.32E-02
2993	23234	4.86E+03	500	5.61E-02
2994	94018	1.30E+03	500	2.32E-02
2995	94846	7.90E+03	75	0.70691359
2996	13968	2.60E+01	500	3.34E-04
2997	94018	1.00E+03	150	0.12979272
2998	94018	1.30E+03	500	2.32E-02
2999	94847	7.80E+02	500	6.29E-03
3000	23234	2.42E+03	150	0.197342426

Figure I-1. Air Modeling Input Files

```
CO STARTING
   TITLEONE  Albuquerque
   TITLETWO  464.3 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  23050.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -1174.35   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    1174.35  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    1174.35  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -1174.35  11  234.87  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  23050.REC
RE FINISHED

ME STARTING
ME INPUTFIL  23050H.MET
ME ANEMHGHT  7 METERS
ME SURFDATA  23050  1985
ME UAIRDATA  23050  1985
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 23050_1C.PLP
   PLOTFILE  ANNUAL 2 23050_1P.PLP
   PLOTFILE  ANNUAL ALL 23050.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Asheville
  TITLETWO  55.4 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  03812.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -236.75   -236.75    0.00
SO LOCATION 1P     AREA    0   -236.75    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    236.75  473.49   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    236.75  473.49   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -236.75  11  47.35  -236.75  11  47.35
RE GRIDCART  ONSITE END
RE INCLUDED  03812.REC
RE FINISHED

ME STARTING
ME INPUTFIL  03812H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  03812  1985
ME UAIRDATA  13723  1985
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 03812_1C.PLP
  PLOTFILE  ANNUAL 2 03812_1P.PLP
  PLOTFILE  ANNUAL ALL 03812.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Atlanta
   TITLETWO  105.9 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  13874.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -327.32   -327.32    0.00
SO LOCATION 1P     AREA    0   -327.32    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    327.32  654.65   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    327.32  654.65   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -327.32  11  65.46  -327.32  11  65.46
RE GRIDCART  ONSITE END
RE INCLUDED  13874.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13874H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  13874  1986
ME UAIRDATA  13873  1986
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 13874_1C.PLP
   PLOTFILE  ANNUAL 2 13874_1P.PLP
   PLOTFILE  ANNUAL ALL 13874.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Billings
   TITLETWO  1241.7 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  24033.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -3140.63   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    3140.63  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    3140.63  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -3140.63  11  628.13  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  24033.REC
RE FINISHED

ME STARTING
ME INPUTFIL  24033H.MET
ME ANEMHGHT  7.6 METERS
ME SURFDATA  24033  1986
ME UAIRDATA  24143  1986
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 24033_1C.PLP
   PLOTFILE  ANNUAL 2 24033_1P.PLP
   PLOTFILE  ANNUAL ALL 24033.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Bismarck
  TITLETWO  923.8 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  24011.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -2336.56   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    2336.56  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1       1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    2336.56  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1       1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -2336.56  11  467.31  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  24011.REC
RE FINISHED

ME STARTING
ME INPUTFIL  24011H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  24011  1984
ME UAIRDATA  24011  1984
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 24011_1C.PLP
  PLOTFILE  ANNUAL 2 24011_1P.PLP
  PLOTFILE  ANNUAL ALL 24011.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Boise
   TITLETWO  194.4 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  24131.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -491.7   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    491.7  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    491.7  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -491.7  11  98.34  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  24131.REC
RE FINISHED

ME STARTING
ME INPUTFIL  24131H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  24131  1978
ME UAIRDATA  24131  1978
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 24131_1C.PLP
   PLOTFILE  ANNUAL 2 24131_1P.PLP
   PLOTFILE  ANNUAL ALL 24131.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Boulder
  TITLETWO  738 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  94018.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -1866.62   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    1866.62  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    1866.62  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -1866.62  11  373.32  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  94018.REC
RE FINISHED

ME STARTING
ME INPUTFIL  94018H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  94018  1986
ME UAIRDATA  23062  1986
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 94018_1C.PLP
  PLOTFILE  ANNUAL 2 94018_1P.PLP
  PLOTFILE  ANNUAL ALL 94018.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Burlington
  TITLETWO  159.2 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  14742.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -402.66   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    402.66  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1      0.3     0.2
SO PARTDENS 1C       1        1        1        1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    402.66  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1      0.3     0.2
SO PARTDENS 1P       1        1        1        1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -402.66  11  80.53  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  14742.REC
RE FINISHED

ME STARTING
ME INPUTFIL  14742H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  14742  1985
ME UAIRDATA  14735  1985
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 14742_1C.PLP
  PLOTFILE  ANNUAL 2 14742_1P.PLP
  PLOTFILE  ANNUAL ALL 14742.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Casper
  TITLETWO  829.6 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  24089.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -2098.3   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    2098.3  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    2098.3  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -2098.3  11  419.66  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  24089.REC
RE FINISHED

ME STARTING
ME INPUTFIL  24089H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  24089  1985
ME UAIRDATA  24021  1985
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 24089_1C.PLP
  PLOTFILE  ANNUAL 2 24089_1P.PLP
  PLOTFILE  ANNUAL ALL 24089.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Charleston
   TITLETWO  80.4 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  13880.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -285.21   -285.21    0.00
SO LOCATION 1P     AREA    0   -285.21    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    285.21  570.41   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    285.21  570.41   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -285.21  11  57.04  -285.21  11  57.04
RE GRIDCART  ONSITE END
RE INCLUDED  13880.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13880H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  13880  1984
ME UAIRDATA  13880  1984
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 13880_1C.PLP
   PLOTFILE  ANNUAL 2 13880_1P.PLP
   PLOTFILE  ANNUAL ALL 13880.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Chicago
  TITLETWO  177.6 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  94846.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -449.2   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    449.2  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    449.2  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -449.2  11  89.84  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  94846.REC
RE FINISHED

ME STARTING
ME INPUTFIL  94846H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  94846  1984
ME UAIRDATA  14842  1984
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 94846_1C.PLP
  PLOTFILE  ANNUAL 2 94846_1P.PLP
  PLOTFILE  ANNUAL ALL 94846.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Cleveland
  TITLETWO  109.2 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  14820.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -332.38   -332.38    0.00
SO LOCATION 1P     AREA    0   -332.38    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    332.38  664.77   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    332.38  664.77   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -332.38  11  66.48  -332.38  11  66.48
RE GRIDCART  ONSITE END
RE INCLUDED  14820.REC
RE FINISHED

ME STARTING
ME INPUTFIL  14820H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  14820  1985
ME UAIRDATA  14733  1985
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 14820_1C.PLP
  PLOTFILE  ANNUAL 2 14820_1P.PLP
  PLOTFILE  ANNUAL ALL 14820.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Fresno
  TITLETWO  46.8 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  93193.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -217.6   -217.6    0.00
SO LOCATION 1P     AREA    0   -217.6    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    217.6  435.19   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    217.6  435.19   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -217.6  11  43.52  -217.6  11  43.52
RE GRIDCART  ONSITE END
RE INCLUDED  93193.REC
RE FINISHED

ME STARTING
ME INPUTFIL  93193H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  93193  1985
ME UAIRDATA  23230  1985
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 93193_1C.PLP
  PLOTFILE  ANNUAL 2 93193_1P.PLP
  PLOTFILE  ANNUAL ALL 93193.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Harrisburg
   TITLETWO  102.8 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  14751.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -322.5   -322.5    0.00
SO LOCATION 1P     AREA    0   -322.5    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    322.5  644.99   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    322.5  644.99   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -322.5  11  64.5  -322.5  11  64.5
RE GRIDCART  ONSITE END
RE INCLUDED  14751.REC
RE FINISHED

ME STARTING
ME INPUTFIL  14751H.MET
ME ANEMHGHT  6.7 METERS
ME SURFDATA  14751  1985
ME UAIRDATA  93734  1985
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 14751_1C.PLP
   PLOTFILE  ANNUAL 2 14751_1P.PLP
   PLOTFILE  ANNUAL ALL 14751.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Hartford
  TITLETWO  50 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  14740.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -224.91   -224.91    0.00
SO LOCATION 1P     AREA    0   -224.91    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    224.91  449.83   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    224.91  449.83   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -224.91  11  44.98  -224.91  11  44.98
RE GRIDCART  ONSITE END
RE INCLUDED  14740.REC
RE FINISHED

ME STARTING
ME INPUTFIL  14740H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  14740  1985
ME UAIRDATA  14735  1985
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 14740_1C.PLP
  PLOTFILE  ANNUAL 2 14740_1P.PLP
  PLOTFILE  ANNUAL ALL 14740.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Houston
  TITLETWO  123.5 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  12960.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -353.48   -353.48    0.00
SO LOCATION 1P     AREA    0   -353.48    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    353.48  706.96   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    353.48  706.96   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -353.48  11  70.7  -353.48  11  70.7
RE GRIDCART  ONSITE END
RE INCLUDED  12960.REC
RE FINISHED

ME STARTING
ME INPUTFIL  12960H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  12960  1985
ME UAIRDATA  3937  1985
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 12960_1C.PLP
  PLOTFILE  ANNUAL 2 12960_1P.PLP
  PLOTFILE  ANNUAL ALL 12960.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Huntington
   TITLETWO  86.7 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  03860.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -296.17   -296.17    0.00
SO LOCATION 1P     AREA    0   -296.17    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    296.17  592.34   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    296.17  592.34   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -296.17  11  59.23  -296.17  11  59.23
RE GRIDCART  ONSITE END
RE INCLUDED  03860.REC
RE FINISHED

ME STARTING
ME INPUTFIL  03860H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  03860  1984
ME UAIRDATA  3860  1984
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 03860_1C.PLP
   PLOTFILE  ANNUAL 2 03860_1P.PLP
   PLOTFILE  ANNUAL ALL 03860.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Las Vegas
  TITLETWO  97.6 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  23169.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -314.24   -314.24    0.00
SO LOCATION 1P     AREA    0   -314.24    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    314.24  628.47   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    314.24  628.47   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -314.24  11  62.85  -314.24  11  62.85
RE GRIDCART  ONSITE END
RE INCLUDED  23169.REC
RE FINISHED

ME STARTING
ME INPUTFIL  23169H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  23169  1986
ME UAIRDATA  3160  1986
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 23169_1C.PLP
  PLOTFILE  ANNUAL 2 23169_1P.PLP
  PLOTFILE  ANNUAL ALL 23169.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Lincoln
  TITLETWO  282.2 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  14935.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -713.77   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    713.77  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    713.77  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -713.77  11  142.75  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  14935.REC
RE FINISHED

ME STARTING
ME INPUTFIL  14935H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  14935  1986
ME UAIRDATA  94918  1986
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 14935_1C.PLP
  PLOTFILE  ANNUAL 2 14935_1P.PLP
  PLOTFILE  ANNUAL ALL 14935.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Little Rock
  TITLETWO  159.1 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  13963.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -402.41   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    402.41  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    402.41  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -402.41  11  80.48  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  13963.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13963H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  13963  1984
ME UAIRDATA  13963  1984
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 13963_1C.PLP
  PLOTFILE  ANNUAL 2 13963_1P.PLP
  PLOTFILE  ANNUAL ALL 13963.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Los Angeles
   TITLETWO  24.2 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  23174.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -156.47   -156.47    0.00
SO LOCATION 1P     AREA    0   -156.47    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    156.47  312.94   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    156.47  312.94   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -156.47  11  31.29  -156.47  11  31.29
RE GRIDCART  ONSITE END
RE INCLUDED  23174.REC
RE FINISHED

ME STARTING
ME INPUTFIL  23174H.MET
ME ANEMHGHT  9.1 METERS
ME SURFDATA  23174  1985
ME UAIRDATA  23230  1985
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 23174_1C.PLP
   PLOTFILE  ANNUAL 2 23174_1P.PLP
   PLOTFILE  ANNUAL ALL 23174.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Meridian
  TITLETWO  123 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  13865.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -352.76   -352.76    0.00
SO LOCATION 1P     AREA    0   -352.76    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    352.76  705.52   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    352.76  705.52   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -352.76  11  70.55  -352.76  11  70.55
RE GRIDCART  ONSITE END
RE INCLUDED  13865.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13865H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  13865  1986
ME UAIRDATA  3940  1986
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 13865_1C.PLP
  PLOTFILE  ANNUAL 2 13865_1P.PLP
  PLOTFILE  ANNUAL ALL 13865.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Miami
   TITLETWO  39.6 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  12839.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -200.16   -200.16    0.00
SO LOCATION 1P     AREA    0   -200.16    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    200.16  400.32   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1       1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    200.16  400.32   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1       1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -200.16  11  40.03  -200.16  11  40.03
RE GRIDCART  ONSITE END
RE INCLUDED  12839.REC
RE FINISHED

ME STARTING
ME INPUTFIL  12839H.MET
ME ANEMHGHT  7 METERS
ME SURFDATA  12839  1972
ME UAIRDATA  12839  1972
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 12839_1C.PLP
   PLOTFILE  ANNUAL 2 12839_1P.PLP
   PLOTFILE  ANNUAL ALL 12839.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Minneapolis
   TITLETWO  208.6 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  14922.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -527.61   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    527.61  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    527.61  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -527.61  11  105.52  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  14922.REC
RE FINISHED

ME STARTING
ME INPUTFIL  14922H.MET
ME ANEMHGHT  6.4 METERS
ME SURFDATA  14922  1986
ME UAIRDATA  14926  1986
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 14922_1C.PLP
   PLOTFILE  ANNUAL 2 14922_1P.PLP
   PLOTFILE  ANNUAL ALL 14922.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Muskegon
   TITLETWO  117.1 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  14840.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -344.2   -344.2    0.00
SO LOCATION 1P     AREA    0   -344.2    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    344.2  688.4   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    344.2  688.4   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -344.2  11  68.84  -344.2  11  68.84
RE GRIDCART  ONSITE END
RE INCLUDED  14840.REC
RE FINISHED

ME STARTING
ME INPUTFIL  14840H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  14840  1977
ME UAIRDATA  14826  1977
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 14840_1C.PLP
   PLOTFILE  ANNUAL 2 14840_1P.PLP
   PLOTFILE  ANNUAL ALL 14840.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Nashville
  TITLETWO  94.4 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  13897.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -309.04   -309.04    0.00
SO LOCATION 1P     AREA    0   -309.04    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    309.04  618.08   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    309.04  618.08   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -309.04  11  61.81  -309.04  11  61.81
RE GRIDCART  ONSITE END
RE INCLUDED  13897.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13897H.MET
ME ANEMHGHT  7.6 METERS
ME SURFDATA  13897  1984
ME UAIRDATA  13897  1984
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 13897_1C.PLP
  PLOTFILE  ANNUAL 2 13897_1P.PLP
  PLOTFILE  ANNUAL ALL 13897.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  New Orleans
   TITLETWO  90.9 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  12916.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -303.26   -303.26    0.00
SO LOCATION 1P     AREA    0   -303.26    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    303.26  606.52   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    303.26  606.52   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -303.26  11  60.65  -303.26  11  60.65
RE GRIDCART  ONSITE END
RE INCLUDED  12916.REC
RE FINISHED

ME STARTING
ME INPUTFIL  12916H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  12916  1985
ME UAIRDATA  3937  1985
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 12916_1C.PLP
   PLOTFILE  ANNUAL 2 12916_1P.PLP
   PLOTFILE  ANNUAL ALL 12916.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Norfolk
   TITLETWO  97.5 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  13737.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -314.07   -314.07    0.00
SO LOCATION 1P     AREA    0   -314.07    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    314.07  628.15   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    314.07  628.15   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -314.07  11  62.81  -314.07  11  62.81
RE GRIDCART  ONSITE END
RE INCLUDED  13737.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13737H.MET
ME ANEMHGHT  10.1 METERS
ME SURFDATA  13737  1986
ME UAIRDATA  93739  1986
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 13737_1C.PLP
   PLOTFILE  ANNUAL 2 13737_1P.PLP
   PLOTFILE  ANNUAL ALL 13737.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Philadelphia
  TITLETWO  39 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  13739.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -198.64   -198.64    0.00
SO LOCATION 1P     AREA    0   -198.64    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    198.64  397.28   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    198.64  397.28   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -198.64  11  39.73  -198.64  11  39.73
RE GRIDCART  ONSITE END
RE INCLUDED  13739.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13739H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  13739  1981
ME UAIRDATA  93734  1981
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 13739_1C.PLP
  PLOTFILE  ANNUAL 2 13739_1P.PLP
  PLOTFILE  ANNUAL ALL 13739.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Phoenix
  TITLETWO  339.7 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  23183.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -859.2   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    859.2  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    859.2  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -859.2  11  171.84  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  23183.REC
RE FINISHED

ME STARTING
ME INPUTFIL  23183H.MET
ME ANEMHGHT  10.1 METERS
ME SURFDATA  23183  1986
ME UAIRDATA  23160  1986
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 23183_1C.PLP
  PLOTFILE  ANNUAL 2 23183_1P.PLP
  PLOTFILE  ANNUAL ALL 23183.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Portland
  TITLETWO  98.2 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  14764.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -315.2   -315.2    0.00
SO LOCATION 1P     AREA    0   -315.2    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    315.2  630.4   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    315.2  630.4   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -315.2  11  63.04  -315.2  11  63.04
RE GRIDCART  ONSITE END
RE INCLUDED  14764.REC
RE FINISHED

ME STARTING
ME INPUTFIL  14764H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  14764  1985
ME UAIRDATA  14764  1985
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 14764_1C.PLP
  PLOTFILE  ANNUAL 2 14764_1P.PLP
  PLOTFILE  ANNUAL ALL 14764.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Raleigh-Durham
   TITLETWO  85.4 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  13722.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -293.94   -293.94    0.00
SO LOCATION 1P     AREA    0   -293.94    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    293.94  587.88   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    293.94  587.88   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -293.94  11  58.79  -293.94  11  58.79
RE GRIDCART  ONSITE END
RE INCLUDED  13722.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13722H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  13722  1986
ME UAIRDATA  13723  1986
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 13722_1C.PLP
   PLOTFILE  ANNUAL 2 13722_1P.PLP
   PLOTFILE  ANNUAL ALL 13722.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Salem
   TITLETWO  44.6 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  24232.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -212.42   -212.42    0.00
SO LOCATION 1P     AREA    0   -212.42    0.00

**         SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    212.42  424.84   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    212.42  424.84   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -212.42  11  42.48  -212.42  11  42.48
RE GRIDCART  ONSITE END
RE INCLUDED  24232.REC
RE FINISHED

ME STARTING
ME INPUTFIL  24232H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  24232  1986
ME UAIRDATA  24232  1986
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 24232_1C.PLP
   PLOTFILE  ANNUAL 2 24232_1P.PLP
   PLOTFILE  ANNUAL ALL 24232.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Salt Lake City
   TITLETWO  143.5 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  24127.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -381.03   -381.03    0.00
SO LOCATION 1P     AREA    0   -381.03    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    381.03  762.05   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    381.03  762.05   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -381.03  11  76.21  -381.03  11  76.21
RE GRIDCART  ONSITE END
RE INCLUDED  24127.REC
RE FINISHED

ME STARTING
ME INPUTFIL  24127H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  24127  1986
ME UAIRDATA  24127  1986
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 24127_1C.PLP
   PLOTFILE  ANNUAL 2 24127_1P.PLP
   PLOTFILE  ANNUAL ALL 24127.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  San Francisco
  TITLETWO  39.8 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  23234.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -200.66   -200.66    0.00
SO LOCATION 1P     AREA    0   -200.66    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    200.66  401.33   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    200.66  401.33   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -200.66  11  40.13  -200.66  11  40.13
RE GRIDCART  ONSITE END
RE INCLUDED  23234.REC
RE FINISHED

ME STARTING
ME INPUTFIL  23234H.MET
ME ANEMHGHT  10.1 METERS
ME SURFDATA  23234  1985
ME UAIRDATA  23230  1985
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 23234_1C.PLP
  PLOTFILE  ANNUAL 2 23234_1P.PLP
  PLOTFILE  ANNUAL ALL 23234.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Seattle
   TITLETWO  40.1 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  24233.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -201.42   -201.42    0.00
SO LOCATION 1P     AREA    0   -201.42    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3     0.0    201.42  402.84   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1       1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3     0.0    201.42  402.84   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1       1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -201.42  11  40.28  -201.42  11  40.28
RE GRIDCART  ONSITE END
RE INCLUDED  24233.REC
RE FINISHED

ME STARTING
ME INPUTFIL  24233H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  24233  1986
ME UAIRDATA  94240  1986
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 24233_1C.PLP
   PLOTFILE  ANNUAL 2 24233_1P.PLP
   PLOTFILE  ANNUAL ALL 24233.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Shreveport
  TITLETWO  110.9 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  13957.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -334.96   -334.96    0.00
SO LOCATION 1P     AREA    0   -334.96    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    334.96  669.92   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1      0.3     0.2
SO PARTDENS 1C      1        1        1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    334.96  669.92   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1      0.3     0.2
SO PARTDENS 1P      1        1        1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -334.96  11  66.99  -334.96  11  66.99
RE GRIDCART  ONSITE END
RE INCLUDED  13957.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13957H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  13957  1986
ME UAIRDATA  3951  1986
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 13957_1C.PLP
  PLOTFILE  ANNUAL 2 13957_1P.PLP
  PLOTFILE  ANNUAL ALL 13957.PLP
OU FINISHED
```

```
CO STARTING
   TITLEONE  Tampa
   TITLETWO  67 ACRES
   MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
   AVERTIME  ANNUAL
   SAVEFILE  12842.SAP
   POLLUTID  PART
   TERRHGTS  FLAT
   ERRORFIL  ERRORS.OUT
   RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -260.36   -260.36    0.00
SO LOCATION 1P     AREA    0   -260.36    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    260.36  520.71   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    260.36  520.71   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -260.36  11  52.07  -260.36  11  52.07
RE GRIDCART  ONSITE END
RE INCLUDED  12842.REC
RE FINISHED

ME STARTING
ME INPUTFIL  12842H.MET
ME ANEMHGHT  6.7 METERS
ME SURFDATA  12842  1986
ME UAIRDATA  12842  1986
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE FIRST
   MAXTABLE  ALLAVE  10
   PLOTFILE  ANNUAL 1 12842_1C.PLP
   PLOTFILE  ANNUAL 2 12842_1P.PLP
   PLOTFILE  ANNUAL ALL 12842.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Tulsa
  TITLETWO  184 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  13968.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -465.39   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    465.39  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    465.39  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -465.39  11  93.08  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  13968.REC
RE FINISHED

ME STARTING
ME INPUTFIL  13968H.MET
ME ANEMHGHT  7 METERS
ME SURFDATA  13968  1984
ME UAIRDATA  13967  1984
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 13968_1C.PLP
  PLOTFILE  ANNUAL 2 13968_1P.PLP
  PLOTFILE  ANNUAL ALL 13968.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Williamsport
  TITLETWO  127.1 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  14778.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -358.59   -358.59    0.00
SO LOCATION 1P     AREA    0   -358.59    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    358.59  717.19   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C      1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    358.59  717.19   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P      1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -358.59  11  71.72  -358.59  11  71.72
RE GRIDCART  ONSITE END
RE INCLUDED  14778.REC
RE FINISHED

ME STARTING
ME INPUTFIL  14778H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  14778  1979
ME UAIRDATA  94823  1979
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 14778_1C.PLP
  PLOTFILE  ANNUAL 2 14778_1P.PLP
  PLOTFILE  ANNUAL ALL 14778.PLP
OU FINISHED
```

```
CO STARTING
  TITLEONE  Winnemucca
  TITLETWO  162.3 ACRES
  MODELOPT  TOXICS RURAL CONC DDEP WDEP DRYDPLT WETDPLT
  AVERTIME  ANNUAL
  SAVEFILE  24128.SAP
  POLLUTID  PART
  TERRHGTS  FLAT
  ERRORFIL  ERRORS.OUT
  RUNORNOT  RUN
CO FINISHED

SO STARTING

SO LOCATION 1C     AREA    -410.5   -400    0.00
SO LOCATION 1P     AREA    0   -400    0.00

**          SRCID    QS       HS     XINIT   YINIT   ROTATE   SZINIT

SO SRCPARAM 1C    1.0E-3      0.0    410.5  800   0.0
SO PARTDIAM 1C    22.5     12.5     6.3     1.3
SO MASSFRAX 1C     0.4      0.1     0.3     0.2
SO PARTDENS 1C       1        1       1       1
SO PARTSLIQ 1C    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1C    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCPARAM 1P    1.0E-3      0.0    410.5  800   0.0
SO PARTDIAM 1P    22.5     12.5     6.3     1.3
SO MASSFRAX 1P     0.4      0.1     0.3     0.2
SO PARTDENS 1P       1        1       1       1
SO PARTSLIQ 1P    6.7E-4  6.7E-4  4.5E-4  6.0E-5
SO PARTSICE 1P    2.2E-4  2.2E-4  1.5E-4  2.0E-5

SO SRCGROUP 1 1C
SO SRCGROUP 2 1P
SO SRCGROUP ALL

SO FINISHED

RE STARTING
RE GRIDCART  ONSITE STA
RE GRIDCART  ONSITE XYINC   -410.5  11  82.1  -400  11  80
RE GRIDCART  ONSITE END
RE INCLUDED  24128.REC
RE FINISHED

ME STARTING
ME INPUTFIL  24128H.MET
ME ANEMHGHT  6.1 METERS
ME SURFDATA  24128  1984
ME UAIRDATA  24128  1984
ME FINISHED

OU STARTING
  RECTABLE  ALLAVE FIRST
  MAXTABLE  ALLAVE  10
  PLOTFILE  ANNUAL 1 24128_1C.PLP
  PLOTFILE  ANNUAL 2 24128_1P.PLP
  PLOTFILE  ANNUAL ALL 24128.PLP
OU FINISHED
```

Appendix J

Surface Water Model

Appendix J

Surface Water Model

The surface water model calculates chemical concentrations in surface water and sediment in the index reservoir and farm pond waterbodies modeled in this analysis. Sludge chemicals applied to an agricultural site move into the adjacent waterbody through direct runoff/erosion from the field and deposition from the atmosphere. The index reservoir also receives a chemical load from the upstream watershed, which has other sludge-applied fields contributing to runoff into the waterbody.

J1.0 Development of the Mathematical Model

J1.1 Assumptions

The Surface Water Model is based on the following assumptions:

- The system consists of two compartments: one well-mixed (continuously stirred tank reactor [CSTR]) water column compartment (compartment 1 in Figure J-1), and one well-mixed (CSTR) underlying sediment compartment (compartment 2 in Figure J-1).
- The single state variable is total chemical concentration (dissolved + sorbed).
- Chemical simulation is treated dynamically.
- Solids are assumed to be at instantaneous steady state.
- Loadings to the water column compartment are from
  - Inflows (dissolved in runoff and sorbed to eroded solids) from the upstream tributary watershed,
  - Inflows (dissolved and sorbed) from the adjacent agricultural site, and
  - Direct deposition of particles and vapors from the atmosphere.
- Kinetic processes simulated include
  - Linear sorption,
  - Overall first order losses, including biodegradation and volatilization,
  - Particulate settling and resuspension, and
  - Diffusive exchange between the water column and sediments.

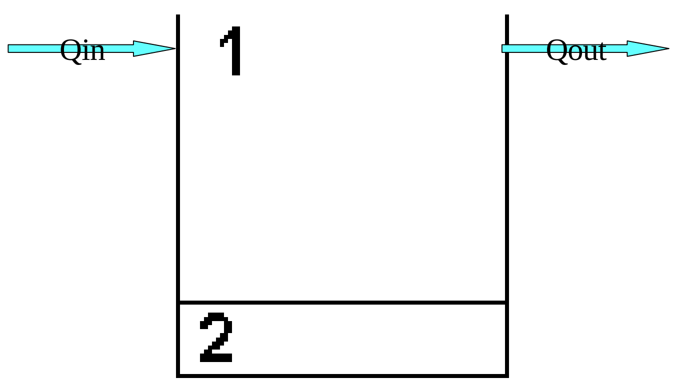

Figure J-1.

The following subsections give the chemical mass and solids balance equations for each of the two compartments. Note that generalized units are provided: M = mass, L = length, and T = time. Only parameters not previously defined are shown for each equation.

J1.2 Chemical Mass Balance in Water Compartment

A mass balance of chemical in the water column results in

$$V_1 \frac{dC_1}{dt} = Q_{inflow} C_{inflow} - Q_{outflow} C_1 - V_1 k_1 C_1 - A v_s C_1 F_{p1} + A v_r C_2 F_{p2} + v_d A \Phi_2 \left(\frac{F_{d2}}{\Phi_2} C_2 - \frac{F_{d1}}{\Phi_1} C_1 \right) + W_1 \qquad \text{(J-1)}$$

where

C_1	=	total (dissolved + sorbed) chemical concentration in compartment 1 (M/L^3)
C_2	=	total (dissolved + sorbed) chemical concentration in compartment 2 (M/L^3)
V_1	=	volume of compartment 1 (L^3)
Q_{inflow}	=	inflow rate (L^3/T)
C_{inflow}	=	chemical concentration in inflow (M/L^3)
$Q_{outflow}$	=	outflow rate (L^3/T)
k_1	=	overall first-order loss rate for compartment 1 (1/T)
A	=	interface area between compartments 1 and 2 (L^2)
v_s	=	suspended solids settling rate (L/T)
v_r	=	sediment solids resuspension rate (L/T)
v_d	=	diffusion rate (L/T)
F_{d1}	=	fraction dissolved in compartment 1 (unitless)
F_{p1}	=	fraction particulate in compartment 1 (unitless) = $(1 - F_{d1})$
Φ_1	=	porosity of the water column (unitless), which can assumed to be 1.0
Φ_2	=	porosity of the sediment (unitless)
W_1	=	total loading to compartment 1 (M/T).

The diffusive flux term in Equation J-1 deserves some explanation regarding the porosities. Recall that the concentration is a total concentration (sorbed plus dissolved) expressed as mass of chemical per *total* volume (solids plus water) in either the water column or sediments. Multiplication of the total concentration by Fd converts total concentration to dissolved concentration, but still based on total volume. Thus, the water column and sediment porosities are included in the denominators to express the dissolved concentration per volume of *water*, i.e. the actual pore water concentration. Regarding the sediment porosity in the vd A Φ_2 term, Φ_2 is there used to account for the fact that diffusion of dissolved chemical will only occur across the interstitial area, not the entire interface area.

J1.3 Chemical Mass Balance in Sediment Compartment

A mass balance of chemical in the sediment compartment is

$$V_2 \frac{dC_2}{dt} = Av_s C_1 F_{p1} - Av_r C_2 F_{p2} - Av_b C_2 F_{p2} + v_d A \Phi_2 \left(\frac{F_{d1}}{\Phi_1} C_1 - \frac{F_{d2}}{\Phi_2} C_2 \right) - V_2 k_2 C_2 \qquad \text{(J-2)}$$

where

V_2 = volume of compartment 2 (L^3)
k_2 = first-order decay rate for compartment 2 (1/T)
v_b = sediment solids burial rate (L/T)
v_d = diffusion rate (L/T)
F_{d2} = fraction dissolved in compartment 2 (unitless)
F_{p2} = fraction particulate in compartment 2 (unitless) = (1 - F_{d2}).

J1.4 Solids Balance in Water Compartment

A mass balance of solids in the water compartment is

$$V_1 \frac{dm_1}{dt} = Q_{inflow} m_{inflow} - Q_{outflow} m_1 - Av_s m_1 + Av_r m_2 \qquad \text{(J-3)}$$

where

m_1 = total suspended solids (TSS) concentration (M/L^3)
m_2 = solids concentration in sediment (bulk density) (M/L^3)
m_{inflow} = TSS in inflow (M/L^3).

J1.5 Solids Balance in Sediment Compartment

A mass balance of solids in the sediment compartment is

$$V_2 \frac{dm_2}{dt} = Av_s m_1 - Av_r m_2 - Av_b m_2 \qquad \text{(J-4)}$$

J2.0 Parameterization of and Solution to the Solids Model

J2.1 Overall Approach

Solids are assumed to be at steady state. For dynamic solutions, this assumption means that steady-state conditions are reached essentially instantaneously following some change in flows or input solids loadings. Equations J-3 and J-4 can then be expressed as

$$0 = Q_{inflow} m_{inflow} - Q_{outflow} m_1 - Av_s m_1 + Av_r m_2 \qquad \text{(J-5)}$$

$$0 = A v_s m_1 - A v_r m_2 - A v_b m_2 \qquad \text{(J-6)}$$

Equations J-5 and J-6 represent two algebraic equations with several unknowns. Assume that Q_{inflow} and $Q_{outflow}$ are known, the water column/bed sediment area is known, the influent TSS (m_{inflow}) is known, and the bulk density of the sediments (m_2) is known. This leaves m_1 and the three velocities (v_s, v_r, and v_b), or four unknowns with only two equations. The suspended solids settling rate, v_s, can either be calculated from Stokes' Law, given a particle size distribution, or be assigned values from empirical data. V_s is discussed in Section J2.2. The burial velocity, v_b, can be assigned values from the literature; however, to be protective (i.e., maximize sediment and water column concentrations) it is assumed to be zero. (Any chemical that is buried is unavailable for biological uptake and exposure.) Indeed, because burial velocities are typically extremely small (or waterbodies would fill up quickly with sediment), it seems reasonable to assume that v_b is zero. This leaves m_1 and the resuspension velocity, v_r, as the two unknowns, which can now be solved for by a simultaneous solution of Equations J-5 and J-6.

From Equation J-6, we can express m_1 as a function of v_r (assuming v_b is zero) as

$$m_1 = \frac{v_r}{v_s} m_2 \qquad \text{(J-7)}$$

Substituting Equation J-7 into Equation J-5, and solving for v_r results in

$$v_r = \frac{v_s \, Q_{inflow} \, m_{inflow}}{Q_{outflow} \, m_2} \qquad \text{(J-8)}$$

Thus, Equation J-8 is first used to calculate v_r, and then Equation J-7 is used to calculate m_1.

A consequence of the steady-state assumption for solids is that an inflow TSS concentration (m_{inflow}) of 0 will result in a water column TSS concentration (m_1) of 0. In reality, for a dynamic system, one would not expect the water column TSS concentration to be 0 simply because no solids entered the waterbody that day (i.e., on a day with no runoff or erosion of solids). Thus, to avoid the situation where zero-runoff days with no influent TSS would produce a TSS of 0 in the water column, we implemented an approximate method that "remembers" the last simulated TSS concentration in the water column on a day with TSS inflow, and decays that concentration in a first-order process during each subsequent day with no influent TSS. The first-order decay rate is based on the settling velocity. If, with this first-order decay, the water column TSS goes below 2 mg/L, it is reset to 2 mg/L, a concentration that we judge would be a near-minimum TSS concentration in a pond or index reservoir after an extended drought condition.

J2.2 Settling Velocity

Stokes' Law describes the unhindered settling of particles in water. "Unhindered" means that the solids themselves do not restrict settling, as they can in very concentrated solutions, such as sludge thickeners. Stokes' Law can be expressed as (Thomann and Mueller, 1987)

$$v_s = 0.033634\alpha(\rho_s - \rho_w)d^2 \qquad \text{(J-9)}$$

where

- v_s = settling velocity (m/day)
- α = a particle form factor (1.0 for a sphere)
- ρ_s = particle density (g/cm^3)
- ρ_w = density of water (g/cm^3) = 1.0
- d = particle diameter (µm).

Alternatively, v_s could be specified directly based on measured settling rates. From Chapra (1996), p. 302, Table 17.2, measured values for clay particles range from 0.3 - 1 m/day (diameters from 2 - 4 µm), and, for silt, 3 - 30 m/day (diameters varying from 10 - 20 µm). Because there are no data on particle form factor, density, or particle diameter such that Equation J-9 can be used to calculate v_s, a triangular distribution with a minimum of 0.3, a mode of 15, and a maximum of 30 is assumed. The range of the distribution is based on the minimum clay settling velocity and the maximum silt velocity as reported in Chapra (1996). The mode was selected as the midpoint of the range.

J2.3 Q_{inflow}, $Q_{outflow}$, and m_{inflow}

Flows and solids loads into the Index Reservoir Model and the Farm Pond Model are generated externally to these models and provided as time-varying, daily inputs. Both flows and loads are estimated by the land application unit (LAU) source model for inputs to the Farm Pond Model. For the Index Reservoir Model, the LAU source model will provide these inputs for the Adjacent LAU, and a scale-up of these data are performed to represent flows and solids loads from the upstream watershed.

For runoff flows and solids loads from the upstream watershed, an execution of the LAU source model under soil and vegetative characteristics representative of the upstream watershed conditions is first performed. These LAU runoff and eroded solids loads outputs are converted to a per unit area basis (i.e., runoff depth and eroded soil mass per square meter) by dividing by the LAU source area. Those unit outputs are then multiplied by the upstream watershed area to estimate surface runoff flows and eroded solids loads from the upstream watershed. Because soil erosion is affected by the area-specific sediment delivery ratio, the LAU's unitized eroded soil flux is also modified to account for the differences in sediment delivery ratios between the LAU area and the upstream watershed area. These runoff flows and solids loads are daily time series, and only occur on days with precipitation. Not all days with precipitation involve runoff and erosion.

In addition to daily inflows from stormwater runoff, the Index Reservoir and Farm Pond also include a "baseflow" component. Baseflow represents the component of streamflow that is not direct surface runoff. Baseflow was estimated as a function of regional watershed area and U.S. Geological Survey (USGS) Hydrological Unit Code (HUC) number using regional regression models. These regression models predict HUC-specific 30Q2 low flows as a function of watershed area. The 30Q2 flow is a statistical estimate of the 30-day average low flow expected to occur, on average, every other year (2-year return period). The 30Q2 low flow was assumed (for this analysis) to be a reasonable representation of stream baseflow.

In summary, daily time series inflows to the Index Reservoir Model consist of stormwater runoff and baseflow from the upstream watershed, and stormwater runoff and baseflow from the Adjacent LAU. Daily solids inflows consist of eroded soil from the upstream watershed (including a sediment delivery ratio adjustment) and eroded soil from the Adjacent LAU. For the Farm Pond, daily time series inflows consist of stormwater runoff and baseflow from the Adjacent LAU only. Daily solids inflows also consist of eroded soil from the Adjacent LAU only.

J3.0 Parameterization of the Chemical Model

J3.1 Fraction Dissolved and Particulate

It can be shown (Chapra, 1996) that the particulate fraction in the water column is given by

$$F_{p1} = \frac{\left(\frac{kd_1}{\Phi_1}\right)m_1}{1 + \left(\frac{kd_1}{\Phi_1}\right)m_1} \qquad \text{(J-10)}$$

where

kd_1 = chemical-specific water/solids partition coefficient (L^3/M) in the water compartment

Similarly, for the sediment compartment, the particulate fraction is given by

$$F_{p2} = \frac{\left(\frac{kd_2}{\Phi_2}\right)m_2}{1 + \left(\frac{kd_2}{\Phi_2}\right)m_2} \qquad \text{(J-11)}$$

where

kd_2 = chemical-specific water/solids partition coefficient (L^3/M) in the sediments

The dissolved fraction, F_d, is calculated from the particulate fraction for either compartment as

$$F_d = (1 - F_p) \qquad \text{(J-12)}$$

J3.2 Overall First-Order Loss Rate and Adjustment for Temperature Effects

For many of the chemicals to be simulated, kinetic data are available only to describe observed half-lives in various media or under various oxygen conditions. This amounts to observing losses from all mechanisms, not simply biochemical degradation. Using such a rate (after conversion from half-life to first-order rate) for decay only, and then including additional, process-specific loss terms, such as volatilization, hydrolysis, or photolysis losses, would be double counting the losses. Therefore, the "k" rates in the water column and sediments reflect overall first-order losses as given by the chemical half-life. Specifically, the water column k-rate is based on observed half-lives in water. The sediment k-rate is based on observed half-lives in an anaerobic environment. To account for temperature effects on this overall loss, it is assumed that the observed half-life-based rate constant is at 20°C. Temperature corrections to this overall loss rate (in the water column and sediments) are made using the following relationship (Chapra, 1996):

$$k = k_{20} * \theta^{T-20} \quad \text{(J-13)}$$

where

θ = temperature correction factor
T = ambient water temperature (°C).

Typical values for θ used in water quality modeling range from 1.024 for oxygen reaeration to 1.08 for sediment oxygen demand (Chapra, 1996). Ambient water temperature is assumed to vary monthly and is estimated by long-term monthly average air temperature. The waterbody is assumed to be at temperature equilibrium with ambient air on a monthly basis, and is also assumed to lag the monthly average air temperature by one month. For example, if the long-term average air temperature for May is 22°C, then it is assumed that the waterbody achieves that monthly average temperature in June.

J3.3 Diffusion Rate

The diffusion transfer velocity v_d between the sediments and water column can be estimated as the water diffusivity, corrected for tortuoisity[1], divided by a "characteristic mixing length". Using a Millington-Quirk (Millington and Quirk, 1961) porosity-based tortuoisity factor, v_d can be expressed as

$$v_d = \frac{D_w \Phi_2^{\frac{4}{3}}}{L_c} \quad \text{(J-14)}$$

where

[1]Tortuoisity refers to the path that a chemical molecule must follow as it diffuses through the interstitial pore spaces between solid particles.

D_w = chemical-specific water diffusivity (L^2/T)
L_c = characteristic mixing length (L), assumed to be 1 cm (DiToro et al., 1981).

J4.0 Loadings (Direct Inputs)

"Loadings" here refer to direct chemical mass inputs to the surface water compartment from (1) direct runoff/erosion from the Adjacent LAU and (2) deposited loads from the atmosphere directly onto the waterbody surface. At each daily time step, all direct loadings for that day are aggregated into the W_1 term in Equation J-1 (i.e., W_1^t where the t superscript denotes day t).

J4.1 Index Reservoir Model

For the Index Reservoir, mass loading inputs from the upstream watershed enter the model as boundary conditions. Thus, the W_1^t term includes runoff/erosion loads from the Adjacent LAU and direct deposition loads from the Adjacent LAU. It is assumed that atmospherically deposited loads from Upstream LAUs occur on the upstream watershed, and are accounted for through the boundary condition. Direct deposition from Upstream LAUs is not assumed to occur on the surface of the Index Reservoir.

J4.2 Farm Pond Model

For the Farm Pond, there is no "upstream watershed," only the Adjacent LAU. Runoff and erosion loads from this Adjacent LAU can be treated either as direct loadings (W_1^t term) or as boundary conditions. Either treatment would result in equivalent results. To be consistent with the Index Reservoir scenario, they are considered as direct loadings. Thus, the boundary condition is constant at zero. Direct deposition atmospheric loads result from the Adjacent LAU only.

J5.0 Estimation of Boundary Conditions

J5.1 Index Reservoir Model

The conceptual model for the Index Reservoir water quality model assumes that the Index Reservoir is located adjacent to one LAU to which biosolids are being applied, while several other LAUs that also involve biosolids application are located in the watershed upstream of the Index Reservoir. The Adjacent LAU is the LAU that is being explicitly modeled by the LAU Source Model. Runoff and erosion flow directly (via overland flow) from the Adjacent LAU into the Index Reservoir. The other LAUs (i.e., those upstream of, as opposed to adjacent to, the Index Reservoir) are called the "Upstream LAUs." Runoff and erosion from the Upstream LAUs do not flow directly into the Index Reservoir, but rather enter the waterbody network comprising the upsteam watershed, and are then transported by that network into the Index Reservoir, which sees these loadings as an upstream boundary condition. Those Upstream LAUs are not explicitly modeled by the LAU Source Model, nor is the upstream watershed's stream network. Thus, the issue here is how to quantify the Index Reservoir's upstream boundary condition to reflect loadings from those Upstream LAUs.

J5.1.1 Proposed Method

In reality, chemical loadings in runoff (dissolved) and eroded solids (sorbed) from an Upstream LAU would enter the upstream waterbody network, and incur some losses due to various fate processes (similar to those modeled in the Index Reservoir) during their transport downstream to the Index Reservoir. Because the upstream waterbody network is not modeled, those losses must be approximated. For sorbed chemical, it is conservatively assumed that the only transit losses incurred are due to sedimentation, either during overland flow or in-stream. The "sediment delivery ratio" is used to estimate these sedimentation losses. This assumption is risk-conservative because additional losses (e.g., decay, hydrolysis) are not considered. For dissolved chemical, the conservative assumption is made that no transit losses occur.

A sediment delivery ratio is the fraction of solids that are mobilized in a watershed due to erosion, yet are not delivered to the watershed outlet due to subsequent redeposition either on land surfaces or in stream channels after mobilization. The sediment delivery ratio is typically nonlinear, so that the ratio decreases at a diminishing rate with increasing watershed size (i.e., larger watersheds deliver less eroded solids to their outlets per unit watershed area than do smaller watersheds). The sediment delivery ratio is modeled as a power function, as follows:

$$Sd = aA_{ws}^{b} \qquad \text{(J-15)}$$

where

A_{ws} = watershed area (L^2)
a = delivery ratio for a unit area
b = negative fraction.

The methodology for estimating upstream boundary conditions due to the Upstream LAUs only (the effects due to atmospheric deposition onto the upstream watershed is considered subsequently) for the Index Reservoir Model is described below. Fundamentally, the methodology uses modeled time series results from the Adjacent LAU and scales them to the Upstream LAUs. It should be noted that this implicitly assumes that the Adjacent LAU and the Upstream LAUs are all on the same lifecycle (i.e., to the extent that chemicals tend to accumulate in soils over time, this same pattern of accumulation will occur contemporaneously for all LAUs). Although it could be argued that multiple LAUs might indeed have such correlations in operating practices (e.g., biosolids become available as fertilizer and many farmers opt to use them), assuming that all LAUs are on the same life cycle is clearly a conservative assumption.

The daily-varying upstream boundary condition due to the Upstream LAUs is given by

$$C0_{UpstreamLAU}^{t} = \frac{LOAD_{adjLAU}^{t} * A_{ws} * LAU_{frac} * (F_p * Sd + F_d)}{Q^{t}} \qquad \text{(J-16)}$$

where

$C0^t_{UpstreamLAU}$	=	upstream boundary condition (M/L^3)
$LOAD^t_{adjLAU}$	=	daily chemical load per unit area emanating from the Adjacent LAU due to runoff and erosion (M/L^2)
LAU_{frac}	=	fraction of A_{ws} that includes Upstream LAUs (unitless)
Fp	=	particulate fraction estimated for the Upstream LAUs' soils (unitless)
Fd	=	dissolved fraction estimated for the Upstream LAUs' soils (unitless)
Q^t	=	daily flow from upstream watershed (L^3/T).

A "t" superscript is used in this section to denote inputs that will be assumed to be time-varying (e.g., Q^t.) The daily chemical load per unit area, $LOAD^t_{adjLAU}$, comes from the modeled Adjacent LAU output time series, normalized to a unit area.

J5.1.2 Model Sensitivity of Index Reservoir Chemical Concentrations to Upstream LAUs

The Index Reservoir model's predicted chemical concentrations vary linearly and in direct proportion with changes in the upstream boundary condition due to Upstream LAUs, $C0^t_{UpstreamLAU}$ (i.e., if $C0^t_{UpstreamLAU}$ doubles, the chemical concentration time series will double). The sensitivity of $C0^t_{UpstreamLAU}$ to changes in LAU_{frac} can be inferred from Equations J-15 and J-16. For fixed values of A_{ws}, Sd, Q, and $LOAD^t_{adjLAU}$, the boundary condition, $C0^t_{UpstreamLAU}$, is linear and in varies in direct proportion to LAU_{frac}. Therefore, for a given upstream watershed area and $LOAD^t_{adjLAU}$, the Index Reservoir's water quality concentrations will vary in direct proportion to changes in LAU_{frac} (i.e., double LAU_{frac} and the Index Reservoir's time series water quality concentrations will double, all other factors remaining the same).

J5.1.3 Atmospheric Deposition

The Index Reservoir model's upstream boundary condition also considers chemical loads arriving at the Index Reservoir as a result of wind erosion and volatilization from the Upstream LAUs, subsequent atmospheric deposition onto the upstream watershed, and eventual transport of these deposited loads to the Index Reservoir as a result of stormwater runoff and solids erosion. It should be noted that this is a load that is in addition to the loadings considered above (the Upstream LAU loads from runoff and erosion). The loads considered above represent chemical mass remaining in Upstream LAU soils (and subsequently transported) after losses due to wind erosion and volatilization. The loadings considered here (the atmospheric deposition loads) represent those wind erosion and volatilization losses and subsequent deposition and transport. These loadings will be considered in an analogous manner to the Upstream LAU loads.

For a given day, and using a similar argument as above regarding losses of sorbed chemical versus no loss of dissolved chemical, the upstream boundary condition due to atmospheric deposition in the upstream watershed is given by

$$C0^t_{AtmDep} = \frac{LOAD^t_{ws} * A_{ws} * (F_p * Sd + F_d)}{Q^t} \qquad \text{(J-17)}$$

where

$C0^t_{AtmDep}$ = upstream boundary condition due to atmospheric deposition in the upstream watershed (M/L^3)

$LOAD^t_{ws}$ = daily total (dissolved + sorbed) chemical load per unit area emanating from the upstream watershed due to runoff and erosion of deposited chemical (M/L^2).

$LOAD^t_{ws}$ is estimated by assuming that erosion carries with it the sorbed fraction and runoff carries with it the dissolved fraction.

The daily boundary condition, $C0^t$ (M/L^3) reflecting both atmospheric deposition over the entire upstream watershed and runoff/erosion/transport from the Upstream LAUs is then given by summing $C0^t_{UpstreamLAU}$ and $C0^t_{AtmDep}$, as follows:

$$C0^t = \frac{(LOAD^t_{adjLAU} * A_{ws} * LAU_{frac} + LOAD^t_{ws} * A_{ws})\ (F_p * Sd + F_d)}{Q^t} \tag{J-18}$$

J5.2 Farm Pond Model

The only inputs to the Farm Pond result from the Adjacent LAU (i.e., no "upstream watershed" is assumed other than the Adjacent LAU itself). As discussed in Section J4.2, those inputs are treated as direct loadings to the Farm Pond surface water compartment, and not as boundary conditions. (Either treatment would give equivalent results.) Thus, the boundary condition for the Farm Pond Model is a time-constant value of zero.

J6.0 References

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Appendix K

Fate, Transport, Exposure, and Hazardous Calculations for Human Health and Ecological Effects

Appendix K

Fate, Transport, Exposure, and Hazard Calculations for Human Health and Ecological Effects

This appendix presents the equations and references for the parameters used in calculating fate, transport, and hazard for the pollutants considered in the sewage sludge screening analysis. This appendix documents the various equations implemented the model using Visual Basic code and Access databases for input and output storage.

Table K-0 lists the equations presented in Tables K1-1 though K10-2. The tables are numbered and ordered by the type of calculation made, as follows:

- **Calculation of Ambient Air Concentrations and Deposition Rates.** Tables K1-1 through K2-5 show the equations used to calculate ambient air concentrations and deposition rates by adjusting the normalized values calculated by the air model with chemical-specific vapor and particulate air emission rates from the source model.

- **Calculation of Soil Concentrations.** Tables K3-1 through K3-13 present the equations used to estimate soil concentrations from source model outputs (i.e., land application and overland transport) and air deposition rates.

- **Calculation of Concentrations in Well Water.** Table K4-1 shows the equation used to calculate the well water concentration.

- **Calculation of Concentration in Vegetation and Animal Products.** Tables K5-1 through K6-3 document the farm food chain equations used to calculate contaminant concentrations in farm produce and vegetation consumed by ecological receptors, as well as concentrations in meat, fish, and dairy products.

- **Calculation of Shower Air Concentration.** Tables K7-1 through K7-10 show the equations used to calculate concentrations in shower air from the volatilization of contaminated groundwater.

- **Calculation of Human Exposure (Daily Dose).** Tables K8-1 through K8-6 show the equation used to calculate the average daily contaminant dose to humans resulting from the ingestion of contaminated soil, produce, meat, milk, and fish.

- **Calculation of Ecological Exposure.** Tables K9-1 through K9-5 present the equations used to calculate ecological exposure through direct contact with contaminated media (soil, sediment, or surface water) and consumption of contaminated plants and prey by ecological receptors.

- **Calculation of Ecological Risk.** Tables K10-1 and K10-2 provide the equations used to calculate the ecological risks (hazard quotients) to organisms living in soil and sediment, as well as to aquatic receptors.

Table K-0. Organization of Tables Documenting Fate, Transport, Exposure, and Hazard Calculations

Table Number	Description
Calculation of Ambient Air Concentrations and Deposition Rates	
K1-1	Total Concentration in Air
K1-2	Vapor Phase Air Concentration
K2-1	Deposition Term for Soil
K2-2	Deposition Term for Impervious Surfaces
K2-3	Deposition Term for Water
K2-4	Particulate Deposition Term for Plants
K2-5	Vapor Phase Deposition Term for Plants
Calculation of Soil Concentrations	
K3-1	Time Average Soil Concentration, Where T1 and T2 <= Td
K3-2	Time Average Soil Concentration, Where T2 and T1 >= Td
K3-3	Instantaneous Soil Concentration at Time, T
K3-4	Loading Term to Soil from Deposition
K3-5	Overall Dissipation Rate Constant in Soil
K3-6	Loss Constant Due to Erosion
K3-7	Loss Constant due to Runoff
K3-8	Loss Constant Due to Leaching
K3-9	Soil-Water Partition Coefficient for Bed Sediment
K3-10	Soil-Water Partition Coefficient
K3-11	Sediment Delivery Ratio
K3-12	Universal Soil Loss Equation
K3-13	Soil Volumetric Water Content
Calculation of Well Water Concentration	
K4-1	Concentration in well water
Calculation of Concentration in Vegetation and Animal Products	
K5-1	Concentration in Aboveground Vegetation Due to Deposition, Transfer, and Uptake
K5-2	Aboveground Vegetative Concentration Due to Air-to-Plant Transfer
K5-3	Aboveground Vegetation Concentration Due to Root Uptake
K5-4	Vegetative Concentration Due to Particle Deposition
K5-5	Concentration in Belowground Vegetation Due to Root Uptake

(continued)

Table K-0. (continued)

Table Number	Description
K5-6	Concentration in Fish at Different Trophic Levels
K6-1	Concentration in animal products
K6-2	Weighted concentration in vegetation proportional to an animal's total diet
K6-3	Weighted concentration in soil proportional to an animal's total diet
Calculation of Shower Air Concentration	
K7-1	Average Daily Concentration in Indoor Air
K7-2	Vapor-Phase Constituent Concentration in the Bathroom at End of Time Step
K7-3	Vapor-Phase Constituent Concentration in the Shower at End of Time Step
K7-4	Fraction of Vapor-Phase Saturation in Shower
K7-5	Fraction of Constituent Emitted from a Droplet
K7-6	Contaminant Mass Emitted in the Shower for a Given Time Step
K7-7	Overall Mass Transfer Coefficient
K7-8	Dimensionless Overall Mass Transfer Coefficient
K7-9	Dimensionless Henry's Law Constant
K7-10	Total Time Spent in Shower Stall
Calculation of Human Exposure (Daily Dose)	
K8-1	Average Daily Dose from Total Ingestion
K8-2	Average Daily Dose from Ingestion of Animal Tissue
K8-3	Average Daily Dose from Consumption of Produce
K8-4	Average Daily Dose from Ingestion of Soil
K8-5	Daily Intake of Contaminant from Drinking Water
K8-6	Lifetime Average Daily Dose
Calculation of Ecological Exposure	
K9-1	Total Exposure Dose from Ingestion
K9-2	Dose from Ingestion of Plants and Prey
K9-3	Concentration in Diet Items
K9-4	Dose from Incidental Ingestion of Soil or Sediment
K9-5	Dose from Ingestion of Surface Water
Calculation of Ecological Risk	
K10-1	Hazard Quotient for Soil and Sediment Invertebrates
K10-2	Hazard Quotient for Surface Water Receptors

Table K1-1. Total Concentration in Air (mg/m^3)

C_{air}

$$C_{air} = Q \times \left[F_v \times C_{yv} + (1 - F_v) \times C_{yp} \right] \times 0.001$$

Name	Description	Value
Q	Emission rate from source (g/s-m^2)	Calculated from source model output
F_v	Fraction of air concentration in vapor phase (unitless)	Calculated from source model output
C_{yp}	Normalized particulate air concentration (ug-s-m^2/g-m^3)	Calculated from dispersion modeling
C_{yv}	Normalized vapor-phase air concentration (ug-s-m^2/g-m^3)	Calculated from dispersion modeling
0.001	Conversion factor (mg/ug)	

Source: U.S. EPA, 1998a.

Table K1-2. Vapor Phase Air Concentration (mg/m^3)

C_{vapor}

$$C_{vapor} = Q \times F_v \times C_{yv} \times 0.001$$

Name	Description	Value
Q	Emission rate from source (g/s-m^2)	Calculated from source model output
F_v	Fraction of air concentration in vapor phase (unitless)	Calculated from source model output
C_{yv}	Normalized vapor-phase air concentration (ug-s-m^2/g-m^3)	Calculated from dispersion modeling
0.001	Conversion factor (mg/ug)	

Source: U.S. EPA, 1998a.

Table K2-1. Deposition Term for Soil (g/m^2-yr)

D_s

$$D_s = Q \times \left[F_v \times \left(D_{ydv} + D_{ywv} \right) + \left(1 - F_v \right) \times \left(D_{ydp} + D_{ywp} \right) \right]$$

$$D_{ydv} = 0.31536 \times V_{dv} \times C_{yv}$$

Name	**Description**	**Value**
D_{ydv}	Normalized annual dry deposition from vapor phase (s-m^2/m^2-yr)	Calculated above
Q	Emission rate from source (g/s-m^2)	Calculated from source model output
F_v	Fraction of air concentration in vapor phase (unitless)	Calculated from source model output
D_{ywv}	Normalized annual average wet deposition from vapor phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
C_{yv}	Normalized vapor-phase air concentration (ug-s-m^2/g-m^3)	Calculated from dispersion modeling
D_{ydp}	Normalized annual average dry deposition from particle phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
D_{ywp}	Normalized annual average wet deposition from particle phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
V_{dv}	Dry deposition velocity of vapors (cm/s)	Chemical data; see Appendix E
0.31536	Unit conversion factor (m-g-s/cm-ug-yr)	

Adapted from U.S. EPA, 1998b.

Table K2-2. Deposition Term for Impervious Surfaces (g/m^2-yr)

D_i

$$D_i = Q \times \left[F_v \times \left(D_{ydv} + D_{ywv} \right) + \left(1 - F_v \right) \times \left(D_{ydp} + D_{ywp} \right) \right]$$

$$D_{ydv} = 0.31536 \times V_{dv} \times C_{yv}$$

Name	Description	Value
D_{ydv}	Normalized annual dry deposition from vapor phase (s-m^2/m^2-yr)	Calculated above
Q	Emission rate from source (g/s-m^2)	Calculated from source model output
F_v	Fraction of air concentration in vapor phase (unitless)	Calculated from source model output
C_{yv}	Normalized vapor-phase air concentration (ug-s-m^2/g-m^3)	Calculated from dispersion modeling
D_{ydp}	Normalized annual average dry deposition from particle phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
D_{ywp}	Normalized annual average wet deposition from particle phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
D_{ywv}	Normalized annual average wet deposition from vapor phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
V_{dv}	Dry deposition velocity of vapors (cm/s)	Chemical data; see Appendix E
0.31536	Unit conversion factor (m-g-s/cm-ug-yr)	

Source: U.S. EPA, 1998a.

Table K2-3. Deposition Term for Water (g/m^2-yr)

D_w

$$D_w = Q \times \left[F_v \times D_{ywv} + (1 - F_v) \times \left(D_{ydp} + D_{ywp} \right) \right]$$

Name	Description	Value
F_v	Fraction of air concentration in vapor phase (unitless)	Calculated from source model output
Q	Emission rate from source (g/s-m^2)	Calculated from source model output
D_{ydp}	Normalized annual average dry deposition from particle phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
D_{ywp}	Normalized annual average wet deposition from particle phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
D_{ywv}	Normalized annual average wet deposition from vapor phase (s-m^2/m^2-yr)	Calculated from dispersion modeling

Source: U.S. EPA, 1998a.

Table K2-4. Particulate Deposition Term for Plants (mg/m^2-yr)

D_p

$$D_p = (1000 \times Q) \times (1 - F_v) \times \left(D_{ydp} + \left(F_w \times D_{ywp}\right)\right)$$

Name	Description	Value
Q	Emission rate from source (g/s-m^2)	Calculated from source model output
F_v	Fraction of air concentration in vapor phase (unitless)	Calculated from source model output
D_{ywp}	Normalized annual average wet deposition from particle phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
D_{ydp}	Normalized annual average dry deposition from particle phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
F_w	Fraction of wet deposition adhering to plant surface (unitless)	Chemical data; see Appendix E
1000	Conversion factor (mg/g)	

Source: U.S. EPA, 1998a.

Table K2-5. Vapor Phase Deposition Term for Plants (mg/m^2-yr)

D_v

$$D_v = 1000 \times Q \times F_v \times \left[D_{ydv} + \left(F_w \times D_{ywv}\right)\right]$$

$$D_{ydv} = 0.31536 \times V_{dv} \times C_{yv}$$

Name	**Description**	**Value**
D_{ydv}	Normalized annual dry deposition from vapor phase (s-m^2/m^2-yr)	Calculated above
F_v	Fraction of air concentration in vapor phase (unitless)	Calculated from source model output
Q	Emission rate from source (g/s-m^2)	Calculated from source model output
D_{yw}	Normalized annual average wet deposition from vapor phase (s-m^2/m^2-yr)	Calculated from dispersion modeling
C_{yv}	Normalized vapor-phase air concentration (ug-s-m^2/g-m^3)	Calculated from dispersion modeling
V_{dv}	Dry deposition velocity of vapors (cm/s)	Chemical data; see Appendix E
F_w	Fraction of wet deposition adhering to plant surface (unitless)	Chemical data; see Appendix E
0.31536	Unit conversion factor (m-g-s/cm-ug-yr)	
1000	Conversion factor (mg/g)	

Source: U.S. EPA, 1998a.

Table K3-1. Time Average Soil Concentration, Where T1 and T2 <= Td (mg/kg)

$C_{soilAvg1}$

$$C_{soilAvg1} = \frac{L_{soil}}{k_s \times (T_2 - T_1)} \times \left[\left(T_2 + \frac{e^{(-k_s \times T_2)}}{k_s} \right) - \left(T_1 + \frac{e^{(-k_s \times T_1)}}{k_s} \right) \right]$$

Name	Description	Value
L_{soil}	Loading to soil due to deposition (mg/kg-yr)	Calculated; see Table K3-4
k_s	Soil loss constant (1/yr)	Calculated; see Table K3-5
T_2	The time at which exposure ends (yr)	Equal to T1 plus the exposure duration
T_1	The time at which exposure begins (yr)	Source data; see Appendix H
T_d	The length of time the unit is operational (yr)	Source data; see Appendix H

Table K3-2. Time Average Soil Concentration, Where T2 and T1 >= Td (mg/kg)

$C_{soilAvg2}$

$$C_{soilAvg\,2} = \frac{C_{soilInstT\,1}}{k_s \times (T_2 - T_1)} \times \left[1 - e^{\,k_s \times (T_2 - T_1)}\right]$$

Name	Description	Value
$C_{soilInstT1}$	Instantaneous soil concentration at T1 (mg/kg)	Calculated ; see Table K3-3
k_s	Soil loss constant (1/yr)	Calculated; see Table K3-5
T_2	The time at which exposure ends (yr)	Equal to T1 plus the exposure duration
T_1	The time at which exposure begins (yr)	Source data; see Appendix H
T_d	The length of time the unit is operational (yr)	Source data; see Appendix H

Table K3-3. Instantaneous Soil Concentration at Time, T (mg/kg)

$C_{soilInst}$

When $T > T_d$,

$$C_{soilInst} = L_{soil} \times \frac{\left[1 - e^{-k_s \times T_d}\right]}{k_s} \times e^{(-k_s \times (T - T_d))}$$

When $T <= T_d$,

$$C_{soilInst} = L_{soil} \times \frac{\left[1 - e^{-k_s \times T}\right]}{k_s}$$

Name	**Description**	**Value**
k_s	Soil loss constant (1/yr)	Calculated; see Table K3-5
L_{soil}	Loading to soil due to deposition (mg/kg-yr)	Calculated; see Table K3-4
T_d	The length of time the unit is operational (yr)	Source data; see Appendix H
T	Instantaeous time (yr)	Source data; see Appendix H

Table K3-4. Loading term to soil from deposition (mg/kg/yr)

L_{soil}

$$L_{soil} = \frac{D_s}{Z \times BD} \times 1000000 \times 0.0001$$

Name	Description	Value
D_s	Deposition Term for Soil (g/m^2-yr)	Calculated; see Table K2-1
BD	Soil bulk density (g/cm^3 or kg/L)	Site data; see Appendix H
Z	Mixing depth of the soil (cm)	Site data; see Appendix H
1000000	Conversion factor (mg/kg)	
0.0001	Conversion factor (m^2/cm^2)	

Adapted from U.S. EPA, 1998a.

Table K3-5. Overall Dissipation Rate Constant in Soil (1/yr)

$\boldsymbol{k_s}$

$$k_s = (k_{sl} + k_{se} + k_{sr} + k_{sg} + k_{sv} + k_{sh}) \times 365$$

Name	**Description**	**Value**
k_{sr}	Loss Constant due to Runoff (1/d)	Calculated; see Table K3-7
k_{se}	Loss Constant due to Erosion (1/d)	Calculated; see Table K3-6
k_{sl}	Loss Constant due to Leaching (1/d)	Calculated; see Table K3-8
k_{sh}	Hydrolysis rate (1/d)	Chemical data; see Appendix E
k_{sg}	Soil degradation rate (1/d)	Chemical data; see Appendix E
k_{sv}	Loss Constant due to Volatilization (1/d)	Set to zero for deposited chemicals to conserve mass
365	Conversion factor (days/yr)	

Source: U.S. EPA, 1998a.

Table K3-6. Loss Constant Due to Erosion (1/d)

k_{se}

$$k_{se} = \frac{0.1 \times X_e \times SD \times ER}{BD \times Z} \times \frac{K_{dsoil} \times BD}{\theta + (K_{dsoil} \times BD)}$$

Name	Description	Value
θ	Soil Volumetric Water Content (ml/cm^3 or cm^3/cm^3)	Calculated; see Table K3-13
K_{dsoil}	Soil-water partition coefficient (L/kg)	Calculated; see Table K3-10
SD	Sediment delivery ratio (unitless)	Calculated; see Table K3-11
X_e	Universal Soil Loss Equation (kg/m^2-d)	Calculated; see Table K3-12
ER	Soil enrichment ratio (unitless)	Site data; see Appendix H
Z	Mixing depth of the soil (cm)	Site data; see Appendix H
BD	Soil bulk density (g/cm^3 or kg/L)	Site data; see Appendix H
0.1	Conversion factor (g-m^2)/(kg-cm^2)	

Source: U.S. EPA, 1998b.

Table K3-7. Loss Constant due to Runoff (1/d)

k_{sr}

$$k_{sr} = \frac{R_f}{\theta \times Z} \times \frac{1}{1 + BD \times \frac{K_{dsoil}}{\theta}}$$

Name	Description	Value
K_{dsoil}	Soil-water partition coefficient (L/kg)	Calculated; see Table K3-10
θ	Soil Volumetric Water Content (ml/cm^3 or cm^3/cm^3)	Calculated; see Table K3-13
R_f	Average daily runoff (cm/day)	Site data; see Appendix H
Z	Mixing depth of the soil (cm)	Site data; see Appendix H
BD	Soil bulk density (g/cm^3 or kg/L)	Site data; see Appendix H

Source: U.S. EPA, 1998a.

Table K3-8. Loss Constant Due to Leaching (1/d)

k_{sl}		

$$k_{sl} = \frac{Rech}{\theta \times Z \times \left[1 + \left(BD \times \frac{K_{dsoil}}{\theta}\right)\right]}$$

Name	Description	Value
θ	Soil Volumetric Water Content (ml/cm^3 or cm^3/cm^3)	Calculated; see Table K3-13
K_{dsoil}	Soil-water partition coefficient (L/kg)	Calculated; see Table K3-10
Rech	Average daily recharge rate (cm/day)	Calculated from source model outputs
BD	Soil bulk density (g/cm^3 or kg/L)	Site data; see Appendix H
Z	Mixing depth of the soil (cm)	Site data; see Appendix H

Adapted from U.S. EPA, 1998a.

Table K3-9. Soil-Water Partition Coefficient for Bed Sediment (ml/g)

K_{dbs}

$$K_{dbs} = K_{oc} \times f_{ocbs}$$

Name	**Description**	**Value**
f_{ocbs}	Fraction of organic carbon in bottom sediment (unitless)	Site data; see Appendix H
K_{oc}	Organic carbon partition coefficient (mL/g)	Chemical data; see Appendix E

Source: U.S. EPA, 1998a.

Table K3-10. Soil-Water Partition Coefficient (mL/g)

K_{dsoil}

$$K_{dsoil} = K_{oc} \times f_{ocsoil}$$

Name	Description	Value
f_{ocsoil}	Fraction organic carbon in soil (unitless)	Site data; see Appendix H
K_{oc}	Organic carbon partition coefficient (mL/g)	Chemical data; see Appendix E

Source: U.S. EPA, 1998a.

Table K3-11. Sediment Delivery Ratio (unitless)

SD

$$SD = A \times Area^{-B}$$

$$AreaSM = \frac{Area}{2590000}$$

Name	**Description**	**Value**
AreaSM	Area receiving pollutant deposition (mile^2)	Calculated above
Area	Surface area (m^2)	Waterbody model; see Appendix J
A	Empirical intercept coefficient related to the size of the area (unitless)	A = 2.1 for AreaSM <= 0.1 sq mi A = 1.9 for 0.1< AreaSM < 1 sq mi A = 1.4 for 1< AreaSM < 10 sq mi A = 1.2 for 10< AreaSM < 100 sq mi A = 0.6 for all other cases
B	Empirical slope coefficient related to the power of the drainage area (unitless)	B=0.125
2590000	Conversion factor (m^2/sq miles)	

Source: U.S. EPA, 1998a.

Table K3-12. Universal Soil Loss Equation (kg/m^2-d)

X_e

$$X_e = \frac{R \times K \times LS \times C \times P}{365}$$

Name	Description	Value
R	USLE rainfall/erosivity factor (1/yr)	Site data; see Appendix H
P	USLE supporting practice factor (unitless)	Site data; see Appendix H
LS	USLE length-slope factor (unitless)	Site data; see Appendix H
K	USLE soil erodibility factor (kg/m^2)	Site data; see Appendix H
C	USLE cover management factor (unitless)	Site data; see Appendix H
365	Conversion factor (days/yr)	

Source: U.S. EPA, 1998a.

Table K3-13. Soil Volumetric Water Content (ml/cm^3 or cm^3/cm^3)

$$\theta$$

$$\theta = WCS \times \left(\frac{Rech \times 365}{K_s} \right)^{(1/(2 \times smb + 3))}$$

Name	Description	Value
Rech	Average daily recharge rate (cm/day)	Calculated from source model outputs
smb	Soil specific exponent rep water retention (unitless)	Site data; see Appendix H
WCS	Saturated volumetric water content or porosity (cm^3/cm^3)	Site data; see Appendix H
K_{sat}	Saturated hydraulic conductivity (cm/yr)	Site data; see Appendix H
365	Conversion factor (days/yr)	

Source: U.S. EPA, 1998a.

Table K4-1. Concentration in Well Water (mg/L)

C_{well}

$$C_{well} = \frac{LeachConc}{DAF}$$

Name	Description	Value
DAF	Dilution attenuation factor (unitless)	Calculated from groundwater model output
LeachConc	Concentration in leachate (mg/L)	Calculated from source model output

This equation is used to calculate the well concentrion using a groundwater dilution attenuation factor (DAF).

Table K5-1. Concentration in Aboveground Vegetation Due to Depostion, Transfer, and Uptake (mg/kg - WW)

P_{ag}

$$P_{ag} = (P_d + P_v + P_r) \times \frac{100 - MAF}{100}$$

Name	Description	Value
P_r	Aboveground vegetation concentration due to root uptake (mg/kg DW)	Calculated; see Table K5-3
P_v	Vegetative concentration due to air-to-plant transfer (mg/kg DW)	Calculated; see Table K5-2
P_d	Vegetative concentration due to particulate deposition (mg/kg DW)	Calculated; see Table K5-4
MAF	Plant tissue-specific moisture adjustment factor to convert DW concentration into WW (percent)	Biota data; see Appendix F
100	Conversion factor to percent (unitless)	

Source: U.S. EPA, 1998a.
Considered exposed and protected fruits and vegetables.

Table K5-2. Aboveground Vegetative Concentration Due to Air-to-Plant Transfer (mg/kg - DW)

P_v

For Log K_{ow} >=5,

$$P_v = \frac{C_{vapor} \times B_v \times VG_{ag} \times 1000}{1200}$$

For Log K_{ow} <5,

$$P_v = \frac{D_v \times R_p \times \left(1 - e^{\left(-K_{pVap} \times Tp\right)}\right)}{Y_p \times K_{pVap}}$$

Name	Description	Value
C_{vapor}	Vapor-phase air concentration (mg/m^3)	Calculated; see Table K1-2
D_v	Deposition term for plants (for vapor) (mg/m^2-yr)	Calculated; see Table K2-5
K_{pVap}	Plant surface loss coefficient, vapor (1/yr)	Chemical data; see Appendix E
T_p	Length of plant exposure to deposition (yr)	Biota data; see Appendix F
Y_p	Crop yield (kg DW/m^2)	Biota data; see Appendix F
R_p	Interception fraction (unitless)	Biota data; see Appendix F
B_v	Air-to-plant biotransfer factor (ug/g DW plant / ug/g air)	Chemical data; see Appendix E
VG_{ag}	Empirical correction factor for above ground vegetables (unitless)	Biota data; see Appendix F
1200	The density of air (g/m^3)	
1000	Conversion factor (g/kg)	

Source: U.S. EPA, 1998a.

Table K5-3. Aboveground Vegetation Concentration Due to Root Uptake (mg/kg - DW)

P_r
$$P_r = C_{soil} \times B_r$$

Name	Description	Value
C_{soil}	Concentration of contaminant in soil (mg/kg)	Calculated based on erosion, runoff, and deposition from LAU.
B_r	Soil-to-plant bioconcentration factor (mg/kg DW plant / mg/kg soil)	Biota data; see Appendix F

Source: U.S. EPA, 1998a.

Table K5-4. Vegetative Concentration Due to Particle Deposition (mg/kg - DW)

P_d

$$P_d = \frac{D_p \times R_p}{Y_p \times K_{pPar}}$$

Name	Description	Value
D_p	Particle deposition term for plants (mg/m^2-yr)	Biota data; see Appendix F
R_p	Interception fraction (unitless)	Biota data; see Appendix F
Y_p	Crop yield (kg DW/m^2)	Biota data; see Appendix F
K_{pPar}	Plant surface loss coefficient, particulate (1/yr)	Chemical data; see Appendix E

Source: U.S. EPA, 2000.

Table K5-5. Concentration in Belowground Vegetation Due to Root Uptake (mg/kg - WW)

P_{bg}

For organics:

$$P_{bg} = \frac{C_{soil} \times RCF \times VG_{bg}}{K_{dsoil}}$$

For metals:

$$P_{bg} = C_{soil} \times Br_{root} \times DW_r$$

$$DW_r = \frac{100 - MAF_{bg}}{100}$$

Name	Description	Value
DW_r	Dry weight fraction for root vegetables (unitless)	Calculated above
K_{dsoil}	Soil-water partition coefficient (L/kg)	Calculated; see Table K3-10
C_{soil}	Concentration of contaminant in soil (mg/kg)	Calculated based on erosion, runoff, and deposition from LAU.
MAF_{bg}	Moisture percentage for root vagetables (percent)	Biota data; see Appendix F
RCF	Root concentration factor (mg/kg WW) / (mg/L soil water)	Chemical data; see Appendix E
Br_{root}	Soil-to-plant bioconcentration factor for roots (mg/kg DW plant / mg/kg soil)	Chemical data; see Appendix E
VG_{bg}	Empirical correction factor for below ground vegetables (unitless)	Biota data; see Appendix F

Source: U.S. EPA, 1998a.

Table K5-6. Concentration in Fish at Different Trophic Levels (mg/kg)

C_{fish}

$$C_{fish} = C_{wt} \times BCF$$

Name	Description	Value
C_{wt}	Concentration in water (total) (mg/L)	Waterbody model; see Appendix J
BCF_{T3F}	Bioconcentration factor for trophic level 3, fish filet (L/kg)	Chemical data; see Appendix E
BCF_{T3W}	Bioconcentration factor for trophic level 3, fish whole (L/kg)	Chemical data; see Appendix E
BCF_{T4F}	Bioconcentration factor for trophic level 4, fish filet (L/kg)	Chemical data; see Appendix E
BCF_{T4W}	Bioconcentration factor for trophic level 4, fish whole (L/kg)	Chemical data; see Appendix E

Source: U.S. EPA, 1998a.

Table K6-1. Concentration in animal products (mg/kg -WW)

A

For cattle:

$$A = BCF \times FF \times \left(AP_{total} + AC_{soil}\right)$$

For all other animal products:

$$A = BCF \times \left(AP_{total} + AC_{soil}\right)$$

Name	**Description**	**Value**
AC_{soil}	Weighted concentration in soil proportional to total diet of an animal (mg/kg)	Calculated; see Table K6-3
AP_{total}	Summed weighted concentration of all vegetation types in animal diet (mg/kg)	Calculated; see Table K7-2
FF*	Feedlot factor for beef fat calculation (<=1 for beef fat and =1 for milk fat) (unitless)	Biota data; see Appendix F
BCF	Concentration ratio of contaminant as determined from vegetative intake (unitless)	Chemical data; see Appendix E

Based on U.S. EPA, 2000.
* Feedlot factor represents the fraction of cattle lifetime spent in a feedlot.

Table K6-2. Weighted concentration in vegetation proportional to an animal's total diet (mg/kg DW)

AP

$$AP = DF \times P_{DW}$$

$$P_{DW} = \frac{P_{ag}}{\left(\frac{100 - MAF}{100}\right)}$$

Name	Description	Value
P_{DW}	Concentration of contaminant in vegetation as dry weight (mg/kg DW)	Calculated above
P_i	Concentration in vegetation as wet weight (mg/kg WW)	Calculated; see Table K5-1
MAF	Plant tissue-specific moisture adjustment factor to convert DW concentration into WW (percent)	Biota data; see Appendix F
DF	Vegetative Fraction in animal's diet (unitless)	Eco Exposure data; see Appendix N

Source: U.S. EPA, 1998a.

Table K6-3. Weighted concentration in soil proportional to an animal's total diet (mg/kg)

AC_{soil}

$$AC_{soil} = DF_{soil} \times B_s \times C_{soil}$$

Name	Description	Value
C_{soil}	Concentration of contaminant in soil (mg/kg)	Calculated based on erosion, runoff, and deposition from LAU.
DF_{soil}	Fraction of animal diet that is soil (unitless)	Eco Exposure data; see Appendix N
B_s	Bioavailability of contaminant on the soil vehicle relative to the vegetative vehicle (unitless)	Chemical data; see Appendix E

Source: U.S. EPA, 2000.

Table K7-1. Average Daily Concentration in Indoor Air (mg/m^3)

$C_{airindoor}$

$$C_{airIndoor} = \frac{(C_{airShower} \times T_{Shower}) + (C_{airBathroom} \times T_{bathroom})}{1440}$$

$$C_{airShower} = \frac{\sum [(y_{s,\,t+ts} + y_{s,\,t})/2] \times 1000}{n_s}$$

$$C_{airBathroom} = \frac{\sum [(y_{b,\,t+ts} + y_{b,\,t})/2] \times 1000}{n_b}$$

Name	Description	Value
$C_{airShower}$	Average concentration in shower (mg/m^3)	Calculated above
$C_{airBathroom}$	Average concentration in bathroom (mg/m^3)	Calculated above
$y_{b,\,t+ts}$	Vapor-phase constituent concentration in the bathroom at the end of time step (mg/L)	Calculated; see Table K7-2
T_{shower}	Total time spent in shower stall (min)	Calculated; see Table K7-10
$y_{s,\,t+ts}$	Vapor-phase constituent concentration in the shower at the end of time step (mg/L)	Calculated; see Table K7-3
$y_{b,\,t}$	Vapor-phase constituent concentration in the bathroom at the beginning of time step (mg/L)	Calculated from last time step
$y_{s,\,t}$	Vapor-phase constituent concentration in the shower at the beginning of time step (mg/L)	Calculated from last time step
$T_{bathroom}$	Time spent in bathroom, not in shower (min)	Eco Exposure data; see Appendix N
1000	Conversion factor (L/m^3)	
n_s	Number of time steps corresponding to time spent in the shower (unitless)	Calculated as Tshower divided by ts
n_b	Number of time steps corresponding to time spent in the bathroom (unitless)	Calculated as Tbathroom divided by ts
1440	Minutes per day (min)	

The above equations are used to calculate the time-weighted average daily indoor air concentration to which a receptor is exposed. The equation assumes that receptors are only exposed to contaminants in the shower and bathroom.

Table K7-2. Vapor-Phase Constituent Concentration in the Bathroom at End of Time Step (mg/L)

$y_{b,\ t+ts}$

$$y_{b,\ t+ts} = y_{b,\ t} + \frac{\left[\left(Q_{sb} \times \left(y_{s,\ t+ts} - y_{b,\ t}\right) - Q_{bh} \times \left(y_{b,\ t} - y_{h,\ t}\right)\right)\right] \times ts}{V_b \times 1000}$$

Name	Description	Value
$y_{s,\ t+ts}$	Vapor-phase constituent concentration in the shower at the end of time step (mg/L)	Calculated; see Table K7-3
$y_{b,\ t}$	Vapor-phase constituent concentration in the bathroom at the beginning of time step (mg/L)	Calculated from last time step
V_b	Volume of bathroom (m^3)	10
Q_{sb}	Volumetric exchange rate between the shower and the bathroom (L/min)	100; estimated from the volume and flow rate in McKone (1987) such that the exchange rate equals the volume divided by the residence time (e.g., 2000L/20 min).
Q_{bh}	Volumetric exchange rate between the bathroom and the house (L/min)	300; estimated from the volume and flow rate in McKone (1987) such that the exchange rate equals the volume divided by the residence time (e.g., 10,000L/30 min).
ts	Time step = 0.2 (min)	
1000	Conversion factor (L/m^3)	
$y_{h,t}$	Vapor-phase constituent concentration in the house at the beginning of time step; Assumed deminimus: yh, t=0 (mg/L)	

The above equations are used to calculate the time-weighted average daily indoor air concentration to which a receptor is exposed. The equation assumes that receptors are only exposed to contaminants in the shower and bathroom.

Table K7-3. Vapor-Phase Constituent Concentration in the Shower at End of Time Step (mg/L)

$y_{s,\ t+ts}$

$$y_{s,\ t+ts} = y_{s,\ t} + \frac{\left[E_s - \left(Q_{sb} \times \left(y_{s,\ t} - y_{b,\ t}\right) \times ts\right)\right]}{V_s \times 1000}$$

Name	Description	Value
E_s	Mass emitted in the shower for a given time step (mg)	Calculated; see Table K7-6
$y_{b,\ t}$	Vapor-phase constituent concentration in the bathroom at the beginning of time step (mg/L)	Calculated from last time step
$y_{s,\ t}$	Vapor-phase constituent concentration in the shower at the beginning of time step (mg/L)	Calculated from last time step
Q_{sb}	Volumetric exchange rate between the shower and the bathroom (L/min)	100; estimated from the volume and flow rate in McKone (1987) such that the exchange rate equals the volume divided by the residence time (e.g., 2000L/20 min).
V_s	Volume of shower stall (m^3)	2
ts	Time step = 0.2 (min)	
1000	Conversion factor (L/m^3)	

This equation is used to calculate the vapor-phase constituent concentration in the shower at end of time step. The equation is derived from Equation 9 in Little (1992).

Table K7-4. Fraction of Vapor-Phase Saturation in Shower (unitless)

f_{sat}

$$f_{sat} = \frac{y_{s,\,t\,+\,ts}}{y_{eq}}$$

Name	Description	Value
$y_{s,\,t+ts}$	Vapor-phase constituent concentration in the shower at the end of time step (mg/L)	Calculated; see Table K7-3
$y_{s,\,t}$	Vapor-phase constituent concentration in the shower at the beginning of time step (mg/L)	Calculated from last time step
y_{eq}	Vapor-phase contaminant concentration in equilibrium between water and air (mg/L)	H' x Cin

This equation is used to calculate the fraction of a given chemical emitted from a droplet of water in the shower. The equation is based on Equation 5 in Little (1992).

Table K7-5. Fraction of Constituent Emitted from a Droplet (unitless)

$\boldsymbol{f_{em}}$
$$f_{em} = (1 - f_{sat}) \times (1 - e^{-N})$$

Name	Description	Value
N	Dimensionless overall mass transfer coefficient (unitless)	Calculated; see Table K7-8
f_{sat}	Fraction of gas-phase saturation (unitless)	Calculated; see Table K7-4

The above equations are used to determine the mass of contaminant emitted for a given time step. The equilibrium concentration in air (y_eq) is calculated from Equation 1 in Little (1992).

Table K7-6. Contaminant Mass Emitted in the Shower for a Given Time Step (mg)

E_s

For Et > Emax,

$$E_s = E_{max}$$

For $E_t \leq E_{max}$,

$$E_s = E_t$$

Where,

$$E_t = C_{in} \times ShowerRate \times ts \times f_{em}$$

$$E_{max} = (y_{eq} - y_{s,t}) \times V_s \times 1000$$

Name	Description	Value
E_t	Potential mass of constituent emitted from shower during time step (mg)	Calculated above
E_{max}	Maximum possible mass of constituent emitted from shower during time step (mg)	Calculated above
f_{em}	Fraction of constituent emitted from a droplet (unitless)	Calculated; see Table K7-5
H’	Dimensionless Henry’s law constant (unitless)	Calculated; see Table K7-9
$y_{s,t}$	Vapor-phase constituent concentration in the shower at the beginning of time step (mg/L)	Calculated from last time step
y_{eq}	Vapor-phase contaminant concentration in equilibrium between water and air (mg/L)	H’ x Cin
C_{in}	Constituent concentration in incoming water (mg/L)	Eco Exposure data; see Appendix N
ShowerRate	Rate of flow from showerhead (L/min)	5.5; calculated based on droplet diameter and nozzle velocity.
V_s	Volume of shower stall (m^3)	2
ts	Time step = 0.2 (min)	
1000	Conversion factor (L/m^3)	

This equation is used to calculate the vapor-phase constituent concentration in the shower at end of time step. The equation is derived from Equation 9 in Little (1992).

Table K7-7. Overall Mass Transfer Coefficient (cm/s)

K_{ol}

$$K_{ol} = \beta \times \left(\frac{2.5}{D_w^{2/3}} + \frac{1}{D_a^{2/3} \times H'} \right)^{-1}$$

Name	Description	Value
H’	Dimensionless Henry’s law constant (unitless)	Calculated; see Table K7-9
D_w	Diffusivity in water (cm^2/s)	Chemical data; see Appendix E
D_a	Diffusivity of chemical in air (cm^2/s)	Chemical data; see Appendix E
β	Proportionality constant (cm-s^-1/3)	216

This equation calculates the dimensionless overall mass transfer coefficient. The above equation is based on Little (1992).

Table K7-8. Dimensionless Overall Mass Transfer Coefficient (unitless)

N

$$N = K_{ol} \times AVRatio \times DropResTime$$

$$AVRatio = \frac{6}{DropDiam}$$

$$DropResTime = \frac{NozHeight \times 100}{DropVel}$$

Name	Description	Value
AVRatio	Area-to-volume ratio for a sphere (cm^2/cm^3)	Calculated above
DropResTime	Residence time for falling drops (s)	Calculated above
K_{ol}	Overall mass transfer coefficient (cm/s)	Calculated; see Table K7-7
DropDiam	Drop diameter (cm)	Eco Exposure data; see Appendix N
NozHeight	Nozzle height (m)	Eco Exposure data; see Appendix N
DropVel	Drop terminal velocity (cm/s)	Eco Exposure data; see Appendix N
100	Conversion factor (cm/m)	

This equation is used to calculate the fraction of a given chemical emitted from a droplet of water in the shower. The equation is based on Equation 5 in Little (1992).

Table K7-9. Dimensionless Henry's Law Constant (unitless)

H'

$$H' = HLC_{coef} \times HLC$$

$$HLC_{coef} = \frac{1}{R \times Temp}$$

Name	**Description**	**Value**
HLC_{coef}	Coefficient to Henry's law constant (unitless)	Calculated above
HLC	Henry's law constant (atm-m^3/mole)	Chemical data; see Appendix E
R	Ideal Gas Constant; R=0.00008205 (atm-m^3/K-mole)	
298	Temperature (K)	

This equation calculates the dimensionless Henry's law constant.

Table K7-10. Total Time Spent in Shower Stall (min)

T_{shower}

$$T_{shower} = T_{showerstall} + T_{showering}$$

Name	Description	Value
$T_{showerstall}$	Time in shower stall after showering (min)	Eco Exposure data; see Appendix N
$T_{showering}$	Duration of shower (min)	Eco Exposure data; see Appendix N

This equation calculates the total time that a receptor is exposed to vapors.

Table K8-1. Average Daily Dose from Total Ingestion (mg/kg BW/d)

$ADD_{TotalIngestion}$

$$ADD_{TotalIngestion} = ADD_{soil} + ADD_{dw} + ADD_{produce} + ADD_{beef} + ADD_{milk} + ADD_{fish}$$

Name	Description	Value
ADD_{fish}	Average daily dose from consumption of fish (mg/kg BW/d)	Calculated; see Tables K8-2
ADD_{soil}	Average daily dose from ingestion of soil (mg/kg BW/d)	Calculated; see Tables K8-4
ADD_{dw}	Daily intake of contaminant from consumption of drinking water (mg/kg BW/d)	Calculated; see Tables K8-5
ADD_{beef}	Average daily dose from consumption of beef (mg/kg BW/d)	Calculated; see Tables K8-2
ADD_{milk}	Average daily dose from consumption of milk (mg/kg BW/d)	Calculated; see Tables K8-2
$ADD_{produce}$	Average daily dose from consumption of produce (mg/kg BW/d)	Calculated; see Tables K8-3

Table K8-2. Average Daily Dose from Ingestion of Animal Tissue (mg/kg BW/d)

ADD_{animal}

$$ADD_{animal} = \frac{1}{1000}\sum_{i=1}^{i=n} A_i \times CR_{Ai} \times F_{Ai} \times \left(1 - L_{Ai}\right)$$

Name	Description	Value
A_i	Concentration of contaminant in animal tissue (mg/kg WW)	Calculated; see Table K6-1
L_{Ai}	Contaminant loss factor (unitless)	Human exposure data; see Appendix L
F_{Ai}	Fraction of animal tissue that is contaminated (unitless)	Human exposure data; see Appendix L
CR_{Ai}	Daily human consumption rate of animal tissue (g WW/kg BW/day)	Human exposure data; see Appendix L

Source: U.S. EPA, 1998a.

Table K8-3. Average Daily Dose from Consumption of Produce (mg/kg BW/d)

$ADD_{produce}$

$$ADD_{produce} = \frac{1}{1000}\sum_{i=1}^{i=n} P_i \times CR_{Pi} \times F_{Pi} \times (1 - L_{Pi})$$

Name	**Description**	**Value**
P_i	Concentration in vegetation as wet weight (mg/kg WW)	Calculated; see Tables K5-1 and Table K5-5
F_{Pi}	Fraction of vegetables grown in contaminated soil (unitless)	Human exposure data; see Appendix L
L_{Pi}	Food preparation loss (unitless)	Human exposure data; see Appendix L
CR_{Ai}	Daily human consumption rate of animal tissue (g WW/kg BW/day)	Human exposure data; see Appendix L
1000	Conversion factor (g/kg)	

Source: U.S. EPA, 1998a.

Table K8-4. Average Daily Dose from Ingestion of Soil (mg/kg BW/d)

ADD_{soil}

$$ADD_{soil} = \frac{C_{soil} \times CR_s \times F_{soil}}{BW} \times 0.000001$$

Name	Description	Value
C_{soil}	Concentration of contaminant in soil (mg/kg)	Calculated based on erosion, runoff, and deposition from LAU.
BW	Body weight (kg)	Human exposure data; see Appendix L
F_{soil}	Fraction of contaminated soil that is ingested (unitless)	Human exposure data; see Appendix L
CR_s	Soil ingestion rate (mg/day)	Human exposure data; see Appendix L
0.000001	Conversion factor (kg/mg)	

Source: U.S. EPA, 1998a.

Table K8-5. Daily Intake of Contaminant from Consumption of Drinking Water (mg/kg BW/d)

ADD_{dw}

$$ADD_{dw} = C_{water} \times CR_{dw} \times \frac{F_{dw}}{BW}$$

Name	**Description**	**Value**
C_{water}	Total concentration in the water (mg/L)	Calculated fro water body model (Appendix J) or from leachate (Table K4-1).
BW	Body weight (kg)	Human exposure data; see Appendix L
F_{dw}	Fraction of drinking water ingested that is contaminated (unitless)	Human exposure data; see Appendix L
CR_{dw}	Consumption rate of water (L/day)	Human exposure data; see Appendix L
1000	Conversion factor (mL/L)	

Source: U.S. EPA, 1998a.

Table K8-6. Lifetime Average Daily Dose (mg/kg/d)

LADD

$$LADD = \frac{ADD \times ED \times EF}{AT \times 365}$$

Name	**Description**	**Value**
ADD	Average daily dose (mg/kg/day)	Calculated; see Tables K8-1 to K8-5
SA	Start age (yr)	Human exposure data; see Appendix L
EF	Exposure frequency (d/yr)	Human exposure data; see Appendix L
AT	Averaging time (yr)	Human exposure data; see Appendix L
ED	Exposure duration (yr)	Human exposure data; see Appendix L
365	Conversion factor (days/yr)	

Calculated from source model emissions. Source: U.S. EPA, 1998a.

Table K9-1. Total Exposure Dose from Ingestion (mg/kg/d)

Dose$_{total}$

$$Dose_{total} = \frac{Dose_{dietitems} + Dose_{soil/sed} + Dose_{sw}}{BW}$$

Name	Description	Value
$Dose_{dietitems}$	Dose from diet items (plants and prey) (mg/d)	Calculated; see Table K9-2
$Dose_{sw}$	Dose from surface water ingestion (L/d)	Calculated; see Table K9-5
$Dose_{soil/sed}$	Dose from soil or sediment ingestion (mg/d)	Calculated; see Table K9-4
BW	Body Weight (kg)	Eco Exposure data; see Appendix N

This equation calculates the total eposure dose for each chemical, for each receptor. Total dose is a summation of the dose from ingestion of plants and prey, incidental soil or sediment, and surface water. Sample et al., 1997.

Table K9-2. Dose from Ingestion of Plants and Prey (mg/d WW)

$Dose_{dietitems}$

$$Dose_{dietitems} = \sum \left(C_{dietitemi} \times DF_{dietitemi} \times IR_{food} \right)$$

Name	**Description**	**Value**
$C_{dietitemi}$	Concentration of contaminant in diet item i (mg/kg WW)	Calculated; see Table K9-3
$DF_{dietitemi}$	Fraction of diet composed of diet item i (unitless)	Eco Exposure data; see Appendix N
IR_{food}	Intake rate of food (mg/kg/d)	Eco Exposure data; see Appendix N

This exuation calculates the exposure dose from ingestion of plants and prey items. Dosedietitems is calculated for each chemical and each receptor. Source: Sample et al., 1997.

Table K9-3. Concentration in Diet Items (mg/kg WW)

$C_{dietitem}$

$$C_{sedimentdietitem} = C_{sed} \times BAF_{sedimentdietitem}$$

$$C_{terrestrialdietitem} = C_{soil} \times BAF_{terrestrialdietitem}$$

$$C_{aquaticdietitem} = C_{sw} \times BAF_{aquaticdietitem}$$

Name	Description	Value
C_{sw}	Concentration of contaminant in surface water (mg/L)	Calculated from waterbody model; see Appendix J
C_{sed}	Concentration of contaminant in sediment (mg/kg)	Calculated from waterbody model; see Appendix J
C_{soil}	Concentration of contaminant in soil (mg/kg)	Calculated based on erosion, runoff, and deposition from LAU.
$BAF_{aquaticdietitem}$	Bioaccumulation factor for aquatic diet item (mg/kg WW)/(mg/kg)	Eco BAF; see Appendix M
$BAF_{sedimentdietitem}$	Bioaccumulation factor for sediment diet item (mg/kg WW)/(mg/kg sediment)	Eco BAF; see Appendix M
$BAF_{terrestrialdietitem}$	Bioaccumulation factor for terrestrial diet item (mg/kg WW)/(mg/kg soil)	Eco BAF; see Appendix M

This equation calculates the chemical concentration in each of 10 different prey items. Concentrations in plant items in receptors' diets are calculated in the human exposure equations, as shown in Section K5.

Table K9-4. Dose from Incidental Ingestion of Soil or Sediment (mg/d)

$Dose_{soil/sed}$

$$Dose_{soil} = IR_{food} \times C_{soil} \times f_{soil}$$

$$Dose_{sed} = IR_{food} \times C_{sed} \times f_{sed}$$

Name	Description	Value
C_{sed}	Concentration of contaminant in sediment (mg/kg)	Calculated from waterbody model; see Appendix J
C_{soil}	Concentration of contaminant in soil (mg/kg)	Calculated based on erosion, runoff, and deposition from LAU.
IR_{food}	Intake rate of food (mg/kg/d)	Eco Exposure data; see Appendix N
f_{sed}	Fraction of sediment in diet (unitless)	Eco Exposure data; see Appendix N
f_{soil}	Fraction of soil in diet (unitless)	Eco Exposure data; see Appendix N

This equation calculates the exposure dose from incidental ingestion of soil or sediment, depending upon where receptors derive the majority of their diet . Source: Sample et al., 1997.

Table K9-5. Dose from Ingestion of Surface Water (L/d)

$\boldsymbol{Dose_{sw}}$

$$Dose_{sw} = IR_{sw} \times C_{sw}$$

Name	Description	Value
C_{sw}	Concentration of contaminant in surface water (mg/L)	Calculated from waterbody model; see Appendix J
IR_{sw}	Ingestion rate of surface water (L/d)	Eco Exposure data; see Appendix N

This equation calculates the exposure dose that comes from ingestion of surface water. Source: Sample et al., 1997.

Table K10-1. Hazard Quotient for Soil and Sediment Invertebrates (unitless)

$HQ_{soil/sedinv}$

$$HQ_{soilinv} = \frac{C_{soil}}{BMK_{soilinv}}$$

$$HQ_{sedinv} = \frac{C_{sed}}{BMK_{sedinv}}$$

Name	Description	Value
C_{sed}	Concentration of contaminant in sediment (mg/kg)	Calculated from waterbody model; see Appendix J
C_{soil}	Concentration of contaminant in soil (mg/kg)	Calculated based on erosion, runoff, and deposition from LAU.
$BMK_{soilinv}$	Benchmark for soil invertebrates (mg/kg)	Eco benchmark data; see Appendix P
BMK_{sedinv}	Benchmark for sediment invertebrates (mg/kg)	Eco benchmark data; see Appendix P

Table K10-2. Hazard Quotient for Surface Water Receptors (unitless)

HQ_{sw}

$$HQ_{aqinv} = \frac{C_{sw}}{BMK_{aqinv}}$$

$$HQ_{aqpl} = \frac{C_{sw}}{BMK_{aqpl}}$$

$$HQ_{fish} = \frac{C_{sw}}{BMK_{fish}}$$

$$HQ_{amph} = \frac{C_{sw}}{BMK_{amph}}$$

$$HQ_{sw} = \frac{C_{sw}}{BMK_{sw}}$$

Name	Description	Value
C_{sw}	Concentration of contaminant in surface water (mg/L)	Calculated from waterbody model; see Appendix J
BMK_{aqinv}	Benchmark for aquatic invertebrates (L/kg)	Eco benchmark data; see Appendix P
BMK_{aqpl}	Benchmark for aquatic plants (L/kg)	Eco benchmark data; see Appendix P
BMK_{fish}	Benchmark for fish (L/kg)	Eco benchmark data; see Appendix P
BMK_{amph}	Benchmark for amphibians (L/kg)	Eco benchmark data; see Appendix P
BMK_{sw}	Benchmark for surface water community (mg/kg)	Eco benchmark data; see Appendix P

Surface water concentrations (Csw) were averaged over time periods corresponding to respective benchmark exposure durations, as shown in Appendix P.

Appendix L

Human Exposure Factors

Appendix L

Human Exposure Factors

This section describes the human exposure assessment that was conducted for the sewage sludge screening analysis to determine or estimate the magnitude, frequency, duration, and route of exposure to sewage sludge pollutants that an individual may experience. The term "exposure," as defined by the EPA exposure guidelines (U.S. EPA, 1992), is the condition that occurs when a contaminant comes into contact with the outer boundary of the body. The exposure of an individual to a contaminant completes an exposure pathway. Once the body is exposed, the constituent can cross the outer boundary and enter the body. The amount of contaminant that crosses and is available for adsorption at internal exchange boundaries is referred to as the "dose" (U.S. EPA, 1992).

Exposure factors are data that quantify human behavior patterns (e.g., ingestion rates of beef and fruit) and characteristics (e.g., body weight) that affect human exposure to environmental contaminants. These data can be used to construct realistic assumptions concerning an individual's exposure to and subsequent intake of a contaminant in the environment. The exposure factors data also enable EPA to differentiate the exposures of individuals of different ages (e.g., a child vs. an adult). Section L.1 presents an overview of the receptors and selected exposure pathways considered for the screening analysis. The derivation and values used for the human exposure factors in this risk assessment are described in Section L.2.

L.1 Receptors and Exposure Pathways

In the agricultural application scenario, both adult and child members of a farm family are assumed to be exposed to contaminants through the application of sewage sludge to their own farm. The farm family is assumed to be living on the farm during the time that sludge is applied. The adults are assumed to be 20 years old or older when exposure begins, and the children in the farm family are assumed to begin exposure at 1 year of age. In the lagoon sludge disposal scenario, receptors of concern include adults and children who reside near the lagoon where sewage sludge is managed.

Table L-1 lists each receptor along with the specific exposure pathways that apply to that receptor for a given exposure scenario. As indicated in Table L-1, not all receptors are exposed through the same pathways. For the agricultural application scenario, the adult and child farmer

Table L-1. Receptors and Exposure Pathways for Sewage Sludge Screening Analysis

Receptor	Exposure Scenario	Inhalation of Ambient Air	Inhalation of Indoor Air[a]	Ingestion of Soil	Ingestion of Drinking Water	Ingestion of Produce	Ingestion of Beef and Dairy Products	Ingestion of Fish (Farm Pond)
Adult farmer	LAU	✓	✓	✓	✓	✓	✓	✓
Child farmer	LAU	✓	✓	✓	✓	✓	✓	✓
Adult resident	SI	✓	✓		✓			
Child resident	SI	✓	✓		✓			

[a] Showering is the only source of contamination considered in the analysis for indoor air.

are exposed via inhalation of air and ingestion of soil, homegrown above- and belowground produce, beef, dairy, fish, and drinking water. The adult and child are also exposed to groundwater or surface water via the inhalation of vapors generated from constituents volatilizing during showering. For the lagoon sludge disposal scenario, the adult and child are exposed via inhalation of air, and ingestion of drinking water, and to groundwater via inhalation during showering.

L.1.1 Childhood Exposure

Children are an important subpopulation to consider in a risk assessment because they are likely to be more susceptible to exposures than adults; compared to adults, children may drink more fluids per unit of body weight. This higher intake-rate-to-body-weight ratio can result in a higher average daily dose (ADD) for children than for adults.

As children mature, their physical characteristics and behavior patterns change. To capture these changes in the analysis, the life of a child was considered in stages represented by the following cohorts: cohort 1 (ages 1 to 5), cohort 2 (ages 6 to 11), cohort 3 (ages 12 to 19), and cohort 4 (ages 20 to 70). Associated with each cohort are distributions of values, called “exposure parameters,” that are required to calculate exposure to an individual. The exposure parameter distributions for each cohort reflect the physical characteristics and behavior patterns of that age range. Data from the *Exposure Factors Handbook* (EFH) were used to derive distributions appropriate for each cohort (U.S. EPA, 1997a,b,c). The distributions for the 20- to 70-year-old cohort were the same as those used for adult receptors.

The development of the child exposure parameters consisted of two steps:

1. Define the start age of the child
2. Select the exposure duration of the child.

To capture the higher intake-rate-to-body-weight ratio of children, a start age of 1 was selected. The distribution of exposure duration for cohort 1 (ages 1 to 5) was used to define exposure duration for each of the 3,000 iterations in the probabilistic analysis.

L.1.2 Exposure Pathways

Human receptors may come into contact with pollutants present in environmental media through a variety of pathways. In general, exposure pathways are either direct, such as inhalation of ambient air, or indirect, such as the farm food chain pathways. The exposure pathways considered in this assessment were inhalation of ambient air; inhalation of indoor air vapors from contaminated water via showering; and ingestion of soil, produce, beef, dairy products, fish, and drinking water.

L.1.2.1 Inhalation of Ambient Air. Both vapors and particles can be inhaled in ambient air by a receptor. Both adults and children were affected via direct inhalation in the agricultural application and sewage sludge lagoon exposure scenarios.

L.1.2.2 Inhalation of Indoor Air. In the agricultural application scenario, tap water was assumed to be either untreated directly from the index reservoir (surface water) or from an onsite well (groundwater). In the sewage sludge lagoon scenario, tap water was assumed to be only from an onsite well (groundwater). The tap water used for drinking water was assumed to also be used for showering by both the adult and child. Pollutants can volatilize from shower water, resulting in inhalation exposures in both scenarios.

L.1.2.3 Ingestion of Soil. In the agricultural application scenario, both adult and child farmer receptors were exposed to soil based on incidental ingestion, mostly as a result of hand-to-mouth behavior. Ingestion of soil was not considered for the sewage sludge lagoon scenario.

L.1.2.4 Ingestion of Above- and Belowground Produce. Ingestion of the following categories of produce was considered for the agricultural application scenario: exposed fruit, protected fruit, exposed vegetables, root vegetables, and protected vegetables. For aboveground produce, the term "exposed" indicates that the edible portion of the plant is exposed to the atmosphere, while the term "protected" indicates that the edible portion of the plant is protected from the atmosphere by an inedible skin. Farmers were assumed to grow a portion of their fruits and vegetables on land amended with sewage sludge. These fruits and vegetables were assumed to become contaminated via soil and air. Belowground produce refers to root crops grown by the farmer. Ingestion of produce was not considered for the lagoon scenario.

L.1.2.5 Ingestion of Beef and Dairy Products. Beef and dairy cattle were assumed to be exposed to pollutants via differing intake rates of contaminated soil, forage, and feed. In the agricultural application scenario, adult and child farmer receptors were assumed to consume beef and drink milk from cattle that grazed in the pasture amended with sewage sludge. Ingestion of beef and dairy were not considered for the lagoon scenario.

L.1.2.6 Ingestion of Fish. Fish are exposed to sewage sludge pollutants via uptake of contaminants from surface waters. In the agricultural application scenario, the fish consumed by the farm family were home caught from the farm pond. Ingestion of fish was not considered for the lagoon scenario.

L.1.2.7 Ingestion of Drinking Water. In addition to inhalation of indoor air, ingestion of drinking water was considered in both exposure scenarios. For the agricultural application scenario, tap water was assumed to be either untreated directly from the index reservoir (surface water) or from an onsite well (groundwater). For the lagoon scenario, tap water was assumed to be only from an onsite well (groundwater).

L.2 Exposure Parameters Used in Probabilistic Analysis

L.2.1 Introduction

The general methodology for collecting human exposure data for the probabilistic analysis relied on the EFH (U.S. EPA, 1997a,b,c), which was used in one of three ways:

1. When EFH percentile data were adequate (most input variables), maximum likelihood estimation was used to fit selected parametric models (gamma, lognormal, Weibull, and generalized gamma) to the EFH data. The chi-square measure of goodness of fit was then used to choose the best distribution. Parameter uncertainty information (e.g., for averages, standard deviations) also was derived using the asymptotic normality of the maximum likelihood estimate or a regression approach.

2. For a few variable conditions when percentile data were not adequate for statistical model fitting, models were selected on the basis of results for other age cohorts or, if no comparable information was available, by assuming lognormal as a default distribution and reasonable coefficients of variation (CVs).

3. Other variables for which data were not adequate for either 1 or 2 above were fixed at EFH-recommended mean values or according to established EPA policy.

Table L-2 summarizes all of the parameters that were varied in the probabilistic analysis. Fixed variables are presented later in Section L.2.3.

Probabilistic risk analyses involve "sampling" values from probability distribution functions (PDFs) and using the values to estimate risk. In some cases, distributions are infinite, and there is a probability, although very small, that very large or very small values might be selected from the distributions. Because selecting extremely large or extremely small values is unrealistic (e.g., the range of adult body weights is not infinite), maximum and minimum values were imposed on the distributions. For the probabilistic analyses, the maximum intake rates for most food items were defined as 2 × (mean + 3 SD). For beef (adult farmer), exposed fruit (adult farmer), and exposed vegetable (child aged 12-19 yrs old), 2 times the 99th percentile value was used as the maximum intake rate. For fish, adult subsistence fisher ingestion rates were used as the maximum. Minimum intake values for all food items were zero. The minimum and maximum values are also included in Table L-2.

Table L-2. Summary of Exposure Parameters Used in Sewage Sludge Screening Analysis

Parameter	Units	Variable Type	Mean (or Shape)	Std Dev (or Scale)	Minimum	Maximum	Reference
Body weight (adult)	kg	Lognormal	7.12E+01	1.33E+01	1.50E+01	3.00E+02	U.S. EPA (1997a); Tbl 7-2, 7-4, 7-5
Body weight (child 1)	kg	Lognormal	1.55E+01	2.05E+00	4.00E+00	5.00E+01	U.S. EPA (1997a); Tbl 7-3, 7-6, 7-7
Body weight (child 2)	kg	Lognormal	3.07E+01	5.96E+00	6.00E+00	2.00E+02	U.S. EPA (1997a); Tbl 7-3, 7-6, 7-7
Body weight (child 3)	kg	Lognormal	5.82E+01	1.02E+01	1.30E+01	3.00E+02	U.S. EPA (1997a); Tbl 7-3, 7-6, 7-7
Consumption rate: beef (adult farmer)	g WW/kg-d	Lognormal	2.50E+00	2.69E+00	0.00E+00	2.30E+01	U.S. EPA (1997b); Tbl 13-36
Consumption rate: beef (child 1 farmer)	g WW/kg-d	Lognormal	3.88E+00	4.71E+00	0.00E+00	3.60E+01	U.S. EPA (1997b); Tbl 13-36
Consumption rate: beef (child 2 farmer)	g WW/kg-d	Lognormal	3.88E+00	4.71E+00	0.00E+00	3.60E+01	U.S. EPA (1997b); Tbl 13-36
Consumption rate: beef (child 3 farmer)	g WW/kg-d	Gamma	2.47E+00	7.10E-01	0.00E+00	1.00E+01	U.S. EPA (1997b); Tbl 13-36
Consumption rate: exposed fruit (adult farmer)	g WW/kg-d	Lognormal	2.36E+00	3.33E+00	0.00E+00	3.10E+01	U.S. EPA (1997b); Tbl 13-61
Consumption rate: exposed fruit (child 1 farmer)	g WW/kg-d	Gamma	1.43E+00	1.58E+00	0.00E+00	1.60E+01	U.S. EPA (1997b); Tbl 13-61
Consumption rate: exposed fruit (child 2 farmer)	g WW/kg-d	Lognormal	2.78E+00	5.12E+00	0.00E+00	3.60E+01	U.S. EPA (1997b); Tbl 13-61
Consumption rate: exposed fruit (child 3 farmer)	g WW/kg-d	Lognormal	1.54E+00	2.44E+00	0.00E+00	1.80E+01	U.S. EPA (1997b); Tbl 13-61
Consumption rate: exposed vegetables (adult farmer)	g WW/kg-d	Lognormal	2.38E+00	3.50E+00	0.00E+00	2.60E+01	U.S. EPA (1997b); Tbl 13-63
Consumption rate: exposed vegetables (child 1 farmer)	g WW/kg-d	Gamma	9.70E-01	2.62E+00	0.00E+00	2.10E+01	U.S. EPA (1997b); Tbl 13-63
Consumption rate: exposed vegetables (child 2 farmer)	g WW/kg-d	Lognormal	1.64E+00	3.95E+00	0.00E+00	2.70E+01	U.S. EPA (1997b); Tbl 13-63
Consumption rate: exposed vegetables (child 3 farmer)	g WW/kg-d	Gamma	9.10E-01	1.19E+00	0.00E+00	1.10E+01	U.S. EPA (1997b); Tbl 13-63
Consumption rate: fish (adult, child)	g/d	Lognormal	6.48E+00	1.99E+01	0.00E+00	1.50E+03	U.S. EPA (1997b); Tbl 10-64
Consumption rate: milk (adult farmer)	g WW/kg-d	Gamma	1.38E+00	1.19E+01	0.00E+00	1.16E+02	U.S. EPA (1997b); Tbl 13-28; CSFII (1997)
Consumption rate: milk (child 1 farmer)	g WW/kg-d	Gamma	9.61E-01	6.18E+01	0.00E+00	4.82E+02	U.S. EPA (1997b); Tbl 11-2, 13-28; USDA (1997)
Consumption rate: milk (child 2 farmer)	g WW/kg-d	Gamma	9.61E-01	3.14E+01	0.00E+00	2.45E+02	U.S. EPA (1997b); Tbl 11-2, 13-28; USDA (1997)
Consumption rate: milk (child 3 farmer)	g WW/kg-d	Gamma	9.61E-01	1.39E+01	0.00E+00	1.09E+02	U.S. EPA (1997b); Tbl 11-2, 13-28; USDA (1997)
Consumption rate: protected fruit (adult farmer)	g WW/kg-d	Gamma	7.38E-01	6.92E+00	0.00E+00	6.50E+01	U.S. EPA (1997b); Tbl 13-62
Consumption rate: protected fruit (child 1 farmer)	g WW/kg-d	Gamma	7.37E-01	1.59E+01	0.00E+00	4.50E+01	U.S. EPA (1997b); Tbl 13-62
Consumption rate: protected fruit (child 2 farmer)	g WW/kg-d	Gamma	7.37E-01	8.15E+00	0.00E+00	2.60E+01	U.S. EPA (1997b); Tbl 13-62
Consumption rate: protected fruit (child 3 farmer)	g WW/kg-d	Gamma	7.36E-01	3.56E+00	0.00E+00	3.80E+01	U.S. EPA (1997b); Tbl 13-62
Consumption rate: protected vegetables (adult farmer)	g WW/kg-d	Lognormal	1.27E+00	1.85E+00	0.00E+00	1.80E+01	U.S. EPA (1997b); Tbl 13-64

(continued)

Table L-2. (continued)

Parameter	Units	Variable Type	Mean (or Shape)	Std Dev (or Scale)	Minimum	Maximum	Reference
Consumption rate: protected vegetables (child 1 farmer)	g WW/kg-d	Lognormal	1.88E+00	1.98E+00	0.00E+00	1.60E+01	U.S. EPA (1997b); Tbl 13-64
Consumption rate: protected vegetables (child 2 farmer)	g WW/kg-d	Lognormal	1.07E+00	1.04E+00	0.00E+00	8.00E+00	U.S. EPA (1997b); Tbl 13-64
Consumption rate: protected vegetables (child 3 farmer)	g WW/kg-d	Lognormal	7.70E-01	6.90E-01	0.00E+00	6.00E+00	U.S. EPA (1997b); Tbl 13-64
Consumption rate: root vegetables (adult farmer)	g WW/kg-d	Lognormal	1.45E+00	2.06E+00	0.00E+00	1.50E+01	U.S. EPA (1997b); Tbl 13-65
Consumption rate: root vegetables (child 1 farmer)	g WW/kg-d	Lognormal	2.31E+00	6.05E+00	0.00E+00	4.10E+01	U.S. EPA (1997b); Tbl 13-65
Consumption rate: root vegetables (child 2 farmer)	g WW/kg-d	Weibull	6.80E-01	1.06E+00	0.00E+00	1.50E+01	U.S. EPA (1997b); Tbl 13-65
Consumption rate: root vegetables (child 3 farmer)	g WW/kg-d	Weibull	8.40E-01	9.10E-01	0.00E+00	9.00E+00	U.S. EPA (1997b); Tbl 13-65
Exposure duration (child)	yr	Weibull	1.32E+00	7.06E+00	1.00E+00	1.00E+02	U.S. EPA (1997c); Tbl 15-168
Exposure duration (adult resident)	yr	Weibull	1.34E+00	1.74E+01	1.00E+00	1.00E+02	U.S. EPA (1997c); Tbl 15-168
Exposure duration (adult farmer)	yr	Gamma	6.07E-01	2.98E+01	1.00E+00	1.00E+02	U.S. EPA (1997c); Tbl 15-163, 15-164
Ingestion rate: drinking water (adult)	mL/d	Gamma	3.88E+00	3.57E+02	1.04E+02	1.10E+04	U.S. EPA (1997a); Tbl 3-6
Ingestion rate: drinking water (child 1)	mL/d	Gamma	2.95E+00	2.37E+02	2.60E+01	3.84E+03	U.S. EPA (1997a); Tbl 3-6
Ingestion rate: drinking water (child 2)	mL/d	Gamma	3.35E+00	2.35E+02	3.40E+01	4.20E+03	U.S. EPA (1997a); Tbl 3-6
Ingestion rate: drinking water (child 3)	mL/d	Gamma	2.82E+00	3.42E+02	3.30E+01	5.40E+03	U.S. EPA (1997a); Tbl 3-6
Time spent showering	min	Gamma	2.83E+00	5.89E+00	1.00E+00	6.00E+01	U.S. EPA (1997c); Tbl 15-21
Time spent in shower stall after showering	min	Weibull	9.60E-01	8.36E+00	0.00E+00	6.00E+01	U.S. EPA (1997c); Tbl 15-23
Time spent in bathroom after shower	min	Weibull	9.80E-01	9.75E+00	0.00E+00	1.20E+02	U.S. EPA (1997c); Tbl 15-32

L.2.2 Exposure Parameter Distribution Methodology

This section describes how stochastic or distributed input data for each exposure factor were collected and processed. Exposure parameter distributions were developed for use in the Monte Carlo analysis. For most variables for which distributions were developed, exposure factor data from the EFH were analyzed to fit selected parametric models (i.e., gamma, lognormal, Weibull). Steps in the development of distributions included preparing data, fitting models, assessing fit, and preparing parameters to characterize distributional uncertainty in the model inputs.

For many exposure factors, EFH data include sample sizes and estimates of the following parameters for specific receptor types and age groups: mean, standard deviation, standard error, and percentiles corresponding to a subset of the following probabilities—0.01, 0.02, 0.05, 0.10, 0.15, 0.25, 0.50, 0.75, 0.85, 0.90, 0.95, 0.98, and 0.99. These percentile data were used as a basis for fitting distributions where available. Although in no case were all of these percentiles actually provided for a single factor, seven or more were typically present in the EFH data. Therefore, using the percentiles is a fuller use of the available information than simply fitting data based on the method of moments (e.g., selecting models that agree with the data mean and standard deviation). For some factors, certain percentiles were not used in the fitting process because sample sizes were too small to justify their use. Percentiles were used only if at least one data point was in the tail of the distribution. If the EFH data repeated a value across several adjacent percentiles, only one value (the most central or closest to the median) was used in most cases (e.g., if both the 98^{th} and 99^{th} percentiles had the same value, only the 98^{th} value was used).

The EFH does not use standardized age cohorts across exposure factors. Different exposure factors have data reported for different age categories. Therefore, to obtain the percentiles for fitting the four standardized age cohorts (i.e., ages 1 to 5, 6 to 11, 12 to 19, and greater than 20), each EFH cohort-specific value for a given exposure factor was assigned to one of these four cohorts. When multiple EFH cohorts fit into a single cohort, the EFH percentiles were averaged within each cohort (e.g., data on 1- to 2- and 3- to 5-year-olds were averaged for the 1- to 5-year old cohort). If sample sizes were available, weighted averages were used, with weights proportional to sample sizes. If sample sizes were not available, equal weights were assumed (i.e., the percentiles were simply averaged).

Because the EFH data are always positive and almost always skewed to the right (i.e., have a long right tail), three two-parameter probability models commonly used to characterize such data (gamma, lognormal, and Weibull) were selected. In addition, a three-parameter model (generalized gamma) was used that unifies the other three models[1] and allows for a likelihood ratio test of the fit of the two-parameter models. However, only the two-parameter models were selected for use in the analysis because the three-parameter generalized gamma model did not significantly improve the goodness of fit over the two-parameter models. This simple setup constitutes a considerable improvement over the common practice of using a lognormal model in which adequate EFH data were available to support maximum likelihood estimation. However,

[1] Gamma, Weibull, and lognormal distributions are all special cases of the generalized gamma distribution.

in a few cases (e.g., inhalation rate), data were not adequate to fit a distribution, and the lognormal model was assumed as the default.

Lognormal, gamma, Weibull, and generalized gamma distributions were fit to each factor data set using maximum likelihood estimation (Burmaster and Thompson, 1998). When sample sizes were available, the goodness of fit was calculated for each of the four models using the chi-square test (Bickel and Doksum, 1977). When percentile data were available but sample sizes were unknown, a regression F-test for the goodness of fit against the generalized gamma model was used. For each of the two-parameter models, parameter uncertainty information (i.e., mean, standard deviation, scale, and shape) was provided as parameter estimates for a bivariate normal distribution that could be used for simulating parameter values (Burmaster and Thompson, 1998). The information necessary for such simulations includes estimates of the two model parameters, their standard errors, and their correlation. To obtain this parameter uncertainty information, the asymptotic normality of the maximum likelihood estimate (Burmaster and Thompson, 1998) was used when sample sizes were available, and a regression approach was used when sample sizes were not available (Jennrich and Moore, 1975; Jennrich and Ralston, 1979). In either case, uncertainty can be expressed as a bivariate normal distribution for the model parameters.

L.2.3 Fixed Parameters

Certain parameters were fixed based on central tendency values from the best available source (usually EFH recommendations), either because no variability was expected or because the available data were not adequate to generate distributions. Fixed (constant) parameters are shown in Table L-3 along with the value selected for the risk analysis and data source. These constants include variables for which limited or no percentile data were provided in the EFH (e.g., exposure frequency and showering frequency). The fraction of consumed trophic level 3 (T3) and trophic level 4 (T4) fish was determined from data in Table 10-66 of the EFH (U.S. EPA, 1997b), which contains the only fish consumption data reported in the handbook with an adequate species breakdown to make this distinction. When evaluating carcinogens, total dose was averaged over the lifetime of the individual, assumed to be 70 years.

Exposure frequency was set to 350 days per year in accordance with EPA policy, assuming that residents take an average of 2 weeks’ vacation time away from their homes each year.

Mean soil ingestion rates were cited as 100 mg/d for children and 50 mg/d for adults (Table 4-23, U.S. EPA, 1997a). No percentile data were recommended for use in the EFH. Adult data were also used for the 6- to 11- and 12- to 19-yr-olds. The soil ingestion rates were not varied for the probabilistic analysis.

Table L-3. Summary of Human Exposure Factor Data Used in Modeling: Constants

Description	Average	Units	Source
Averaging time for carcinogens	7.00E+01	yr	U.S. EPA (1989) (RAGS)
Exposure frequency	3.50E+02	d/y	U.S. EPA (1991)
Fraction food preparation loss: exposed fruit	2.10E-01	Fraction	EFH, Table 13-6
Fraction food preparation loss: exposed vegetables	1.61E-01	Fraction	EFH, Table 13-7
Fraction food preparation loss: protected fruit	2.90E-01	Fraction	EFH, Table 13-6
Fraction food preparation loss: protected vegetables	1.30E-01	Fraction	EFH, Table 13-7
Fraction food preparation loss: root vegetables	5.30E-02	Fraction	EFH, Table 13-7
Percent cooking loss: beef	2.70E-01	Fraction	EFH, Table 13-5
Percent postcooking loss: beef	2.40E-01	Fraction	EFH, Table 13-5
Percent cooking loss: milk	0.00E+00	Fraction	U.S. EPA Policy
Percent postcooking loss: milk	0.00E+00	Fraction	U.S. EPA Policy
Fraction of fish consumed that is trophic level 3 (T3) fish	3.60E-01	Fraction	EFH, Table 10-66
Fraction of fish consumed that is trophic level 4 (T4) fish	6.40E-01	Fraction	EFH, Table 10-66
Ingestion rate: soil (adult, child 2, child 3)	5.00E+01	mg/d	EFH, Table 4-23
Ingestion rate: soil (child 1)	1.00E+02	mg/d	EFH, Table 4-23
Shower frequency (adult)	1.00E+00	x/d	EFH, Table 15-19

Source: EFH (U.S. EPA, 1997a, 1997b, 1997c)

L.2.4 Variable Parameters

L.2.4.1 <u>Exposed Fruit Consumption</u>. Table L-4 presents exposed fruit consumption data. Data for consumption of homegrown exposed fruit were obtained from Table 13-61 of the EFH (U.S. EPA, 1997b). Data (in g WW/kg-d) were presented by age groups and for farmers (adults). For the 1- to 5-year old age group, data were only available for those aged 3 to 5 years (not available for 1- to 2-year-olds); therefore, these data were used for the entire 1- to 5-year-old age group. Percentile data were used to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select the most appropriate model.

Table L-4. Exposed Fruit Consumption Data and Distributions

		EFH Data (g WW/kg-d)											Distributions		
Age Cohort	**N**	**Data Mean**	**Data SDev**	**P01**	**P05**	**P10**	**P25**	**P50**	**P75**	**P90**	**P95**	**P99**	**Distribution**	**Pop-Estd Mean**	**Pop-Estd SDev**
1-5	49	2.6	3.947			0.373	1	1.82	2.64	5.41	6.07		Gamma	2.25	1.89
6-11	68	2.52	3.496		0.171	0.373	0.619	1.11	2.91	6.98	11.7		Lognormal	2.78	5.12
12-19	50	1.33	1.457		0.123	0.258	0.404	0.609	2.27	3.41	4.78		Lognormal	1.54	2.44
Adult Farmer	112	2.32	2.646	0.072	0.276	0.371	0.681	1.3	3.14	5	6.12	15.7	Lognormal	2.36	3.33

N = Number of samples; P01-P99 = Percentiles; Pop-Estd = Population-estimated; SDev = Standard deviation.

L.2.4.2 <u>Protected Fruit Consumption</u>. Data for consumption of homegrown protected fruit were obtained from Table 13-62 of the EFH (U.S. EPA, 1997b) and are presented in Table L-5 below. Data (in g WW/kg/d) were presented for the following cohorts: 12- to 19-year-olds; 20- to 39-year-olds; 40- to 69-year-olds; and all ages combined. No data for adult farmers or the 1- to 5- and 6- to 11-year-olds were available for homegrown protected fruit consumption. Per capita intake data for protected fruit (including store-bought products), however, were available from the EFH for those aged 1 to 2, 3 to 5, and 6 to 11 years (data in the EFH were based on the 1989–1991 CSFII). Therefore, data for the general population were used to calculate adjustment factors to develop distributions for the nonadult age groups for consumption of homegrown protected fruit. The population estimated mean and standard deviation for those aged 20 years and older (derived from the weighted average of means and standard deviations of those aged 20 to 39 years and those aged 40 to 69 years) were used to represent adult farmers for the analysis.

Available percentile data were used to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select gamma as the most appropriate model in all cases. It was assumed that the relative standard deviations (RSD) for consumption rates were the same for all age groups; the similarity of CVs suggest that this is a reasonable approximation for the general population. To develop distributions for the child age groups for the consumption of homegrown protected fruit, it was also assumed that the mean intake rates have the same fixed ratio for all the age groups of a given food type. That is, the ratio of the mean amount consumed of homegrown protected fruit divided by the mean amount consumed of protected fruit in the general population is the same for any two age groups. These two assumptions (i.e., constant RSD and constant mean ratio) were used to infer the parameters of the gamma distributions for the home-produced foods from those of the general population. Each age-specific ratio (or adjustment factor) was multiplied by the "all ages" group data (e.g., mean, standard deviation) to estimate each age-specific consumption rate.

Table L-5. Protected Fruit Consumption Data and Distributions

Source	Age cohort	EFH Protected Fruit Consumption Data (g WW/kg-d)									Distributions		
		Data Mean	Data SDev	P05	P10	P25	P50	P75	P90	P95	Distribu-tion	Pop-Estd Shape	Pop-Estd Scale
EFH (gen)	All ages	1.692					0.598	2.316	4.687	6.717			
EFH (gen)	1-5	4.5					2.3	7.3	13	17			
EFH (gen)	6-11	2.339					1.079	3.727	6.920	8.688			
EFH (gen)	12-19	1.401					0.598	2.234	4.341	5.761			
EFH (gen)	20-69	1.2					0.35	1.9	3.6	4.7			
HP	1-5										gamma	0.737	15.88
HP	6-11										gamma	0.737	8.146
EFH (HP)	12-19	2.960	4.4	0.16	0.283	0.393	1.23	2.84	7.44	11.4	gamma	0.736	3.562
EFH (HP)	20-69	5.1	6.7	0.3	0.39	0.94	2	6.9	15	19	gamma	0.738	6.924
EFH (HP)	All ages	5.740	8.2	0.266	0.335	0.933	2.34	7.45	16	19.7	gamma	0.71	7.718

gen = general population data; EFH = U.S. EPA (1997b); HP = home-produced data; P05-P95 = Percentiles; SDev = standard deviation; Pop-Estd = population-estimated.

L.2.4.3 <u>Exposed Vegetable Consumption</u>. Table L-6 presents exposed vegetable consumption data and distribution. Data for consumption of homegrown exposed vegetables were obtained from Table 13-63 of the EFH (U.S. EPA, 1997b). Data (in g WW/kg/d) were presented for those ages 1 to 2, 3 to 5, 6 to 11, 12 to 19, 20 to 39, and 40 to 69 years, as well as for farmers. Weighted averages of percentiles, means, and standard deviations were calculated for the 1- to 5-year-old age group (combining groups of those aged 1 to 2 years and 3 to 5 years). Percentile data were used to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select the most appropriate model.

Table L-6. Exposed Vegetable Consumption Data and Distributions

Age Cohort	N	EFH Data (g WW/kg-d)										Distributions		
		Data Mean	Data SDev	P05	P10	P25	P50	P75	P90	P95	P99	Distribution	Pop-Estd Mean	Pop-Estd SDev
1-5	105	2.453	2.675	0.102	0.37	0.833	1.459	3.226	6.431	8.587		Gamma	2.55	2.58
6-11	134	1.39	2.037	0.044	0.094	0.312	0.643	1.6	3.22	5.47	13.3	Lognormal	1.64	3.95
12-19	143	1.07	1.128	0.029	0.142	0.304	0.656	1.46	2.35	3.78	5.67	Gamma	1.08	1.13
Adult farmer	207	2.17	2.316	0.184	0.372	0.647	1.38	2.81	6.01	6.83	10.3	Lognormal	2.38	3.5

N = Number of samples; P01-P99 = Percentiles; Pop-Estd = Population-estimated; SDev = Standard deviation.

L.2.4.4 Root Vegetable Consumption. Table L-7 presents root vegetable consumption rate and distributions. Homegrown root vegetable consumption data were obtained from Table 13-65 of the EFH (U.S. EPA, 1997b). Data (in g WW/kg/d) were presented for those ages 1 to 2, 3 to 5, 6 to 11, 12 to 19, 20 to 39, 40 to 69 years, and for adult farmers. Weighted averages of percentiles, means, and standard deviations were calculated for the child 1 age group (combining groups of those aged 1 to 2 and 3 to 5 years). Percentile data were used to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select the most appropriate model.

Table L-7. Root Vegetable Consumption Data and Distributions

Age Cohort	N	EFH Data (g WW/kg-d)											Distributions		
		Data Mean	Data SDev	P01	P05	P10	P25	P50	P75	P90	P95	P99	Distribution	Pop-Estd Mean	Pop-Estd SDev
1-5	45	1.886	2.371		0.081	0.167	0.291	0.686	2.653	5.722	7.502		Lognormal	2.31	6.05
6-11	67	1.32	1.752		0.014	0.036	0.232	0.523	1.63	3.83	5.59		Weibull	1.38	2.07
12-19	76	0.937	1.037		0.008	0.068	0.269	0.565	1.37	2.26	3.32		Weibull	0.99	1.19
Adult farmer	136	1.39	1.469	0.111	0.158	0.184	0.365	0.883	1.85	3.11	4.58	7.47	Lognormal	1.45	2.06

N = Number of samples; P01-P99 = Percentiles; Pop-Estd = Population-estimated; SDev = Standard deviation.

L.2.4.5 Protected Vegetable Consumption. Homegrown protected vegetable consumption data were obtained from Table 13-64 of the EFH (U.S. EPA, 1997b) and are presented in Table L-8 below. Data (in g WW/kg/d) were presented for those aged 1 to 2, 3 to 5, 6 to 11, 12 to 19, 20 to 39, and 40 to 69 years, as well as for farmers. Weighted averages of percentiles, means, and standard deviations were calculated for the 1- to 5-year-old age group (combining groups of those aged 1 to 2 and 3 to 5 years). Percentile data were used to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select the most appropriate model.

Table L-8. Protected Vegetable Consumption Data and Distributions

EFH Protected Vegetable Consumption Data (g WW/kg/d)													Distributions		
Age Cohort	N	Data Mean	Data SDev	P01	P05	P10	P25	P50	P75	P90	P95	P99	Distrib-ution	Pop-Estd Mean	Pop-Estd SDev
1-5	53	1.76	1.79		0.265	0.408	0.829	1.397	2.066	3.053	6.812		lognormal	1.88	1.98
6-11	63	1.1	1.064		0.208	0.318	0.387	0.791	1.31	2.14	3.12		lognormal	1.07	1.04
12-19	51	0.776	0.622		0.161	0.239	0.354	0.583	0.824	1.85	2.2		lognormal	0.77	0.69
Farmer	142	1.3	1.728	0.087	0.166	0.209	0.337	0.599	1.4	3.55	5.4	9.23	lognormal	1.27	1.85

N = number of samples; P01-P99 = percentiles; Pop-Estd = population-estimated; SDev = standard deviation.

L.2.4.6 <u>Dairy Products (Milk) Consumption</u>. Table L-9 presents summary statistics on consumption of dairy products. Home-produced dairy product consumption rate data were obtained from Table 13-28 of the EFH (U.S. EPA, 1997b) for farmers, all ages combined, and individual age groups. No age-specific data for children were available for home-produced dairy products consumption. Per capita intake data for dairy products (including store-bought products), however, were available for those aged 1 to 2, 3 to 5, 6 to 11, and 12 to 19 from the EFH and from USDA (1997); the data in the EFH were based on the 1989–1991 CSFII, and it was decided to use the more recent 1994–1996 CSFII raw data. Therefore, data for the general population were used to calculate adjustment factors to develop distributions for the nonadult age groups for consumption of home-produced dairy products.

Percentile data (USDA, 1997) were used to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select gamma as the most appropriate model in all cases. It was assumed that the RSD for consumption rates were the same for all age groups; the similarity of CVs suggests that this is a reasonable approximation for the general population. The other assumption used to develop distributions for the child age groups for the consumption of home-produced dairy products was that the mean intake rates have the same fixed ratio for all the age groups of a given food type. That is, the ratio of the mean amount consumed of home-produced dairy products divided by the mean amount of dairy products consumed in the general population is the same for any two age groups. These two assumptions, of constant RSD and constant mean ratio, were used to infer the parameters of the gamma distributions for the home-produced foods from those of the general population (i.e., mean, standard deviation, shape, and scale).

Table L-9. Dairy Products (Milk) Consumption Data and Distributions

Source	Age Cohort	Data (g WW/kg-d)									Distributions		
		Data Mean	Data SDev	P05	P10	P25	P50	P75	P90	P95	Distribu-tion	Pop-Estd Shape	Pop-Estd Scale
CSFII (gen)	All	6.81	10.8	0.199	0.392	1.14	3.25	7.59	16.9	26.1			
CSFII (gen)	1-5	27.4	22.3	1.12	4.39	12.2	22.3	37.1	55.9	70.1			
CSFII (gen)	6-11	14	10	0.826	2.16	6.48	12.3	19.2	27.3	33.5			
CSFII (gen)	12-19	6.2	5.87	0.264	0.484	1.88	4.55	8.88	13.5	17.8			
CSFII (gen)	20-69	3.23	3.3	0.162	0.303	0.854	2.22	4.48	7.45	9.88			
HP	1-5										Gamma	0.961	61.80
HP	6-11										Gamma	0.961	31.40
HP	12-19										Gamma	0.961	13.90
EFH (HP)	20_39	7.41	6.12	0.396	0.446	1.89	6.46	12.1	15.4	19.5	Gamma	0.961	8.01
EFH (HP)	All	14	15.28	0.446	0.508	3.18	10.2	19.5	34.2	44	Gamma	0.78	18.26
EFH (HP)	Adult farmer	17.1	15.8	0.736	3.18	9.06	12.1	20.4	34.9	44	Gamma	1.38	11.85

CSFII = USDA (1997); gen = general population data; EFH = U.S. EPA (1997b); HP = home-produced data; P05-P95 = Percentiles; Sdev = standard deviation; Pop-Estd = population-estimated

L.2.4.7 <u>Beef Consumption</u>. Table L-10 presents beef consumption data and distributions. Home-produced beef consumption data were obtained from Table 13-36 of the EFH (U.S. EPA, 1997b). Data (in g WW/kg-d) were presented for farmers and those aged 6 to 11, 12 to 19, 20 to 39, and 40 to 69. Percentile data were used to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select the most appropriate model.

Data were not available for those aged 1 to 2 and 3 to 5. For beef consumption for 1- to 5-year-olds, the lognormal model was used because, among the other age groups, it was the best-fitted model in all but one case. The population-estimated mean and standard deviation for 6- to 11-year-olds were used for 1- to 5-year-olds for the analysis (normalized for body weight) and are supported by data in Table 11-3 (per capita intake for beef, including store-bought products), which indicate that those aged 1 to 2, 3 to 5, and 6 to 11 have the highest consumption rate of beef on a g/kg-d basis.

Beef consumption rate data were adjusted to account for food preparation and cooking losses. A mean net cooking loss of 27 percent accounts for dripping and volatile losses during cooking (averaged over various cuts and preparation methods). A mean net postcooking loss of 24 percent accounts for losses from cutting, shrinkage, excess fat, bones, scraps, and juices. These data were obtained from Table 13-5 of the EFH (U.S. EPA, 1997b).

Table L-10. Beef Consumption Data and Distributions

		EFH Data (g WW/kg-d)											Distributions		
Age Cohort	N	Data Mean	Data SDev	P01	P05	P10	P25	P50	P75	P90	P95	P99	Distribution	Pop-Estd Mean	Pop-Estd SDev
1-5		ND	ND										Lognormal	3.88	4.71
6-11	38	3.77	3.662		0.663	0.753	1.32	2.11	4.43	11.4	12.5		Lognormal	3.88	4.71
12-19	41	1.72	1.044		0.478	0.513	0.896	1.51	2.44	3.53	3.57		Gamma	1.77	1.12
Adult farmer	182	2.63	2.644	0.27	0.394	0.585	0.896	1.64	3.25	5.39	7.51	11.3	Lognormal	2.5	2.69

N = Number of samples; P01-P99 = Percentiles; Pop-Estd = Population-estimated; SDev = Standard deviation.

L.2.4.8 <u>Fish Consumption</u>. Table L-11 presents fish consumption data and distributions. Fish consumption data were obtained from Table 10-64 of the EFH (U.S. EPA, 1997b). Data (in g/d) were available for freshwater anglers in Maine. The Maine fish consumption study was one of four recommended freshwater angler studies in the EFH (U.S. EPA, 1997b). The other recommended fish consumption studies (i.e., Michigan and New York) had large percentages of anglers who fished from the Great Lakes, which is not consistent with the modeling scenarios used in this risk analysis. The anglers in the Maine study fished from streams, rivers, and ponds; these data are more consistent with modeling scenarios for this risk analysis. Although the Maine data have a lower mean than the Michigan data, the Maine data compared better with a national USDA study. Also, the Maine study had percentile data available, which were necessary to develop a distribution.

Percentile data were used to fit parametric models (gamma, lognormal, and Weibull) and measures of goodness of fit were used to select lognormal as the most appropriate model. The fraction of consumed T3 and T4 fish was 0.36 and 0.64, respectively (Table 10-66, U.S. EPA, 1997b).

Table L-11. Fish Consumption Data and Distributions

		EFH Data (g/d)							Distributions		
Age Cohort	N	Data Mean	Data SDev	P50	P66	P75	P90	P95	Distribution	Pop-Estd Mean	Pop-Estd SDev
All ages	1,053	6.4		2	4	5.8	13	26	Lognormal	6.48	19.9

N = Number of samples; P50-P95 = Percentiles; Pop-Estd = Population-estimated; SDev = Standard deviation.

L.2.4.9 <u>Drinking Water Intake</u>. Table L-12 presents drinking water intake data and distributions. Drinking water intake data were obtained from Table 3-6 of the EFH (U.S. EPA, 1997a). Data (in mL/d) were presented by age groups. Weighted averages of percentiles, means, and standard deviations were calculated for the three child age groups and adults.

Table L-12. Drinking Water Intake Data and Distributions

EFH Data (mL/d)													Distributions		
Age Cohort	N	Data Mean	Data SDev	P01	P05	P10	P25	P50	P75	P90	P95	P99	Distribution	Pop-Estd Mean	Pop-Estd SDev
1-5	3,200	697.1	401.5	51.62	187.6	273.5	419.2	616.5	900.8	1,236	1,473	1,917	Gamma	698	406
6-11	2,405	787	417	68	241	318	484	731	1,016	1,338	1,556	1,998	Gamma	787	430
12-19	5,801	963.2	560.6	65.15	241.4	353.8	574.4	868.5	1,247	1,694	2,033	2,693	Gamma	965	574
20+	13,394	1,384	721.6	207.6	457.5	607.3	899.6	1,275	1,741	2,260	2,682	3,737	Gamma	1,383	703

N = Number of samples; P01-P99 = Percentiles; Pop-Estd = Population-estimated; SDev = Standard deviation.

Percentile data were used to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select the most appropriate model.

L.2.4.10 <u>Shower Parameters</u>. Table L-13 presents shower parameters and distributions. Percentile data for time spent taking a shower, time spent in the shower stall after showering, and time spent in the bathroom immediately following a shower were provided in EFH Tables 15-21, 15-23, and 15-32, respectively (U.S. EPA, 1997c). Percentile data were used to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select the most appropriate model for each variable. Fixed shower model parameters are presented in Table L-14.

Table L-13. Shower Parameters and Distributions

EFH Data (minutes)													Distributions		
Parameter	**Age Cohort**	**N**	**P02**	**P10**	**P25**	**P50**	**P75**	**P90**	**P95**	**P98**	**P99**	**Distribution**	**Pop-Estd Shape**	**Pop-Estd Scale**
Time spent showering	all ages	3,547	4	5	10	15	20	30	35	50	60	gamma	2.83	5.89
Time spent in shower stall after showering	all ages	3,533		1	3	5	10	20	30	40	50	Weibull	0.96	8.36
Time spent in bathroom after shower	all ages	4,182		1	4	5	15	20	30	40	60	Weibull	0.98	9.75

N = number of samples; P02-P99 = percentiles; Pop-Estd = population-estimated.

Table L-14. Fixed Shower Parameters

Description	Value	Units	Source
Diameter of shower water drop	0.098	cm	RTI-derived value
Terminal velocity of water drop	400	cm/s	RTI-derived value
Height of shower head	1.8	m	Little (1992)
Volumetric exchange rate between the bathroom and the house	300	L/min	RTI-derived value based on McKone (1987) data
Volumetric exchange rate between the shower and the bathroom	100	L/min	RTI-derived value based on McKone (1987) data
Rate of water flow from shower head	10	L/min	RTI-derived value based on Little (1992) data
Volume of the bathroom	10	m^3	McKone (1987)
Volume of shower	2	m^3	McKone (1987)

L.2.4.11 <u>Body Weight</u>. Table L-15 presents body weight data and distributions. Body weight data were obtained from Tables 7-2 through 7-7 of the EFH (U.S. EPA, 1997a). Data (in kg) were presented by age and gender. Weighted averages of percentiles, means, and standard deviations were calculated for 1- to 5-year-olds, 6- to 11-year-olds, 12- to 19-year-olds, and adult age groups; male and female data were weighted and combined for each age group. These percentile data were used as the basis for fitting distributions. These data were analyzed to fit parametric models (gamma, lognormal, and Weibull) using maximum likelihood estimation. Measures of goodness of fit were used to select the most appropriate model.

Table L-15. Body Weight Data and Distributions

Age Cohort	N	EFH Data (kg)											Distributions		
		Data Mean	Data SDev	P05	P10	P15	P25	P50	P75	P85	P90	P95	Distribution	Pop-Estd Mean	Pop-Estd SDev
1-5	3,762	15.52	3.719	12.5	13.1	13.45	14.03	15.26	16.67	17.58	18.32	19.45	Lognormal	15.5	2.05
6-11	1,725	30.84	9.561	22.79	24.05	25.07	26.44	29.58	33.44	36.82	39.66	43.5	Lognormal	30.7	5.96
12-19	2,615	58.45	13.64	43.84	46.52	48.31	50.94	56.77	63.57	68.09	71.98	79.52	Lognormal	58.2	10.2
20+	12,504	71.41	15.45	52.86	55.98	58.21	61.69	69.26	78.49	84.92	89.75	97.64	Lognormal	71.2	13.3

N = Number of samples; P05-P95 = Percentiles; Pop-Estd = Population-estimated; SDev = Standard deviation.

L.2.4.12 <u>Exposure Duration</u>. Table L-16 presents exposure duration data and distributions. Exposure duration was assumed to be equivalent to the average residence time for each receptor. Exposure durations for adult and child residents were determined using data on residential occupancy from the EFH, Table 15-168 (U.S. EPA, 1997c). The data represent the total time a person is expected to live at a single location, based on age. The table presented male and female data combined. Adult resident aged 21 to 90 were pooled. For children, the 3-year-old age group was used to represent 1- to 5-year-olds.

In an analysis of residential occupancy data, Myers et al. (U.S. EPA, 2000) found that the data, for most ages, were best fit by a Weibull distribution. The Weibull distribution as implemented in Crystal Ball® is characterized by three parameters: location, shape, and scale. Location is the minimum value and, in this case, was presumed to be 0. Shape and scale were determined by fitting a Weibull distribution to the pooled data, as follows. To pool residential occupancy data for the age cohorts, an arithmetic mean of data means was calculated for each age group. Then, assuming a Weibull distribution, the variance within each age group (e.g., 3-year-olds) was calculated in the age cohort. These variances in turn were pooled over the age cohort using equal weights. This is not the usual type of pooled variance, which would exclude the variation in the group means. However, this way the overall variance reflected the variance of means within the age groups (e.g., within the 3-year-old age group). The standard deviation was estimated as the square root of the variance. The coefficient of variation was calculated as the ratio of the standard deviation divided by the Weibull mean. For each cohort, the population-estimated parameter uncertainty information (e.g., shape and scale) was calculated based on a Weibull distribution, the calculated data mean for the age cohort, and the CV.

Exposure duration for adult farmers was determined using data on residential occupancy from the EFH, Tables 15-163 and 15-164 (U.S. EPA, 1997c). The data represent the total time a person is expected to live at a single location, based on household type. Age-specific data were not provided. For residence duration of farmers (U.S. EPA 1997c, Tables 15-163 and 15-164), the gamma model was used because it was the best-fitted model in five age groups and was the second-best-fitted model in two cases (based on data in U.S. EPA 1997c, Tables 15-167 and 15-168). A population mean of 18.07 years and a population standard deviation of 23.19 years were calculated for adult farmers.

Table L-16. Exposure Duration Data and Distributions

EFH Data		Distributions		
Age Cohort	**Data Mean (yr)**	**Distribution**	**Pop-Estd Shape (yr)[a]**	**Pop-Estd Scale (yr)**
Child (1- to 5-yr-olds)	6.5	Weibull	1.32	7.059
Adult resident	16.0	Weibull	1.34	17.38
Adult farmer	18.75	Gamma	0.607	29.76

Pop-Estd = Population-estimated.
[a] Distributions used in risk assessment.

L.3 References

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Appendix M

Bioaccumulation Factors and Bioconcentration Factors Used in the Ecological Screening Analysis

Appendix M

Bioaccumulation Factors and Bioconcentration Factors Used in the Ecological Screening Analysis

M1.0 Introduction

Bioaccumulation factors (BAFs) are used to estimate contaminant concentrations in food items for the ecological ingestion pathway analysis, as given by Equation M-1. The BAF values used in the screening analysis are presented in Table M-1.

$$C_{diet\ Aj} = ConcMedium_A \times BAF_{Aj} \tag{M-1}$$

C_diet_{Aj}.	=	Concentration of chemical A in diet item j (mg/kgWW)
$ConcMedium_A$.	=	Concentration of chemical A in soil (mg/kg) or surface water (mg/L)
BAF_{Aj}	=	Soil BAF for chemical A, diet item j [(mg/kgWW) /(mg/kg/soil)] or Surface water BAF, diet item j [mg/kgWW/mg/L water]

Concentrations in aquatic food items, such as fish and aquatic plants, are calculated using biological uptake values identified in EPIWIN. These values are presented in EPIWIN as bioconcentration factors (BCFs) for fish. BCFs are a measure of chemical accumulation associated with exposure to the surrounding media only (e.g., surface water), whereas BAFs are associated primarily with the additive exposure from both ingestion and contact with the surrounding media. The uptake pathways for the EPIWIN BCFs are not explicit in the EPIWIN documentation and may in some cases include ingestion (U.S. EPA, 2000). Therefore, for simplicity, the term “BAF” is used in Equation M-1 for the biological uptake in both terrestrial and aquatic food items and refers to a ratio derived from empirical data.

The BAFs for aquatic food items are the ratio of the concentration in the food item to the concentration in surface water. These same BAF values are used for aquatic food items in the ecological analysis and to estimate whole fish concentrations for the human fish ingestion pathway. The majority of aquatic BAFs were selected from EPIWIN, which executes several algorithms to estimate BAFs from a chemical’s log K_{ow}. For several chemicals, empirical data were identified in the literature. Data for biouptake into aquatic food items other than fish were not identified, and the fish BAFs were used for all three types of aquatic food items in the ecological receptors’ diets—fish, sediment invertebrates, and aquatic plants.

Soil BAFs were used for terrestrial prey items, such as small mammals and soil invertebrates. BAFs are the ratio of the concentration in the food item to the concentration in soil and generally reflect uptake through ingestion. BAFs for organic constituents are generally lacking, and a suitable equation for estimating BAFs was not identified in the literature. Therefore, a default BAF of 1 was assumed for terrestrial prey items for organics. A discussion of the sources of BAF values for metal contaminants is presented below.

Many receptors assessed in the ingestion pathway analysis also eat a variety of terrestrial plant items, such as roots, grains, and forage. Uptake from soil into these food items is calculated using uptake factors specific to vegetation (Br variables), which are described in Appendix E of this document. The plant concentrations used in the ecological screening are the same as those used to estimate human exposure but are converted to a wet weight basis. The moisture adjustment factors used to convert the plant concentrations are shown in Appendix F.

M2.0 BAFs for Metals

The screening analysis addresses four metal constituents in sewage sludge—barium, beryllium, manganese, and silver. Three compendia of information were consulted for metal BAFs for soil:

1. Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II, and T.L. Ashwood. 1998a. *Development and Validation of Bioaccumulation Models for Earthworms*. ES/ER/TM-220. Oak Ridge National Laboratory, Oak Ridge, TN.

2. Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998b. *Development and Validation of Bioaccumulation Models for Small Mammals*. ES/ER/TM-221. Oak Ridge National Laboratory, Oak Ridge, TN.

3. U.S. Army. 2001. *Development of Terrestrial Exposure and Bioaccumulation Information for the Army Risk Assessment Modeling System (ARAMS)*. Center for Health Promotion and Preventative Medicine, Health Effects Research Program, Aberdeen Proving Ground, MD.

The BAFs for metals used in the analysis were taken from the two Sample et al. documents (Sample et al., 1998a and 1998b). These documents present median uptake factors calculated based on empirical data sets. The third document (U.S. Army, 2001) is a collection of recommended values identified in the literature; the values in this reference for the four sewage sludge metals were all taken from Sample et al. (1998a and 1998b).

The BAFs used in the screening analysis for worms and other soil invertebrates were derived from data for earthworms and assume a linear relationship between the concentration in soil and in food items. Median values were used in all cases. Available BAFs for terrestrial vertebrates consist of small mammal BAFs. These are median values derived from data for a variety of small mammals and also assume a linear relationship between concentrations in soil and concentrations in prey items. Although it has been shown that bioaccumulation in soil invertebrates and in small mammals is nonlinear, these values are relatively conservative and, therefore, are considered adequate for a screening analysis.

Data for terrestrial prey other than small mammals are generally lacking in the literature. Therefore, the BAFs for small mammals were also used to estimate concentrations in the other terrestrial vertebrate prey, including larger omnivorous and herbivorous vertebrates, small birds, and herpetofauna. There is uncertainty associated with using small mammal BAFs to estimate concentrations in other terrestrial vertebrates; however, this uncertainty has not been quantified. Given the lack of available BAF data, this approach was assumed to be reasonable.

The BAFs reported in Sample et al. (1998a and 1998b) are expressed in terms of dry weight of the prey item. Therefore, they were converted to a wet weight basis using Equation M-2 (U.S. Army, 2001).

$$C_{wet} = C_{dry} \times P_{dry} \qquad \text{(M-2)}$$

where

C_{wet} = wet weight concentration
C_{dry} = dry weight concentration
P_{dry} = proportion of dry matter content of food item.

Values for P_{dry} for worms (16%) and small mammals (32%) were taken from the EPA Wildlife Exposure Factors Handbook (U.S. EPA, 1993).

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Acetophenone (98-86-2)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	4.70E-01	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	4.70E-01	EPIWIN (v3.10)
Anthracene (120-12-7)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	5.30E+02	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	5.30E+02	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Azinphos Methyl (86-50-0)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	2.60E+01	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	2.60E+01	EPIWIN (v3.10)
Barium and Compounds (7440-39-3)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.80E-02	Sample et al., 1998b
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.80E-02	Sample et al., 1998b
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.80E-02	Sample et al., 1998b
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.80E-02	Sample et al., 1998b
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.80E-02	Sample et al., 1998b
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.46E-02	Sample et al., 1998b
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.46E-02	Sample et al., 1998a
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.20E+00	Default value
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.20E+00	Default value

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Benzoic Acid (65-85-0)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)
Beryllium and Compounds (7440-41-7)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	4.80E-05	Sample et al., 1998b
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	4.80E-05	Sample et al., 1998b
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	4.80E-05	Sample et al., 1998b
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	4.80E-05	Sample et al., 1998b
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	4.80E-05	Sample et al., 1998b
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	7.20E-03	Sample et al., 1998b
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	7.20E-03	Sample et al., 1998a
BCF_Bff	Sediment to biota bioaccumulation (unitless)	1.90E+01	Barrows et al., 1980
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	1.90E+01	Barrows et al., 1980

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Biphenyl, 1,1- (92-52-4)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	2.30E+02	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	2.30E+02	EPIWIN (v3.10)
Butyl Benzyl Phthalate (85-68-7)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	8.80E+02	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	8.80E+02	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Carbon Disulfide (75-15-0)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	6.20E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	6.20E+00	EPIWIN (v3.10)
Chloroaniline, 4- (106-47-8)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	5.10E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	5.10E+00	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Chlorobenzene (108-90-7)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.10E+01	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.10E+01	EPIWIN (v3.10)
Chlorobenzilate (510-15-6)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	8.90E+02	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	8.90E+02	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Chlorpyrifos (2921-88-2)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	1.30E+03	RED/IRED
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	1.30E+03	RED/IRED
Cresol, o- (95-48-7)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	6.30E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	6.30E+00	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Diazinon (333-41-5)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	5.40E+02	RED/IRED
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	5.40E+02	RED/IRED
Dichloroethene, 1,2-trans- (156-60-5)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	8.10E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	8.10E+00	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Dichloromethane (75-09-2)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	1.80E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	1.80E+00	EPIWIN (v3.10)
Dioxane, 1,4- (123-91-1)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Endrin (72-20-8)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	2.00E+03	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	2.00E+03	EPIWIN (v3.10)
Ethyl p-nitrophenyl Phenylphosphorothioate (2104-64-5)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	9.60E+02	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	9.60E+02	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Fluoranthene (206-44-0)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	1.90E+03	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	1.90E+03	EPIWIN (v3.10)
Hexachlorocyclohexane, alpha- (319-84-6)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.10E+02	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.10E+02	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Hexachlorocyclohexane, beta- (319-85-7)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.10E+02	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.10E+02	EPIWIN (v3.10)
Isobutyl Alcohol (78-83-1)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Manganese (7439-96-5)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	6.56E-03	Sample et al., 1998b
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	6.56E-03	Sample et al., 1998b
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	6.56E-03	Sample et al., 1998b
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	3.20E+00	EPIWIN (v3.10)
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	6.56E-03	Sample et al., 1998b
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	3.20E+00	EPIWIN (v3.10)
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	8.64E-03	Sample et al., 1998a
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.20E+00	Default value
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.20E+00	Default value
MIBK (108-10-1)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	2.00E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	2.00E+00	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Naled (300-76-5)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.80E-01	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.80E-01	EPIWIN (v3.10)
Nitrosodiphenylamine, N- (86-30-6)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	5.10E+01	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	5.10E+01	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Phenol (108-95-2)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	2.70E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	2.70E+00	EPIWIN (v3.10)
Pyrene (129-00-0)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	1.10E+03	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	1.10E+03	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Silver and Compounds (7440-22-4)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.28E-03	Sample et al., 1998b
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.28E-03	Sample et al., 1998b
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.28E-03	Sample et al., 1998b
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.28E-03	Sample et al., 1998b
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.28E-03	Sample et al., 1998b
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	3.27E-01	Sample et al., 1998b
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	3.27E-01	Sample et al., 1998a
BCF_Bff	Sediment to biota bioaccumulation (unitless)	0.00E+00	Barrows et al., 1980
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	0.00E+00	Barrows et al., 1980
Sodium Nitrite (7632-00-0)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.20E+00	Default value
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.20E+00	Default value

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Total Nitrate Nitrogen (14797-55-8)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.20E+00	Default value
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.20E+00	Default value
Trichlorofluoromethane (75-69-4)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	1.80E+01	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	1.80E+01	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Trichlorophenoxy) Propionic Acid, 2-(2,4,5- (93-72-1)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)
Trichlorophenoxyacetic Acid, 2,4,5- (93-76-5)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	3.20E+00	EPIWIN (v3.10)

Table M-1. Bioaccumulation and Bioconcentration Factors for Ecological Analysis

Parameter	Description	Value	Reference
Trifluralin (1582-09-8)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	2.60E+03	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	2.60E+03	EPIWIN (v3.10)
Xylenes (1330-20-7)			
BAF_HerbVert	Soil to tissue bioaccumulation for herbivorous vertebrates (unitless)	1.00E+00	Default value
BAF_OmnVert	Soil to tissue bioaccumulation for omnivorous vertebrates (unitless)	1.00E+00	Default value
BAF_SmBirds	Soil to tissue bioaccumulation for small birds (unitless)	1.00E+00	Default value
BAF_SmHerp	Soil to tissue bioaccumulation for small herpetofauna (unitless)	1.00E+00	Default value
BAF_SmMammals	Soil to tissue bioaccumulation for small mammals (unitless)	1.00E+00	Default value
BAF_SoilInvert	Soil to tissue bioaccumulation for soil invertebrates (unitless)	1.00E+00	Default value
BAF_Worms	Soil to tissue bioaccumulation for worms (unitless)	1.00E+00	Default value
BCF_Bff	Sediment to biota bioaccumulation (unitless)	5.00E+01	EPIWIN (v3.10)
BCF_WaterVeg	Surface water to aquatic plants bioaccumulation (unitless)	5.00E+01	EPIWIN (v3.10)

Appendix N

Ecological Exposure Factors

Appendix N

Ecological Exposure Factors

Ecological exposure factors are receptor-specific parameters used to estimate exposure dose for the ingestion pathway. Exposure dose was calculated as a function of ingestion rate, body weight, and the concentrations in the various diet items. In addition to prey and plant items, drinking water consumption and soil and sediment ingestion, as a fraction of total diet, were accounted for (Equation N-1).

$$Dose_A = \frac{\sum \left(IR_{diet} \times C_{diet\ Aj} \times DietFrac_j\right) + \left(C_{soil/sed\ A} \times IR_{diet} \times S_{frac}\right) + \left(ConcSW_A \times IR_{water}\right)}{BW} \quad \text{(N-1)}$$

$Dose_A$	=	Exposure dose for chemical A (mg/kg-d)
IR_{diet}	=	Species-specific dietary ingestion rate (kg WW/d)
$C_{diet\ Aj}$	=	Concentration of chemical A in diet item j (mg/kg WW); see Appendix M)
$DietFrac_j$	=	Fraction of diet consisting of item j (unitless).
$C_{soil/sed\ A}$	=	Concentration of chemical A in soil or sediment (mg/kg)
S_{frac}	=	Fraction of soil or sediment in the diet (unitless)
$ConcSW_A$	=	Concentration of chemical A in surface water (mg/L)
IR_{water}	=	Species-specific water ingestion rate (L/d)
BW	=	Species-specific average adult body weight (kg).

Tables N-1 through N-27 show the exposure parameter data used in the ecological screening, along with the data sources. Body weights and ingestion rates were taken primarily from EPA's *Wildlife Exposure Factors Handbook* (U.S. EPA, 1993) and Sample et al. (1997). Average adult body weights and adult ingestion rates were used throughout the assessment. Species-specific dietary composition data were taken from a variety of sources, as shown in Table N-30.

Dietary composition for each receptor was based on species-specific data on foraging and feeding behavior and reflected a year-round adult diet. The receptor diets were constructed to represent variability in feeding habits. Diet items are grouped in 17 categories, including different types of vegetation (e.g., fruits, forage, grain, roots)

Diet Items For Ingestion Exposure

Terrestrial Prey Types	**Vegetation**
Worms	Aquatic plants
Other soil invertebrates	Exposed fruits
Small mammals	Exposed vegetables
Small birds	Forage
Small herpetofauna	Roots
Herbivorous vertebrates	Silage
Omnivorous vertebrates	Grains
Aquatic Prey Types	**Other**
Benthic filter feeders	Soil
Trophic level 3 fish	Sediment
Trophic level 4 fish	Surface water

and several categories of prey (e.g., small birds, small mammals, invertebrates, fish; see text box). For example, the American robin's dietary percentage ranges are as follows (Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996):

Diet Item	Dietary Percentage Range
Soil invertebrates (other than earthworms)	8 to 93
Fruits	7 to 92
Earthworms	15 to 27
Forage	0 to 24

Each receptor's diet was constructed using the midpoints of the dietary percentage ranges, beginning with the item with highest midpoint value and proceeding through the diet items until a full diet (100 percent) was accumulated. Thus, the robin's diet would consist of 50.5 percent soil invertebrates and 49.5 percent fruits, based on the following dietary percentage midpoints:

Diet Item	Dietary Percentage Midpoint
Soil invertebrates	50.5
Fruits	49.5
Earthworms	21
Forage	12

The dietary composition used for each receptor species is presented with other ecological exposure data in Tables N-1 through N-29.

Table N-1. Ecological Exposure Factors for American Kestrel

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.119	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.096	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.014	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.01	EPA, 1993
DF_2	Midpoint diet fraction for Other invertebrates	0.38	Multiple sources; see Table N-30
DF_3	Midpoint diet fraction for Small mammals	0.255	Multiple sources; see Table N-30
DF_6	Midpoint diet fraction for Small birds	0.11	Multiple sources; see Table N-30
DF_20	Midpoint diet fraction for Small herpetofauna	0.255	Multiple sources; see Table N-30

Table N-2. Ecological Exposure Factors for American Robin

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.077	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.072	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.011	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.01	EPA, 1993
DF_2	Midpoint diet fraction for Other invertebrates	0.505	Multiple sources; see Table N-30
DF_11	Midpoint diet fraction for Exposed fruits	0.495	Multiple sources; see Table N-30

Table N-3. Ecological Exposure Factors for American Woodcock

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.177	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.124	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.019	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.104	EPA, 1993
DF_1	Midpoint diet fraction for Worms	0.851	Multiple sources; see Table N-30
DF_2	Midpoint diet fraction for Other invertebrates	0.090	Multiple sources; see Table N-30
DF_13	Midpoint diet fraction for Forage	0.059	Multiple sources; see Table N-30

Table N-4. Ecological Exposure Factors for Belted Kingfisher

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.147	EPA, 1993

CR_Food	Food consumption rate (Kg/day)	0.11	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.016	EPA, 1993
CRfrac_Sed	Sediment fraction as a receptor consumption rate (unitless)	0.059	EPA, 1993
DF_2	Midpoint diet fraction for Other invertebrates	0.25	Multiple sources; see Table N-30
DF_8	Midpoint diet fraction for T3 Fish	0.75	Multiple sources; see Table N-30

Table N-5. Ecological Exposure Factors for Black Bear

Parameter	Description	Value	Reference
BW	Body weight (Kg)	128.9	Schafer and Sargent, 1990
CR_Food	Food consumption rate (Kg/day)	24.33	Schafer and Sargent, 1990
CR_Water	Water consumption rate (L/day)	7.848	Schafer and Sargent, 1990
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.028	Schafer and Sargent, 1990
DF_2	Midpoint diet fraction for Other invertebrates	0.4	Multiple sources; see Table N-30
DF_8	Midpoint diet fraction for T3 Fish	0.025	Multiple sources; see Table N-30
DF_11	Midpoint diet fraction for Exposed fruits	0.4	Multiple sources; see Table N-30
DF_13	Midpoint diet fraction for Forage	0.175	Multiple sources; see Table N-30

Table N-6. Ecological Exposure Factors for Canada Goose

Parameter	Description	Value	Reference
BW	Body weight (Kg)	2.997	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.782	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.123	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.082	EPA, 1993
DF_13	Midpoint diet fraction for Forage	0.6	Multiple sources; see Table N-30
DF_14	Midpoint diet fraction for Grains	0.4	Multiple sources; see Table N-30

Table N-7. Ecological Exposure Factors for Coopers Hawk

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.405	Sample et al., 1997
CR_Food	Food consumption rate (Kg/day)	0.213	Sample et al., 1997
CR_Water	Water consumption rate (L/day)	0.032	Sample et al., 1997
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.01	Sample et al., 1997

DF_3	Midpoint diet fraction for Small mammals	0.43	Multiple sources; see Table N-30
DF_6	Midpoint diet fraction for Small birds	0.57	Multiple sources; see Table N-30

Table N-8. Ecological Exposure Factors for Coyote

Parameter	Description	Value	Reference
BW	Body weight (Kg)	13.13	Sample et al., 1997
CR_Food	Food consumption rate (Kg/day)	3.722	Sample et al., 1997
CR_Water	Water consumption rate (L/day)	1.005	Sample et al., 1997
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.028	Sample et al., 1997
DF_2	Midpoint diet fraction for Other invertebrates	0.056	Multiple sources; see Table N-30
DF_3	Midpoint diet fraction for Small mammals	0.4	Multiple sources; see Table N-30
DF_4	Midpoint diet fraction for Herbivorous vertebrates	0.103	Multiple sources; see Table N-30
DF_5	Midpoint diet fraction for Omnivorous vertebrates	0.103	Multiple sources; see Table N-30
DF_6	Midpoint diet fraction for Small birds	0.159	Multiple sources; see Table N-30
DF_11	Midpoint diet fraction for Exposed fruits	0.128	Multiple sources; see Table N-30
DF_20	Midpoint diet fraction for Small herpetofauna	0.051	Multiple sources; see Table N-30

Table N-9. Ecological Exposure Factors for Deer Mouse

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.02	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.018	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.003	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.02	EPA, 1993
DF_2	Midpoint diet fraction for Other invertebrates	0.325	Multiple sources; see Table N-30
DF_11	Midpoint diet fraction for Exposed fruits	0.235	Multiple sources; see Table N-30
DF_13	Midpoint diet fraction for Forage	0.055	Multiple sources; see Table N-30
DF_14	Midpoint diet fraction for Grains	0.385	Multiple sources; see Table N-30

Table N-10. Ecological Exposure Factors for Eastern Cottontail

Parameter	Description	Value	Reference
BW	Body weight (Kg)	1.226	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.530	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.119	EPA, 1993

CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.063	EPA, 1993
DF_13	Midpoint diet fraction for Forage	0.824	Multiple sources; see Table N-30
DF_16	Midpoint diet fraction for Silage	0.176	Multiple sources; see Table N-30

Table N-11. Ecological Exposure Factors for Great Blue Heron

Parameter	Description	Value	Reference
BW	Body weight (Kg)	2.229	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.645	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.101	EPA, 1993
CRfrac_Sed	Sediment fraction as a receptor consumption rate (unitless)	0.094	EPA, 1993
DF_8	Midpoint diet fraction for T3 Fish	0.515	Multiple sources; see Table N-30
DF_9	Midpoint diet fraction for T4 Fish	0.485	Multiple sources; see Table N-30

Table N-12. Ecological Exposure Factors for Green Heron

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.226	Sample et al., 1997
CR_Food	Food consumption rate (Kg/day)	0.145	Sample et al., 1997
CR_Water	Water consumption rate (L/day)	0.022	Sample et al., 1997
CRfrac_Sed	Sediment fraction as a receptor consumption rate (unitless)	0.094	Sample et al., 1997
DF_1	Midpoint diet fraction for Worms	0.106	Multiple sources; see Table N-30
DF_2	Midpoint diet fraction for Other invertebrates	0.126	Multiple sources; see Table N-30
DF_3	Midpoint diet fraction for Small mammals	0.025	Multiple sources; see Table N-30
DF_8	Midpoint diet fraction for T3 Fish	0.657	Multiple sources; see Table N-30
DF_13	Midpoint diet fraction for Forage	0.015	Multiple sources; see Table N-30
DF_20	Midpoint diet fraction for Small herpetofauna	0.056	Multiple sources; see Table N-30

Table N-13. Ecological Exposure Factors for Least Weasel

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.041	Sample et al., 1997
CR_Food	Food consumption rate (Kg/day)	0.032	Sample et al., 1997
CR_Water	Water consumption rate (L/day)	0.006	Sample et al., 1997
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.01	Sample et al., 1997

DF_2	Midpoint diet fraction for Other invertebrates	0.059	Multiple sources; see Table N-30
DF_3	Midpoint diet fraction for Small mammals	0.882	Multiple sources; see Table N-30
DF_6	Midpoint diet fraction for Small birds	0.059	Multiple sources; see Table N-30

Table N-14. Ecological Exposure Factors for Little Brown Bat

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.009	Sample et al., 1997
CR_Food	Food consumption rate (Kg/day)	0.009	Sample et al., 1997
CR_Water	Water consumption rate (L/day)	0.001	Sample et al., 1997
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0	Sample et al., 1997
DF_2	Midpoint diet fraction for Other invertebrates	1	Multiple sources; see Table N-30

Table N-15. Ecological Exposure Factors for Long-Tailed Weasel

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.189	Sample et al., 1997
CR_Food	Food consumption rate (Kg/day)	0.114	Sample et al., 1997
CR_Water	Water consumption rate (L/day)	0.022	Sample et al., 1997
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.028	Sample et al., 1997
DF_1	Midpoint diet fraction for Worms	0.052	Multiple sources; see Table N-30
DF_2	Midpoint diet fraction for Other invertebrates	0.052	Multiple sources; see Table N-30
DF_3	Midpoint diet fraction for Small mammals	0.503	Multiple sources; see Table N-30
DF_4	Midpoint diet fraction for Herbivorous vertebrates	0.131	Multiple sources; see Table N-30
DF_5	Midpoint diet fraction for Omnivorous vertebrates	0.131	Multiple sources; see Table N-30
DF_6	Midpoint diet fraction for Small birds	0.131	Multiple sources; see Table N-30

Table N-16. Ecological Exposure Factors for Mallard Duck

Parameter	Description	Value	Reference
BW	Body weight (Kg)	1.170	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.424	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.066	EPA, 1993
CRfrac_Sed	Sediment fraction as a receptor consumption rate (unitless)	0.033	EPA, 1993
DF_2	Midpoint diet fraction for Other invertebrates	0.25	Multiple sources; see Table N-30

DF_14	Midpoint diet fraction for Grains	0.75	Multiple sources; see Table N-30

Table N-17. Ecological Exposure Factors for Meadow Vole

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.021	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.019	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.003	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.024	EPA, 1993
DF_13	Midpoint diet fraction for Forage	0.75	Multiple sources; see Table N-30
DF_14	Midpoint diet fraction for Grains	0.075	Multiple sources; see Table N-30
DF_15	Midpoint diet fraction for Roots	0.175	Multiple sources; see Table N-30

Table N-18. Ecological Exposure Factors for Mink

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.992	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.446	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.098	EPA, 1993
CRfrac_Sed	Sediment fraction as a receptor consumption rate (unitless)	0.094	EPA, 1993
DF_2	Midpoint diet fraction for Other invertebrates	0.1	Multiple sources; see Table N-30
DF_8	Midpoint diet fraction for T3 Fish	0.45	Multiple sources; see Table N-30
DF_9	Midpoint diet fraction for T4 Fish	0.45	Multiple sources; see Table N-30

Table N-19. Ecological Exposure Factors for Muskrat

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.873	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.401	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.088	EPA, 1993
CRfrac_Sed	Sediment fraction as a receptor consumption rate (unitless)	0.033	EPA, 1993
DF_7	Midpoint diet fraction for Benthic filter feeders	0.07	Multiple sources; see Table N-30
DF_13	Midpoint diet fraction for Forage	0.415	Multiple sources; see Table N-30

Table N-20. Ecological Exposure Factors for Northern Bobwhite

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.191	EPA, 1993

CR_Food	Food consumption rate (Kg/day)	0.130	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.019	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.093	EPA, 1993
DF_2	Midpoint diet fraction for Other invertebrates	0.181	Multiple sources; see Table N-30
DF_11	Midpoint diet fraction for Exposed fruits	0.126	Multiple sources; see Table N-30
DF_13	Midpoint diet fraction for Forage	0.126	Multiple sources; see Table N-30
DF_14	Midpoint diet fraction for Grains	0.568	Multiple sources; see Table N-30

Table N-21. Ecological Exposure Factors for Prairie Vole

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.042	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.033	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.006	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.024	EPA, 1993
DF_11	Midpoint diet fraction for Exposed fruits	0.075	Multiple sources; see Table N-30
DF_13	Midpoint diet fraction for Forage	0.75	Multiple sources; see Table N-30
DF_15	Midpoint diet fraction for Roots	0.175	Multiple sources; see Table N-30

Table N-22. Ecological Exposure Factors for Raccoon

Parameter	Description	Value	Reference
BW	Body weight (Kg)	5.691	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	1.873	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.474	EPA, 1993
CRfrac_Sed	Sediment fraction as a receptor consumption rate (unitless)	0.094	EPA, 1993
DF_2	Midpoint diet fraction for Other invertebrates	0.445	Multiple sources; see Table N-30
DF_11	Midpoint diet fraction for Exposed fruits	0.555	Multiple sources; see Table N-30

Table N-23. Ecological Exposure Factors for Red Fox

Parameter	Description	Value	Reference
BW	Body weight (Kg)	4.532	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	1.553	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.386	EPA, 1993

CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.028	EPA, 1993
DF_3	Midpoint diet fraction for Small mammals	0.51	Multiple sources; see Table N-30
DF_6	Midpoint diet fraction for Small birds	0.19	Multiple sources; see Table N-30
DF_11	Midpoint diet fraction for Exposed fruits	0.3	Multiple sources; see Table N-30

Table N-24. Ecological Exposure Factors for Red-Tailed Hawk

Parameter	Description	Value	Reference
BW	Body weight (Kg)	1.131	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.415	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.064	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.01	EPA, 1993
DF_2	Midpoint diet fraction for Other invertebrates	0.125	Multiple sources; see Table N-30
DF_3	Midpoint diet fraction for Small mammals	0.5	Multiple sources; see Table N-30
DF_4	Midpoint diet fraction for Herbivorous vertebrates	0.125	Multiple sources; see Table N-30
DF_5	Midpoint diet fraction for Omnivorous vertebrates	0.125	Multiple sources; see Table N-30
DF_6	Midpoint diet fraction for Small birds	0.125	Multiple sources; see Table N-30

Table N-25. Ecological Exposure Factors for Short-Tailed Shrew

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.015	EPA, 1993
CR_Food	Food consumption rate (Kg/day)	0.014	EPA, 1993
CR_Water	Water consumption rate (L/day)	0.004	EPA, 1993
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.01	EPA, 1993
DF_1	Midpoint diet fraction for Worms	0.417	Multiple sources; see Table N-30
DF_2	Midpoint diet fraction for Other invertebrates	0.333	Multiple sources; see Table N-30
DF_3	Midpoint diet fraction for Small mammals	0.056	Multiple sources; see Table N-30
DF_11	Midpoint diet fraction for Exposed fruits	0.056	Multiple sources; see Table N-30
DF_12	Midpoint diet fraction for Exposed vegetables	0.139	Multiple sources; see Table N-30

Table N-26. Ecological Exposure Factors for Short Tail Weasel

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.202	Sample et al., 1997

CR_Food	Food consumption rate (Kg/day)	0.120	Sample et al., 1997
CR_Water	Water consumption rate (L/day)	0.023	Sample et al., 1997
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.028	Sample et al., 1997
DF_2	Midpoint diet fraction for Other invertebrates	0.125	Multiple sources; see Table N-30
DF_3	Midpoint diet fraction for Small mammals	0.65	Multiple sources; see Table N-30
DF_6	Midpoint diet fraction for Small birds	0.125	Multiple sources; see Table N-30
DF_20	Midpoint diet fraction for Small herpetofauna	0.1	Multiple sources; see Table N-30

Table N-27. Ecological Exposure Factors for Tree Swallow

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.021	Sample et al., 1997
CR_Food	Food consumption rate (Kg/day)	0.031	Sample et al., 1997
CR_Water	Water consumption rate (L/day)	0.004	Sample et al., 1997
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.01	Sample et al., 1997
DF_2	Midpoint diet fraction for Other invertebrates	0.719	Multiple sources; see Table N-30
DF_11	Midpoint diet fraction for Exposed fruits	0.140	Multiple sources; see Table N-30
DF_13	Midpoint diet fraction for Forage	0.140	Multiple sources; see Table N-30

Table N-28. Ecological Exposure Factors for Western Meadowlark

Parameter	Description	Value	Reference
BW	Body weight (Kg)	0.106	Sample et al., 1997
CR_Food	Food consumption rate (Kg/day)	0.089	Sample et al., 1997
CR_Water	Water consumption rate (L/day)	0.013	Sample et al., 1997
CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0	Sample et al., 1997
DF_2	Midpoint diet fraction for Other invertebrates	0.857	Multiple sources; see Table N-30
DF_14	Midpoint diet fraction for Grains	0.143	Multiple sources; see Table N-30

Table N-29. Ecological Exposure Factors for White-Tailed Deer

Parameter	Description	Value	Reference
BW	Body weight (Kg)	69.42	Smith, 1991
CR_Food	Food consumption rate (Kg/day)	14.63	Smith, 1991
CR_Water	Water consumption rate (L/day)	4.497	Smith, 1991

CRfrac_Soil	Soil fraction as a receptor consumption rate (unitless)	0.068	Smith, 1991
DF_13	Midpoint diet fraction for Forage	0.75	Multiple sources; see Table N-30
DF_14	Midpoint diet fraction for Grains	0.25	Multiple sources; see Table N-30

Table N-30. Sources for Dietary Composition Data

Species	Scientific Name	References
American kestrel	*Falco sparverius*	Terres, 1980; U.S. EPA, 1993; Lane and Fischer, 1997; Stokes and Stokes, 1996
American robin	*Turdus migratorius*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
American woodcock	*Scolopax minor*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Belted kingfisher	*Ceryle alcyon*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Black bear	*Ursus americanus*	Schaefer and Sargent, 1990; Stokes and Stokes, 1986; Whitaker, 1997
Canada goose	*Branta canadensis*	Terres, 1980; U.S. EPA, 1993; Niering, 1985; Stokes and Stokes, 1996
Cooper's hawk	*Accipiter cooperi*	Terres, 1980; Sample et al., 1997; Stokes and Stokes, 1996
Coyote	*Canis latrans*	Bekoff, 1977; Sample et al, 1997; Whitaker, 1997; Stokes and Stokes, 1986
Deer mouse	*Peromyscus maniculatus*	Whitaker, 1997; U.S. EPA, 1993; Stokes and Stokes, 1986
Eastern cottontail rabbit	*Sylvilagus floridanus*	Stokes and Stokes, 1986; Chapman et al., 1980; Whitaker, 1997; U.S. EPA, 1993
Great blue heron	*Ardea herodias*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996; Niering, 1985
Green heron	*Butorides virescens*	Terres, 1980; Sample et al., 1997; Stokes and Stokes, 1996; Niering, 1985
Least weasel	*Mustela nivalis*	Whitaker, 1997; Stokes and Stokes, 1986; Sample et al., 1997
Little brown bat	*Myotis lucifugus*	Whitaker, 1997; Sample et al., 1997.
Long-tailed weasel	*Mustela frenata*	Sutton and Sutton, 1985; Sample et al., 1997; Stokes and Stokes, 1996
Mallard	*Anas platyrhynchos*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996; Niering, 1985
Meadow vole	*Microtus pennsylvanicus*	Whitaker, 1997; U.S. EPA, 1993; Stokes and Stokes, 1986
Mink	*Mustela vison*	Niering, 1985; U.S. EPA, 1993; Whitaker, 1997; Stokes and Stokes,1986
Muskrat	*Ondatra zibethicus*	Niering, 1985; U.S. EPA, 1993; Stokes and Stokes, 1986; Willner et al., 1980; Whitaker, 1997

(continued)

Table N-30. (continued)

Species	Scientific Name	References
Northern bobwhite	*Colinus virginianus*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Prairie vole	*Microtus ochrogaster*	Whitaker, 1997; U.S. EPA, 1993
Raccoon	*Procyon lotor*	Lotze and Andersen, 1979; U.S. EPA, 1993; Whitaker, 1997; Stokes and Stokes, 1986
Red fox	*Vulpes vulpes*	Whitaker, 1997; U.S. EPA, 1993; Stokes and Stokes, 1986
Red-tailed hawk	*Buteo jamaicensis*	Terres, 1980; U.S. EPA, 1993; Stokes and Stokes, 1996
Short-tailed shrew	*Blarina brevicauda*	Whitaker, 1997; U.S. EPA, 1993; Stokes and Stokes, 1986
Short-tailed weasel	*Mustela erminea*	King, 1983; Sample et al., 1997; Whitaker, 1997
Tree swallow	*Tachycineta bicolor*	Terres, 1980; Sample et al., 1997; Stokes and Stokes, 1996
Western meadowlark	*Sturnella neglecta*	Terres, 1980; Sample et al., 1997; Stokes and Stokes, 1996
White-tailed deer	*Odocoileus virginianus*	Whitaker, 1997; Stokes and Stokes, 1986; Smith, 1991

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Appendix O

Human Health-Based

Chemical Selection Process

December 19, 2003

Office of Water
Office of Science and Technology

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Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
AUR	Air unit risk
Cal EPA	California Environmental Protection Agency
CASRN	Chemical Abstracts Service Registry Number
CC	Critical concentration
CWA	Clean Water Act
EPA	U.S. Environmental Protection Agency
FQPA	Food Quality Protection Act
FY	Fiscal year
HEAST	Health effects assessment summary tables
HHB	Human health benchmark
HQ	Hazard quotient
IRED	Interim reregistration eligibility decision
IRIS	Integrated Risk Information System
MRL	Minimal risk level
NRC	National Research Council
NSSS	National sewage sludge survey
NTP	National Toxicology Program
OCD	Oral critical dose
OPP	Office of Pesticide Programs
OSF	Oral slope factor
OW	Office of Water
PAD	Population adjusted dose
PPRTV	Provisional peer reviewed toxicity values
RED	Reregistration eligibility decision
RfC	Reference concentration
RfD	Reference dose
TADI	Theoretical average daily intake
THQ	Theoretical hazard quotient
UL	Tolerable upper intake level

1. INTRODUCTION

Under the Clean Water Act, the U.S. EPA must periodically review sewage sludge regulations for the purpose of identifying additional toxic pollutants for potential regulations. Section 405(d)(2)(C) of the CWA states:

> "(C) Review. – From time to time, but not less often than every 2 years, the Administrator shall review the regulations promulgated under this paragraph for the purpose of identifying additional toxic pollutants and promulgating regulations for such pollutants consistent with the requirements of this paragraph."

As part of fulfilling this statutory requirement, EPA developed a screening process to identify chemicals in sewage sludge that qualify for exposure and hazard screening, and could qualify for further risk characterization and potential future regulatory action. The flowchart for the entire screening process is depicted in Figure 1 and a description of this screening process follows.

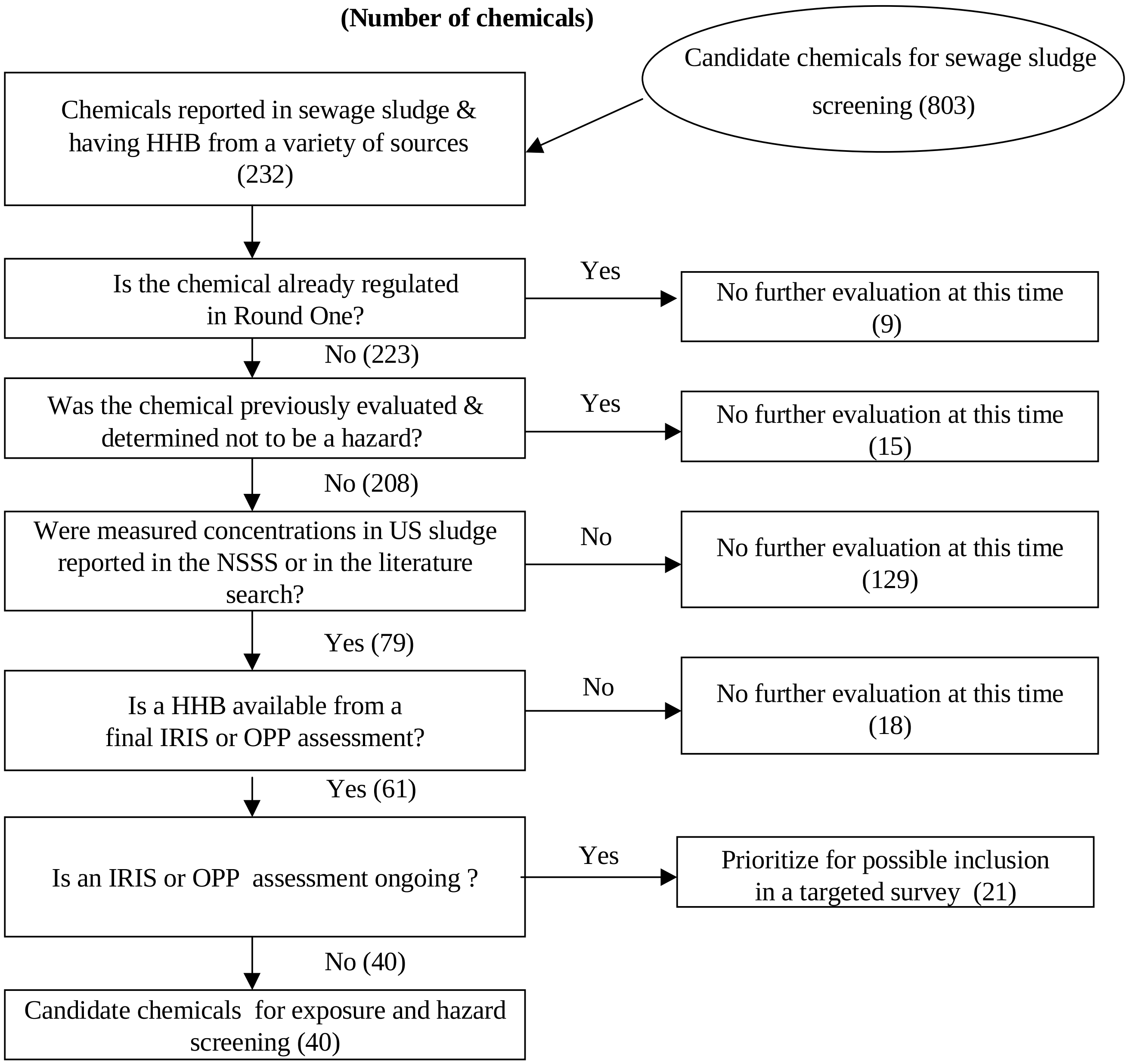
2. OCCURRENCE INFORMATION

EPA conducted an extensive literature search to obtain publicly available information on chemicals that may occur in sewage sludge, both at the national and international level. The literature search covered the period 1990-2002 and identified a substantial number of chemicals that were analyzed for in sewage sludge from 25 countries (Australia, Austria, Belgium, Brazil, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Hong Kong, Italy, Japan, Jordan, the Netherlands, Poland, Portugal, South Africa, Spain, Sweden, Switzerland, Taiwan, the United Kingdom and the USA). In addition, more than 400 chemicals were monitored in the 1989 National Sewage Sludge Survey (NSSS) (EPA, 1996; 1990). These were combined with the chemicals identified in the literature search, resulting in a total of 803 candidate chemicals for the screening analysis. These chemicals are listed in Table 1 and include the "classical" pollutants, as well as a number of emerging chemical categories such as pharmaceuticals, brominated flame retardants, and personal-care products, which have recently been identified in sewage sludge. Polychlorinated dibenzodioxins, polychlorinated dibenzofurans and coplanar polychlorinated biphenyls ("dioxins") are not listed in Table 1 since these are the subject of another Agency review (EPA, 2003a).

Frequency of detection is indicated in Table 1 for the NSSS in three broad categories: not detected, detected in 1% of the samples analyzed, or detected in greater than 1% of the samples analyzed (EPA, 1996; 1990). Only qualitative information ("yes" or "no") is presented in Table 1 for those chemicals found in sewage sludge based on the national and international literature search.

Figure 1. Human Health-Based Chemical Selection Process

(Number of chemicals)



3. HUMAN HEALTH BENCHMARKS

Table 1 indicates whether or not human health benchmarks (HHBs) are available for the 803 chemicals. HHBs used at this step were from any of the following data sources:

- Integrated Risk Information System (IRIS). Health assessments by IRIS undergo internal (EPA) and external peer reviews and are available on IRIS website at: http://www.epa.gov/iris/subst/index.htm. IRIS assessments may include oral reference doses (RfD) and inhalation reference concentrations (RfC) for chronic noncarcinogenic health effects, and oral slope factors (OSF) and inhalation air unit risks (AUR) for carcinogenic effects.

- Office of Pesticide Programs (OPP) Reregistration Eligibility Decisions (REDs) or Interim Reregistration Eligibility Decisions (IREDs) available on OPP website at: http://cfpub.epa.gov/oppref/rereg/status.cfm?show=rereg. OPP establishes RfDs for chronic and acute oral exposures, acute and chronic Population Adjusted Doses (PAD) which take into account the Food Quality Protection Act (FQPA) safety factor for the protection of infants and children, and oral cancer slope factors. During the review of the toxicity data and the dose-response assessment, the pesticide being evaluated undergoes review by several in-house peer review committees. Public comments are also received on the health assessments.

- Health Effects Assessment Summary Tables (HEAST). The HEAST is a database of human health toxicity values developed for chemicals of interest to Superfund, the Resource Conservation and Recovery Act, and the EPA in general. Most of the toxicity values in the HEAST are "provisional." HEAST is not available on the Internet.

- EPA's Office of Research and Development, National Center for Environmental Assessment Provisional Peer Reviewed Toxicity Values (PPRTV). PPRTVs are developed for the EPA Superfund Program to provide time-critical information for chemicals that lack toxicity values on IRIS or HEAST. PPRTVs are not available on the Internet.

- Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs) for non-neoplastic endpoints. ATSDR derives MRLs for acute, intermediate, and chronic exposure durations, and for the oral and inhalation routes of exposure. Cancer risk estimates from oral or inhalation exposures are not quantified. MRLs are available in ATSDR's Toxicological Profiles at: http://www.atsdr.cdc.gov/toxpro2.html#-A-.

- California Environmental Protection Agency toxicity values address both cancer and noncancer effects. Cal EPA toxicity values are listed at: http:www.oehha.ca.gov/risk/chemicalDB//index.asp.

4. CHEMICAL SELECTION PROCESS

A series of screening criteria was applied to the master Table 1 of 803 chemicals. Chemicals failing successive screening steps were eliminated from further consideration. Each of these screening steps is described below (see also Figure 1).

4.1 Availability of Human Health Benchmarks and Occurrence Information

Chemicals with no human health benchmarks from any of the data sources described in Section 3 (IRIS, OPP, PPRTV, HEAST, ATSDR, Cal EPA) were removed from consideration since further hazard screening is not possible in the absence of HHBs. In addition, if a chemical was monitored but not detected in the NSSS ("A" in that column in Table 1) *and* not reported in the national and international literature search ("no" in that column in Table 1), the chemical was deleted from further consideration, because it appears not to be present in sewage sludge and therefore does not constitute a health hazard.

Applying these two screening criteria to chemicals listed in Table 1 resulted in the elimination of 571 chemicals. The remaining 232 chemicals are listed in Table 2.

4.2 Is the Chemical Already Regulated in Round One?

Nine metals listed in Table 3 were regulated in Round One of the Part 503 sewage sludge standards. EPA intends to assess the need and appropriate level for a numerical standard for molybdenum in sewage sludge using the results and conclusions of a Workshop held in 2000 and supplemented with additional data developed since 2000. EPA expects to complete this assessment in 2005. New IRIS health assessments are ongoing for arsenic, cadmium, copper, nickel and zinc. These new assessments may influence the HHBs to be used for the exposure and hazard screening analysis. In addition, EPA plans to include Round One metals in a targeted survey, using improved analytical techniques, to be initiated in FY 2005. For these reasons, these nine metals are, for the time being, eliminated from further consideration.

4.3 Chemicals Evaluated and Determined not to be Hazardous in Sewage Sludge

Table 4 lists 15 chemicals that are unlikely to pose a hazard from their presence in sewage sludge. Calcium and magnesium are essential nutrients. The magnitudes of the tolerable upper intake levels (ULs) for calcium and magnesium of 2.5 g/day and 0.35 g/day, respectively (IOM, 1999), indicate unlikely hazards from their presence in sewage sludge. Phthalic anhydride was removed from consideration because of its extremely rapid degradation in soil for the required sewage sludge 30-day holding period. Chromium can be present in the environment as chromium III or the more toxic chromium VI species. In sewage sludge, it is present in the less toxic chromium III form and is therefore unlikely to present a hazard. The remaining 11 chemicals (aldrin, chlordane, DDD, DDE, DDT, dieldrin, heptachlor, heptachlor epoxide, hexachlorobenzene, lindane and toxaphene) are banned or severely restricted pesticides. These organochlorine pesticides were evaluated in 1992 and were not considered to present a health hazard from their presence in sewage sludge (EPA, 1992). Indications are that concentrations of these pesticides in sewage sludge are on the decline in the U.S. In addition, NRC concluded that it seems highly unlikely that the banned or severely restricted chlorinated pesticides, at their level of occurrence in sewage sludge, will harm crops or their consumers (NRC, 1996).

Except for lindane, there were no changes in oral human health benchmarks for these banned or severely restricted pesticides since their evaluation in 1992. OPP's recent health assessment of lindane has resulted in a chronic population adjusted dose (PAD) of 0.0016 mg/kg/day compared to the 1988 IRIS RfD of 0.0003 mg/kg/day (EPA, 1988; 2002). Under the 1999 draft revised guidelines for carcinogen risk assessment, OPP concluded that lindane shows *suggestive evidence of carcinogenicity, but not sufficient to assess human carcinogenic potential* (EPA, 1999; 2002). Quantitative cancer assessment of lindane was also not available in the 1988 IRIS file. The new OPP health assessment of lindane will make it even less likely to be a health hazard in sewage sludge.

For the above reasons, it is considered not necessary to conduct an exposure screening analysis for these 15 chemicals.

4.4 Identifying Chemicals with Concentration Values in U.S. Sewage Sludge

Table 5 lists the remaining 208 chemicals not eliminated in the above described previous steps. These chemicals were reported in sewage sludge, and have human health benchmarks from a variety of data sources.

It is considered appropriate in this screening exercise to use only concentration values found in U.S. sewage sludge. The nature and concentration of chemicals in sewage sludge are highly dependent on national laws and regulations governing the use of chemicals, and operation of wastewater treatment plants. Pretreatment regulations can vary significantly from country to country, and as a consequence, the final repository concentration of chemicals in sewage sludge will also vary significantly from country to country. Wastewater pretreatment regulations, which became effective in the U.S. in 1978, have dramatically reduced the discharge of industrial wastes into sewage treatment works and therefore also the concentrations of industrial chemicals in the resultant biosolids (NRC, 2002). As a result, chemicals found in sewage sludge from other countries, will not necessarily be found in sewage sludge in the U.S., and vice versa. In addition, concentration values for chemicals in sewage sludge, for example in Canada, Poland, Spain or the UK, are highly unlikely to be representative of concentrations found in U.S. sewage sludge. For these reasons, in this screening step, only those concentration values that have been measured in U.S. sewage sludge are considered appropriate for estimating exposure of the U.S. population to chemicals in sewage sludge.

On the basis of availability of concentration data for U.S. sewage sludge, chemicals not detected or not monitored in the NSSS *and* with no literature concentration values in *U.S. sewage sludge* were deleted from further consideration giving a list of 79 chemicals qualifying for additional screening (Table 6).

4.5 Identifying Chemicals Occurring in U.S. Sewage Sludge and with IRIS or OPP Chronic Human Health Benchmarks

Table 6 also identifies whether or not IRIS or OPP chronic HHBs are available for these 79 chemicals.

Of the health assessment databases described in Section 3, EPA considers that IRIS and OPP databases are best suited for the Agency's potential regulatory activities: human health benchmarks developed by IRIS or OPP have received adequate internal and external peer reviews, these databases are readily available to the public on the Internet, provide detailed explanation of the scientific basis of the health assessment, and are not likely to change rapidly making any sewage sludge regulation obsolete before the next two-year review cycle. EPA is therefore using only IRIS and OPP human health benchmarks in this screening process.

If a pesticide has human health benchmarks from both IRIS and OPP, OPP health assessment of a pesticide registered for food uses takes precedence over IRIS assessment of the same pesticide.

Of the 79 chemicals listed in Table 6, no IRIS or OPP toxicity values were available for 17 chemicals. Strontium has an IRIS human health benchmark and was not monitored for in the NSSS but a mean concentration of 230 mg/kg in U.S. sludge was reported in the literature (Raven and Loeppert, 1997). However, available data on the environmental properties of strontium are inadequate to conduct exposure screening for this chemical. These 18 chemicals are therefore deleted from further consideration. The remaining 61 chemicals with final IRIS or OPP chronic human health benchmarks qualify for additional screening and are listed in Table 7. Table 7 also indicates whether or not new assessments are ongoing for these chemicals.

4.6 Is an IRIS or OPP Assessment Ongoing?

IRIS and OPP are currently conducting, as of October 1, 2003, a detailed review of recent scientific information for 20 chemicals (EPA, 2003b, 2003c). In addition, at the request of OW, the National Research Council is reviewing the toxicological, epidemiological, clinical, and exposure data on orally ingested fluoride, and potential risks to children. Because the results of the new health assessments for these 21 chemicals with existing IRIS or OPP HHBs are not yet available, OW does not believe it appropriate to include these 21 chemicals, listed in Table 8, in the exposure screening analysis at this time: the completed health assessments could result in significant changes in the existing toxicity values, making these chemicals of more or less potential health concerns, and potentially requiring a change in rule-making process. However, OW recognizes that chemicals of potential health concerns that are undergoing reevaluation may need to be included in a targeted survey so that concentration values in sewage sludge may be obtained and used in future reviews or screening activities. As a substitute for the probabilistic exposure model used in the exposure screening analysis, a simple estimate of oral exposure was used to determine which chemicals with ongoing health assessments may be of priority health concern, and thus could be included, subject to the availability of adequate budgetary resources, in a targeted survey to be initiated in FY 2005. This prioritization scheme is further described in Section 6 below.

4.7 Candidate Chemicals for Exposure and Hazard Screening Analysis

Table 9 lists 40 chemicals passing all the screening steps and qualifying for exposure and hazard screening using a probabilistic exposure model. Concentrations of chemicals in U.S. sewage sludge are needed before the exposure screening can proceed for these 40 chemicals. The screening concentrations (mg/kg dry weight of sludge) used in this analysis were the higher of the following values:

- The 95th percentile concentration of the chemical in sewage sludge in the 1989 NSSS, or
- The upper concentration values of the chemical measured in U.S. sewage sludge from the literature search. Upper concentration values varied from a single value to a mean, maximum or 90th percentile concentrations.

Surprisingly, only a limited number of publications on chemicals in U.S. sewage sludge could be located, postdating the 1989 NSSS. In addition, when concentration values in U.S. sludge were available from the literature, the upper reported literature concentrations were lower than those reported at the 95th percentile level in the NSSS (Kelley, 1997; Raven and Loeppert, 1997; Mata-Gonzalez et al. 2002; Barker, 2001; Gutenmann et al. 1994). For this reason, only the NSSS 95th percentile values are used in the exposure screening analysis. Although the available literature data are too limited to draw any firm conclusions, this perhaps indicates that concentrations of certain xenobiotic chemicals are on the decline in U.S. sewage sludge.

5. QUANTITATIVE INFORMATION ON HUMAN HEALTH BENCHMARKS

IRIS and OPP human health benchmarks for chronic oral and inhalation exposures, and for noncancer and cancer endpoints were used in this screening exercise.

5.1 Oral Human Health Benchmarks

Chronic RfDs or chronic PADs were used as the HHBs for oral exposure to threshold chemicals. The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (EPA, 2003e). The PAD includes an additional safety factor applied to the RfD of up to ten-fold, if necessary, to account for uncertainty in data relative to children, a requirement of the 1996 FQPA which places an emphasis on protecting the health of infants, children, or other sensitive individuals exposed to pesticides (EPA, 2003f). RfD and PAD are usually expressed in mg per kilogram of body weight per day (mg/kg/day).

For carcinogenic chemicals, the oral slope factor (OSF) is an upper bound estimate, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to the chemical. This estimate is usually expressed in units of proportion (of a population) affected per mg/kg/day (EPA, 2003e). The dose for a cancer risk level of E-5 (1 in 100,000) was calculated from the OSF.

The oral critical dose (OCD) is the lower of the RfD, PAD and dose corresponding to E-5 cancer risk. Table 10.A. lists the 40 chemicals together with their 95th percentile concentration from the NSSS, the various oral HHBs for each chemical, and the OCD used in subsequent exposure screening.

5.2 Inhalation Human Health Benchmarks

Inhalation RfCs are established for threshold chemicals. The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (EPA, 2003e). RfCs are usually expressed in units of mg/m^3. OPP does not establish RfCs for pesticides since the margin of exposure (MOE) approach is used for characterization of risk via the inhalation exposure. However, for this exercise, OPP derived "equivalent" inhalation benchmarks for azinphos methyl, chlorpyrifos, diazinon and naled, based on information contained in the IREDs for these pesticides (OPP, 2003).

For carcinogenic chemicals, the air unit risk (AUR) is the 95% upper bound excess lifetime cancer risk estimated to result from continuous exposure to the chemical at a concentration of 1 mg/m^3 in air (EPA, 2003e). The air concentration associated with a risk level of E-5 (1 in 100,000) was calculated from the AUR.

The inhalation critical concentration (CC) is the lower of the RfC and concentration for E-5 cancer risk. Table 10.B. lists the 40 chemicals together with their 95th percentile concentration from the NSSS, the oral critical dose determined in Table 10.A, IRIS RfCs or OPP-derived "equivalent" inhalation benchmarks, IRIS concentration corresponding to E-5 cancer risk, and the CC used in subsequent exposure screening.

6. PRIORITIZATION OF CHEMICALS WITH ONGOING ASSESSMENTS FOR POSSIBLE INCLUSION IN A TARGETED SURVEY

As a substitute for the EPA probabilistic exposure model, a simple estimate of exposure is used to determine which chemicals listed in Table 8 with ongoing health assessments at October 1, 2003, may be of priority health concern, and thus could be included in the targeted survey, to be initiated in FY 2005.

6.1 Theoretical Average Daily Intake

An estimate of "Theoretical Average Daily Intake" (TADI) is made using the exposure scenario of a 1-3 year old child, one of the most highly exposed population group on a kg body weight basis. The following assumptions are made:

- Child body weight is 13 kg (EPA, 1997a);
- Total daily diet consumed by child consists of 0.8 kg food (EPA, 1997b) and 0.3 kg drinking water (EPA, 2000);
- The average concentration (C_{avg}) in mg/kg of sludge (dry weight basis) of the chemical is assumed to be entirely translocated to the daily total diet of 1.1 kg.

$$\text{TADI, mg/kg/day} = \frac{C_{avg} \times 1.1}{13}$$

TADIs calculated in this manner are based on conservative assumptions and are, in effect, equivalent to the daily consumption of 1.1 kg of dried sewage sludge containing average concentration of the chemical under consideration.

A Theoretical Hazard Quotient (THQ) is then derived. The THQ is the ratio of the TADI to the oral critical dose (OCD), where the OCD, in mg/kg/day, is the lower of the reference dose, population adjusted dose, or dose for 10^{-5} cancer risk, i.e.,

$$\text{THQ} = \frac{\text{TADI}}{\text{OCD}}$$

The THQs have been calculated for each of the 20 chemicals with ongoing health assessments and with IRIS or OPP existing oral human health benchmarks. These THQs are given in Table 11 and are sorted in decreasing order.

6.2 Comparison of Theoretical Hazard Quotients to Exposure and Hazard Screening Results

Forty chemicals qualified for exposure and hazard screening using the EPA probabilistic exposure model. Hazard quotients (HQ) have been calculated for these chemicals (EPA, 2003d). The HQ is the ratio of the estimated exposure derived using the probabilistic model, to the oral critical dose (OCD), where the OCD, in mg/kg/day, is the lower of the reference dose, population adjusted dose, or dose corresponding to 10^{-5} cancer risk. Chemicals "failing" the exposure screen for oral exposure i.e., with HQ greater than one are barium, 4-chloroaniline, manganese, nitrate, nitrite and silver (EPA, 2003d). Theoretical hazard quotients (THQs) were also calculated for these 40 chemicals and are listed in Table 12. It can be seen from Table 12 that the six chemicals having HQ >1 always had THQs equal to or greater than 75 using the TADI approach.

On this basis, a prioritization scale was established for the 20 chemicals with ongoing health assessments and IRIS or OPP oral human health benchmarks:

THQ $\geq$75: High priority chemicals for inclusion in the targeted survey.

THQ < 75: Low priority chemicals

Using this priority scale, chemicals with THQs equal to or greater than 75 are high priority chemicals of potential health concern and could be included, subject to the availability of adequate budgetary resources, in the targeted survey to be initiated in FY 2005. These are benzo[a]pyrene, polychlorinated biphenyl congeners and Aroclors (excluding coplanar PCB congeners already included in the 2001 dioxins survey), di(2-ethylhexyl)phthalate, thallium, antimony, carbon tetrachloride and fluoride. Chemicals with THQs less than 75 are considered of low priority and are not planned to be included in the survey.

Inhalation exposure was not included in this theoretical estimation of exposure since in all cases of application of the probabilistic exposure model, the inhalation route of exposure was negligible (EPA, 2003d).

Priority for inclusion or exclusion of chemicals with ongoing health assessments in the planned survey will be reconsidered if the results of ongoing IRIS, OPP or NRC assessments become available and indicate a different priority order.

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Table 1: Candidate Chemical for Sewage Sludge Screening

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Acenaphthene	83329	yes	yes	A	
Acenaphthylene	208968	yes	no	A	
Acetaldehyde	75070	yes	yes	NA	E
Acetaminophen	103902	yes	no	NA	
Acetone; 2-Propanone	67-64-1	yes	yes	C	
Acetophenone	98862	yes	yes	C	
Acetyl-1,1,3,4,4,6-hexamethyl tetrahydronaphthalene, 7- ; AHTN	21145777	yes	no	NA	
Acetyl-3-isopropyl,1,1,2,6-tetramethylindane, 5-	68140487	yes	no	NA	
Acetyl-6-tertbutyl-1,1-dimethylindane, 4-	13171001	yes	no	NA	
Acrolein; Propenal, 2-	107028	no	yes	A	
Acrylonitrile	107131	no	yes	A	
Albuteral	18559949	yes	no	NA	
Aldrin	309002	yes	yes	C	
Aliphatics	NA	yes	no	NA	
Alkylbenzene sulfonates, linear	NA	yes	no	NA	
Alkylbenzenes, linear; LABs	NA	yes	no	NA	
Alkylphenol diethoxylate	NA	yes	no	NA	
Alkylphenol mono-ethoxylate	NA	yes	no	NA	
Alkylphenol polyethoxylates	NA	yes	no	NA	
Allopurinol	315300	yes	no	NA	
Allyl chloride; Chloropropene, 3-	107051	no	yes	A	
Allyl Mercaptan	870235	yes	no	NA	
Alum	7784249	yes	no	NA	
Aluminum	7429905	yes	yes	C	
Aminobiphenyl, 4-	92671	no	yes	A	
Aminosalicylic acid, 5- ; Mesalazine	89576	yes	no	NA	
Ammonia	7664417	yes	yes	NA	
Amoxycillin	26787780	yes	no	NA	
Amyl mercaptan	110667	yes	no	NA	
Androsterone, cis-	53418	yes	no	NA	
Aniline	62533	yes	yes	A	
Aniline, 2,4,5-trimethyl	137177	no	no	A	
Anisidine, o-	90040	no	yes	A	
Anthracene	120127	yes	yes	C	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Antimony and compounds	7440360	yes	yes	C	E
Aramite	140578	no	yes	A	
Aroclor 1016	12674112	yes	yes	A	
Aroclor 1210	147601874	yes	no	NA	
Aroclor 1216	151820278	yes	no	NA	
Aroclor 1221	11104282	yes	no	A	
Aroclor 1231	37234405	yes	no	NA	
Aroclor 1232	11141165	yes	no	A	
Aroclor 1240	71328897	yes	no	NA	
Aroclor 1242	53469219	yes	no	A	
Aroclor 1248	12672296	yes	no	C	
Aroclor 1250	165245512	yes	no	NA	
Aroclor 1252	89577786	yes	no	NA	
Aroclor 1254	11097691	yes	yes	C	
Aroclor 1260	11096825	yes	no	C	
Aroclor 1262	37324235	yes	no	NA	
Aroclor 1268	11100144	yes	no	NA	
Arsenic and compounds*	7440-38-2	yes	yes	C	E
Aspirin	50782	yes	no	NA	
Atenolol	29122687	yes	no	NA	
Atrazine	1912249	yes	yes	NA	E
Azinphos ethyl	2642719	yes	no	A	
Azinphos methyl	86500	yes	yes	C	
Barium	7440393	yes	yes	C	
Benzamide	55210	yes	no	NA	
Benzanthrone	82053	no	no	A	
Benzene	71432	yes	yes	A	
Benzenesulfonic acid, linear alkyl derivatives	42615292	yes	no	NA	
Benzenethiol	108985	yes	yes	A	
Benzidine	92875	no	yes	A	
Benzo[a]anthracene	56553	yes	yes	C	
Benzo[a]carbazole	243287	yes	no	NA	
Benzo[a]fluorene; Benzofluorene,1,2-	238846	yes	no	NA	
Benzo[a]pyrene	50328	yes	yes	C	E
Benzo[b]fluoranthene	205992	yes	yes	C	
Benzo[b]fluorene; Benzofluorene, 2,3-	243174	yes	no	A	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Benzo[b]naphtho(2,3-d)furan	243425	yes	no	NA	
Benzo[c]phenanthrene	195197	yes	no	NA	
Benzo[e]pyrene	192-97-2	yes	no	NA	
Benzo[ghi]perylene	191242	yes	no	A	
Benzo[j]fluoranthene	205823	yes	yes	NA	
Benzo[k]fluoranthene	207089	yes	yes	C	
Benzoic acid	65-85-0	yes	yes	C	
Benzoic acid phenylester	93992	yes	no	NA	
Benzonitrile, 3,5-dibromo-4-hydroxy; Bromoxynil	1689845	no	yes	A	
Benzyl alcohol	100-51-6	yes	no	A	
Benzyl Mercaptan	100538	yes	no	NA	
Beryllium	7440417	yes	yes	C	
Betaxolol	63659187	yes	no	NA	
Bezafibrate	41859670	yes	no	NA	
Biphenyl, 1,1-	92524	yes	yes	B	
Biphenyl, 4-nitro	92933	no	no	A	
Bis(2-chloroethoxy)methane	111911	yes	no	A	
Bis(2-chloroethyl)ether	111444	yes	yes	A	
Bis(2-chloroisopropyl)ether	108601	yes	yes	A	
Bis[(4-anilino-6-morpholino-1,3,5-triazin-2-yl)-amino]stilbene-2,2'-disulfonate, 4,4'- ; DAS	81118	yes	no	NA	
Bismuth	7440699	yes	no	NA	
Bisoprolol	66722449	yes	no	NA	
Bisphenol A	80057	yes	yes	NA	
Boron	7440428	yes	yes	C	E
Brominated dibenzofurans	NA	yes	no	NA	
Brominated dibenzo-p-dioxins	NA	yes	no	NA	
Bromo-2-chlorobenzene, 1-	694804	no	no	A	
Bromo-3-chlorobenzene, 1-	108372	no	no	A	
Bromobiphenyl, 3-	2113577	yes	no	NA	
Bromobiphenyl, 4-	92660	yes	no	NA	
Bromodichloromethane	75274	no	yes	A	E
Bromodiphenyl ether, 4-	101553	yes	no	A	
Bromomethane	74839	no	yes	A	
Butanol, n- ; n-Butyl alcohol	71363	yes	yes	NA	
Butyl amine	109739	yes	no	NA	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Butyl benzyl phthalate	85687	yes	yes	C	
Butylated hydroxy toluene	128370	yes	no	NA	
Butylphen	98544	yes	no	NA	
Cadmium and compounds[*]	7440439	yes	yes	C	E
Caffeine	58082	yes	no	NA	
Calcium	7440-70-2	yes	yes	C	D
Captafol	2425061	yes	yes	A	
Captan	133062	yes	yes	A	
Carazolol	57775298	yes	no	NA	
Carbamazepine	298464	yes	no	NA	
Carbaryl	63252	yes	yes	NA	
Carbazole	86748	yes	no	A	
Carbodox	6804075	yes	no	NA	
Carbon disulfide	75-15-0	yes	yes	C	
Carbon tetrachloride; Tetrachloromethane	56-23-5	yes	yes	C	E
Carbophenothion; Trithion	786196	yes	no	A	
Cerium	7440451	yes	no	NA	
Cesium	7440462	yes	no	NA	
Chlordane	57749	yes	yes	A	
Chlordane, cis-	5103719	yes	yes	NA	
Chlorine	7782505	yes	yes	NA	
Chloro-2-methyl-phenol, 4-	1570645	yes	no	NA	
Chloro-2-methyl-phenoxy acetic acid, 4- ; MCPA	94746	yes	yes	NA	E
Chloro-2-nitroaniline, 4-	89634	no	no	A	
Chloro-3-methylphenol, 4- ; p-Chloro-m-cresol; PCMC	59507	yes	yes	A	
Chloro-3-nitrobenzene, 1-	121733	no	no	A	
Chloro-6-methyl-phenol, 2-	87649	yes	no	NA	
Chloroacetonitrile	107142	no	no	A	
Chloroaniline, 4-; p-Chloroaniline	106478	yes	yes	C	
Chloroanilines	27134265	yes	yes	NA	
Chlorobenzene; Phenyl chloride	108907	yes	yes	C	
Chlorobenzilate	510156	yes	yes	C	
Chloroethane	75003	no	yes	A	E
Chloroethylvinyl ether, 2-	110758	no	no	A	
Chlorofenvinphos	470906	yes	no	A	
Chloroform	67663	yes	yes	B	E

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Chloronaphthalene, 1-	90131	yes	no	NA	
Chloronaphthalene, 2-	25586430	yes	no	B	
Chlorophenol	25167800	yes	yes	NA	
Chlorophenol, 2-	95578	yes	yes	A	
Chlorophenol, 4-	106489	yes	yes	NA	
Chlorophenylphenyl ether, 4-	7005723	yes	no	A	
Chloroprene; 2-Chloro-1,3-butadiene	126998	yes	yes	A	E
Chlorpyrifos	2921882	yes	yes	C	
Chlortetracycline	57625	yes	no	NA	
Cholesterol	57885	yes	no	NA	
Chromium and compounds	7440-47-3	yes	yes	C	E (NTP)
Chrysene	218019	yes	yes	C	
Cimetidine	51481619	yes	no	NA	
Ciprofloxacin	85721331	yes	no	NA	
Clenbuterol	37148279	yes	no	NA	
Clolibric Acid	882097	yes	no	NA	
Cobalt	7440484	yes	yes	C	E
Codeine	76573	yes	no	NA	
Copper and compounds*	7440508	yes	yes	C	E
Coprostanol	360689	yes	no	NA	
Coronene	191071	yes	no	NA	
Cotinine	486566	yes	no	NA	
Coumaphos	56724	yes	yes	A	
Cresol, m- ; 3-Methylphenol	108394	yes	yes	NA	
Cresol, o- ; 2-Methylphenol	95-48-7	yes	yes	C	
Cresol, p- ; 4-Methylphenol	106445	yes	yes	C	
Crotonaldehyde	4170303	no	yes	A	
Crotoxyphos; Ciodrin	7700176	yes	no	A	
Cyanides (soluble salts & complexes)	NA	yes	no	C	E: HCN
Cyclophosphamide	50180	yes	no	NA	
Cymene p-	99-87-6	yes	no	C	
DDD, 4,4'-	72548	yes	yes	A	
DDE, 4,4'-	72559	yes	yes	B	
DDT ; p,p'-Dichlorodiphenyltrichloroethane	50293	yes	yes	C	
Decabromobiphenyl , 2,2',3,3',4,4',5,5',6,6' -	13654096	yes	no	NA	
Decabromodiphenyl ether	1163195	yes	yes	NA	E

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Decane n-	124-18-5	yes	no	C	
Dehydronifedipine	67035227	yes	no	NA	
Demeton	8065483	yes	yes	A	
Di(2-ethylhexyl)adipate; DEHA	103231	yes	yes	NA	E
Di(2-ethylhexyl)phthalate; DEHP	117817	yes	yes	C	E
Diallate	2303164	yes	yes	A	
Diazinon	333415	yes	yes	C	
Dibenz[a,h]acridine	226368	yes	yes	NA	
Dibenz[a,h]anthracene	53703	yes	yes	A	
Dibenz[a,j]acridine	224420	yes	yes	NA	
Dibenzo[a,e]pyrene	192654	yes	yes	NA	
Dibenzo[a,h]pyrene	189640	yes	yes	NA	
Dibenzo[a,i]pyrene	189559	yes	yes	NA	
Dibenzo[a,l]pyrene	191300	yes	yes	NA	
Dibenzo[c,g]carbazole, 7H-	194592	yes	yes	NA	
Dibenzofuran	132-64-9	yes	no	C	
Dibenzothiophene	132650	yes	no	A	
Dibromo-3-chloropropane, 1,2-; DBCP	96128	no	yes	A	
Dibromobiphenyl	27479658	yes	no	NA	
Dibromobiphenyl, 2,2'	13029099	yes	no	NA	
Dibromobiphenyl, 2,3-	115245062	yes	no	NA	
Dibromobiphenyl, 2,3'-	49602906	yes	no	NA	
Dibromobiphenyl, 2,4'-	49602917	yes	no	NA	
Dibromobiphenyl, 2,4-	53592102	yes	no	NA	
Dibromobiphenyl, 2,5-	57422772	yes	no	NA	
Dibromobiphenyl, 2,6-	59080329	yes	no	NA	
Dibromobiphenyl, 3,3'-	16400514	yes	no	NA	
Dibromobiphenyl, 3,4'	57186900	yes	no	NA	
Dibromobiphenyl, 3,4-	60108727	yes	no	NA	
Dibromobiphenyl, 3,5-	16372966	yes	no	NA	
Dibromobiphenyl, 4,4'-	92864	yes	no	NA	
Dibromochloromethane	124481	no	yes	A	E
Dibromodiphenyl ether, p,p'-	2050477	yes	no	NA	
Dibromoethane, 1,2-; Ethylene dibromide	106934	no	yes	A	E
Dibromomethane	74953	no	yes	A	
Dibutyl amine	111922	yes	no	NA	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Dibutyl phthalate	84742	yes	yes	C	E
Dichloro-2-butene, trans-1,4-	110576	no	no	A	
Dichloro-2-propanol, 1,3-	96231	no	no	A	
Dichloro-4-nitroaniline, 2,6-	99309	no	no	A	
Dichloro-6-methyl-phenol, 2,4-	1570656	yes	no	NA	
Dichloroaniline, 2,3-	608275	no	no	A	
Dichloroaniline, 2,4-	554007	yes	no	NA	
Dichlorobenzene, 1,2-	95501	yes	yes	A	E
Dichlorobenzene, 1,3-	541731	yes	yes	A	E
Dichlorobenzene, 1,4-	106467	yes	yes	C	E
Dichlorobenzenes, total (mixed isomers)	25321226	yes	yes	NA	
Dichlorobenzidine, 3,3'	91941	yes	yes	A	
Dichloroethane, 1,1-	75343	no	yes	A	
Dichloroethane, 1,2- ; Ethylene dichloride	107062	yes	yes	A	E
Dichloroethene, 1,1-	75-35-4	yes	yes	A	
Dichloroethene, 1,2-trans-	156-60-5	yes	yes	B	
Dichloroisopropanol, 1,3-	96-23-1	yes	no	A	
Dichloromethane; Methylene chloride	75092	yes	yes	C	
Dichloronitrobenzene, 2,3-	3209221	no	no	A	
Dichlorophenol, 2,4-	120832	yes	yes	A	
Dichlorophenol, 2,5-	583788	yes	no	NA	
Dichlorophenol, 2,6-	87650	yes	no	A	
Dichlorophenol, 3,5-	591355	yes	no	NA	
Dichlorophenoxyacetic acid, 2,4- ; 2,4-D	94757	yes	yes	C	E
Dichloropropane, 1,2-	78875	no	yes	A	
Dichloropropane, 1,3-	142289	no	no	A	
Dichloropropene, trans-1,3-	10061026	no	yes	A	
Dichlorvos; DDVP	62737	yes	yes	A	E
Dichoropropene, cis-1,3-	10061015	no	yes	A	
Diclofenac sodium	15307796	yes	no	NA	
Dicrotophos; Bidrin	141662	yes	yes	A	
Dieldrin	60571	yes	yes	C	
Diepoxybutane, 1,2,3,4-	1464-53-5	yes	no	C	
Diethyl ether	60297	no	yes	A	
Diethyl phthalate	84662	yes	yes	A	
Diethylstilbestrol	56531	yes	yes	NA	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Diethyltoluamide, N,N'-; DEET	134623	yes	no	NA	
Digoxigenin	1672464	yes	no	NA	
Digoxin	20830755	yes	no	NA	
Diisopropylamine	108189	yes	no	NA	
Diltiazem	42399417	yes	no	NA	
Diltiazem Hydrochloride	33286225	yes	no	NA	
Dimethoate	60515	yes	yes	B	E
Dimethoxybenzidine, 3,3'-	119904	no	yes	A	
Dimethyl phthalate	131113	yes	no	B	
Dimethyl sulfide	75183	yes	no	NA	
Dimethyl sulfone	67710	no	no	A	
Dimethylamine	124403	yes	no	NA	
Dimethylaminoazobenzene, p-	60117	no	yes	A	
Dimethylbenz(a)anthracene, 7,12-	57976	no	yes	A	
Dimethyldisulfide	624920	yes	no	NA	
Dimethylformamide, N,N'-	68122	no	yes	A	
Dimethylnaphthalene, 2,6-	581420	yes	no	NA	
Dimethylphenanthrene, 3,6-	1576676	no	no	A	
Dimethylphenol, 2,4-; Xylenol	105679	yes	yes	A	
Dimethylxanthine, 1,7-	611596	yes	no	NA	
Dinitro-2,6-dimethyl-4-tertbutylacetophenone, 3,5,-	81141	yes	no	NA	
Dinitrobenzene, 1,4-	100254	no	yes	A	
Dinitrophenol (mixed isomers)	25550587	yes	yes	NA	
Dinitrophenol, 2,4-	51285	yes	yes	A	
Dinitropyrene, 1,6-	42397648	yes	yes	NA	
Dinitropyrene, 1,8-	42397659	yes	yes	NA	
Dinitrotoluene, 2,4-	121142	yes	yes	A	
Dinitrotoluene, 2,6-	606202	yes	yes	A	
Di-N-octyl phthalate	117840	yes	yes	B	
Dinonylphenol, 2,4-	137995	yes	no	NA	
Dinoseb	88857	yes	yes	NA	
Di-N-propylnitrosamine	621647	no	yes	A	
Dioxane, 1,4-	123-91-1	yes	yes	C	
Dioxathion	78342	yes	no	A	
Diphenylamine	122394	no	yes	A	
Diphenyldisulfide	882337	no	no	A	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Diphenylhydrazine, 1,2-	122667	no	yes	A	
Disulfoton	298044	yes	yes	A	
Ditallowdimethylammonium chloride; DTDMAC	68783788	yes	no	NA	
Di-tert-butyl-1,4-benzoquinone, 2,6-	719222	yes	no	A	
Di-tert-butylphenol, 2,6-	128392	yes	no	NA	
Docosane n-	629-97-0	yes	no	C	
Dodecane n-	112-40-3	yes	no	C	
Dodecylphenols	27193868	yes	no	NA	
Dodecyltrimethylammonium salt	112005	yes	no	NA	
Doxycycline	564250	yes	no	NA	
Dysprosium	7429916	yes	no	NA	
Eicosane n-	112-95-8	yes	no	C	
Enalaprilat	76420729	yes	no	NA	
Endosulfan	115297	yes	yes	NA	
Endosulfan I; alpha-Endosulfan	959988	yes	yes	B	
Endosulfan II; beta-Endosulphan	33213659	yes	yes	C	
Endosulfan sulfate	1031078	yes	no	A	
Endrin	72208	yes	yes	C	
Endrin aldehyde	7421934	yes	no	A	
Endrin ketone	53494705	yes	no	A	
Enrofloxacin	93106606	yes	no	NA	
Equilenin	517099	yes	no	NA	
Equilin	474862	yes	no	NA	
Erbium	7440520	yes	no	NA	
Erythromycin	114078	yes	no	NA	
Estradiol	50271	yes	no	NA	
Estradiol, 17alpha-	57910	yes	no	NA	
Estradiol, 17beta-	50282	yes	no	NA	
Estrone	53167	yes	no	NA	
Ethanol, 2-(2-(nonylphenoxy)ethoxy)-	27176938	yes	no	NA	
Ethanol, 2-butoxy-phosphate	78513	yes	no	NA	
Ethion	563122	yes	yes	A	E
Ethyl cyanide	107120	no	no	A	
Ethyl mercaptan	75081	yes	no	NA	
Ethyl methacrylate	97632	no	yes	A	
Ethyl methanesulfonate	62500	no	no	A	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104645	yes	yes	C	
Ethylamine	75047	yes	no	NA	
Ethylbenzene	100414	yes	yes	C	E
Ethylenethiourea	96457	no	yes	A	
Ethynyl estradiol, 17alpha-	57636	yes	no	NA	
Europium	7440531	yes	no	NA	
Famphur	52857	yes	no	A	
Fensulfothion	115902	yes	no	A	
Fenthion	55389	yes	yes	A	
Ferric chloride	7705080	yes	no	NA	
Ferrous sulfate	7720787	yes	no	NA	
Flucoxacillim sodium	5250395	yes	no	NA	
Fluoranthene	206440	yes	yes	C	
Fluorene	86737	yes	yes	A	
Fluoride	16984488	yes	yes	C	E (NRC)
Fluoxetine	54910893	yes	no	NA	
Gadolinium	7440542	yes	no	NA	
Gallium	7440553	yes	no	NA	
Gemfibrozil	25812300	yes	no	NA	
Germanium	7440564	yes	no	NA	
Gliclazide	21187984	yes	no	NA	
Gold	7440575	yes	no	NA	
Hafnium	7440586	yes	no	NA	
Heptabromobiphenyl	35194786	yes	no	NA	
Heptabromobiphenyl, 2,2',3,3',4,4',5-	69278600	yes	no	NA	
Heptabromobiphenyl, 2,2',3,3',4,5,5'-	82865927	yes	no	NA	
Heptabromobiphenyl, 2,2',3,3',4,5,6'-	88700043	yes	no	NA	
Heptabromobiphenyl, 2,2',3,3',5,5',6-	119264549	yes	no	NA	
Heptabromobiphenyl, 2,2',3,4,4',5,5'-	67733522	yes	no	NA	
Heptabromobiphenyl, 2,2',3,4,4',5,6'-	119264550	yes	no	NA	
Heptabromobiphenyl, 2,2',3,4,4',6,6'-	119264561	yes	no	NA	
Heptabromobiphenyl, 2,2',3,4',5,5',6-	84303491	yes	no	NA	
Heptabromobiphenyl, 2,2',3,4,5,6,6'-	119264572	yes	no	NA	
Heptabromobiphenyl, 2,3,3',4,4',5,5'-	88700065	yes	no	NA	
Heptabromobiphenyl, 2,3,3',4,4',5,6-	79682250	yes	no	NA	
Heptabromobiphenyl, 2,3',3,4',5,6,6'-	119264583	yes	no	NA	

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Heptabromodibenzofuran, 1,2,3,4,6,7,8-	NA	yes	no	NA	
Heptabromodibenzofuran, 1,2,3,4,7,8,9-	NA	yes	no	NA	
Heptabromodibenzo-p-dioxin, 1,2,3,4,6,7,8-	NA	yes	no	NA	
Heptabromodiphenyl ether	68928803	yes	no	NA	
Heptachlor	76448	yes	yes	A	
Heptachlor epoxide	1024573	yes	yes	C	
Heptaoxatricosan-1-ol, 23-(nonylphenoxy)-3,6,9,12,15,18,21-	27177055	yes	no	NA	
Hexabromobiphenyl	36355018	yes	no	NA	
Hexabromobiphenyl, 2,2',3,3',4,4'-	82865892	yes	no	NA	
Hexabromobiphenyl, 2,2',3,3',4,5'-	82865905	yes	no	NA	
Hexabromobiphenyl, 2,2',3,3',4,6'-	119264505	yes	no	NA	
Hexabromobiphenyl, 2,2',3,3',5,5'-	55066767	yes	no	NA	
Hexabromobiphenyl, 2,2',3,3',5,6'-	119264516	yes	no	NA	
Hexabromobiphenyl, 2,2',3,4,4',5'-	67888986	yes	no	NA	
Hexabromobiphenyl, 2,2',3,4,4',5-	81381524	yes	no	NA	
Hexabromobiphenyl, 2,2',3,4,5,5'-	120991471	yes	no	NA	
Hexabromobiphenyl, 2,2',3,4',5',6-	69278597	yes	no	NA	
Hexabromobiphenyl, 2,2',3,4',5,6'-	93261837	yes	no	NA	
Hexabromobiphenyl, 2,2',3,4,5',6-	119264527	yes	no	NA	
Hexabromobiphenyl, 2,2',3,5,5',6-	119264538	yes	no	NA	
Hexabromobiphenyl, 2,2',4,4',5,5'-	59080409	yes	no	NA	
Hexabromobiphenyl, 2,2',4,4',5,6'-	36402150	yes	no	NA	
Hexabromobiphenyl, 2,2',4,4',6,6'-	59261084	yes	no	NA	
Hexabromobiphenyl, 2,3,3',4,4',5'-	84303479	yes	no	NA	
Hexabromobiphenyl, 2,3,3',4,4',5-	77607091	yes	no	NA	
Hexabromobiphenyl, 2,3,3',4,5,5'-	120991482	yes	no	NA	
Hexabromobiphenyl, 2,3,3',4',5',6-	82865916	yes	no	NA	
Hexabromobiphenyl, 2,3',4,4',5,5'-	67888997	yes	no	NA	
Hexabromobiphenyl, 2,3',4,4',5',6-	84303480	yes	no	NA	
Hexabromobiphenyl, 3,3',4,4',5,5'-	60044260	yes	no	NA	
Hexabromodibenzofuran, 1,2,3,4,7,8-	NA	yes	no	NA	
Hexabromodibenzofuran, 1,2,3,6,7,8-	NA	yes	no	NA	
Hexabromodibenzofuran, 1,2,3,7,8,9-	NA	yes	no	NA	
Hexabromodibenzofuran, 2,3,4,6,7,8-	NA	yes	no	NA	
Hexabromodibenzo-p-dioxin, 1,2,3,4,7,8-	NA	yes	no	NA	
Hexabromodibenzo-p-dioxin, 1,2,3,6,7,8-	NA	yes	no	NA	

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Hexabromodibenzo-p-dioxin, 1,2,3,7,8,9-	NA	yes	no	NA	
Hexabromodiphenyl ether	36483600	yes	no	NA	E
Hexachlorobenzene	118741	yes	yes	A	
Hexachlorobutadiene	87683	yes	yes	A	E
Hexachlorocyclohexane, alpha-	319846	yes	yes	C	
Hexachlorocyclohexane, beta-	319857	yes	yes	C	
Hexachlorocyclohexane, delta-	319868	yes	no	C	
Hexachlorocyclopentadiene	77474	yes	yes	A	E
Hexachloroethane	67721	no	yes	A	
Hexachloronaphthalene	1335871	yes	no	NA	
Hexachloropropene	1888717	no	no	A	
Hexacosane n-	630-01-3	yes	no	C	
Hexadecane n-	544-76-3	yes	no	C	
Hexadecyltrimethylammonium salt	112027	yes	no	NA	
Hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-g-2-benzopyrane,1,3,4,6,7,8-	1222055	yes	no	NA	
Hexanoic acid-n	142-62-1	yes	no	C	
Hexanone 2-	591-78-6	yes	no	C	
Holmium	7440600	yes	no	NA	
Hydrogen	1333740	yes	no	NA	
Hydrogen sulfide	7783-06-4	no	yes	NA	E
Ibuprofen	15687271	yes	no	NA	
Ifosfamide	3778732	yes	no	NA	
Indeno[1,2,3-cd]pyrene	193395	yes	yes	A	
Indium	7440746	yes	no	NA	
Indole	120729	yes	no	NA	
Iodine	7553562	yes	yes	NA	
Iodomethane; Methyl iodide	74884	no	no	A	
Iridium	7439885	yes	no	NA	
Iron	7439896	yes	no	C	
Isobutyl alcohol	78-83-1	yes	yes	C	
Isodrin	465736	yes	no	A	
Isophorone	78591	no	yes	A	
Isopropylnaphthalene, 2-	2027170	no	no	A	
Isosafrole	120581	no	no	A	
Ketoprofen	22071154	yes	no	NA	

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Lanthanum	7439910	yes	no	NA	
Lead and compounds*	7439921	yes	yes	C	
Leptophos	21609905	yes	no	A	
Levonorgestrel	797637	yes	no	NA	
Lime	1305788	yes	no	NA	
Lincomycin	154212	yes	no	NA	
Lindane; gamma-Hexachlorocyclohexane	58899	yes	yes	A	
Linuron	330552	yes	yes	NA	
Lithium	7439932	yes	no	NA	
Longifolene	475207	no	no	A	
Lopamidol	60166930	yes	no	NA	
Lopromide	73334073	yes	no	NA	
Lutetium	7439943	yes	no	NA	
Magnesium	7439-95-4	yes	yes	C	D
Malachite green	569642	no	yes	A	
Malathion	121755	yes	yes	A	E
Manganese	7439965	yes	yes	C	
Mebeverine hydrochloride	2753459	yes	no	NA	
Mefenamic acid	61687	yes	no	NA	
Mercury and compounds*	Various	yes	yes	C	Includes MeHg
Mestranol	72333	yes	no	A	
Metformin	657249	yes	no	NA	
Methapyrilene	91805	no	no	A	
Methoxychlor	72435	yes	yes	A	E
Methyl chloride; Chloromethane	74873	yes	yes	A	
Methyl ethyl ketone; 2-Butanone	78-93-3	yes	yes	C	
Methyl isobutyl ketone; MIBK; Methyl-2-pentanone, 4-	108101	yes	yes	C	
Methyl mercaptan	74931	yes	no	NA	
Methyl methacrylate	80626	no	yes	A	
Methyl methansulfonate	66273	no	no	A	
Methyl parathion	298000	yes	yes	A	
Methyl pentanone	63072-44-6	yes	no	NA	
Methyl-1H-benzotriazole, 5-	136856	yes	no	NA	
Methylamine	74895	yes	no	NA	
Methylbenzothiazole, 2-	120752	no	no	A	

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Methylcholanthrene, 3-	56495	no	yes	A	
Methylchrysene, 5-	3697243	yes	yes	NA	
Methylene bis(2-chloroaniline), 4,4'-	101144	no	yes	A	
Methylene phenanthrene, 4,5-	203-64-5	no	no	A	
Methylfluorene, 1-	1730376	no	no	A	
Methylnaphthalene, 1-	90120	yes	yes	NA	
Methylnaphthalene, 2-	91576	yes	no	B	E
Methylphenanthrene, 1-	832699	yes	no	A	
Methylthio benzothiazole, 2-	615-22-5	yes	no	NA	
Metoprolol	37350586	yes	no	NA	
Mevinphos; Phosdrin	7786347	yes	yes	A	
Mineral oils	8012951	yes	no	NA	
Mirex	2385855	yes	yes	A	E
Molybdenum and compounds*	7439987	yes	yes	C	
Monobromobiphenyl	26264108	yes	no	NA	
Monocrotophos	6923224	yes	no	A	
Monuron	150685	yes	no	NA	
Musk xylene	81152	yes	no	NA	
Musks	NA	yes	no	NA	
Nadolol	42200339	yes	no	NA	
Naled	300765	yes	yes	C	
Naloxone	465656	yes	yes	NA	
Naphthalene	91203	yes	yes	B	E
Naphthalenediamine, 1,5-	2243621	no	no	A	
Naphthoquinone, 1,4-	130-15-4	no	no	A	
Naphthoquinone, 2,3-dichloro, 1,4-	117806	yes	no	A	
Naphthylamine, alpha-	134327	no	no	A	
Naphthylamine, beta-	91598	no	yes	A	
Naproxen	22204531	yes	no	NA	
n-Butyl Mercaptan	109795	yes	no	NA	
Neodymium	7440008	yes	no	NA	
Nickel and compounds*	7440020	yes	yes	C	E
Niobium	7440031	yes	no	NA	
Nitrate	14797558	yes	yes	C	
Nitrite	14797-65-0	yes	yes	C	
Nitroaniline, 2-	88744	no	yes	A	

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Nitroaniline, 3-	99092	no	no	A	
Nitroaniline, 4-	100016	no	no	A	
Nitrobenzamide, 4-	619807	yes	no	NA	
Nitrobenzene	98953	yes	yes	A	E
Nitrochrysene, 6-	2043937	no	no	NA	
Nitrofen (TOK)	NA	yes	yes	C	
Nitrofluorene, 2-	607578	yes	yes	NA	
Nitrogen	7727379	yes	no	NA	
Nitrogen, organic & inorganic-	14798039	yes	no	NA	
Nitro-o-toluidine, 5-	99558	no	yes	A	
Nitrophenol, 2-	88755	yes	no	A	
Nitrophenol, 4-	100027	yes	yes	A	
Nitropyrene, 1-	5522430	yes	yes	NA	
Nitropyrene, 4-	57835924	yes	yes	NA	
Nitrosamines	35576911	yes	no	NA	
N-Nitrosodiethylamine	55185	yes	yes	A	
N-nitrosodimethylamine (NDMA)	62759	yes	yes	A	
N-Nitrosodi-N-butylamine	924163	no	yes	A	
N-Nitrosodiphenylamine	86306	yes	yes	B	
N-Nitrosomethylethylamine	10595956	no	yes	A	
N-Nitrosomethylphenylamine	614-00-6	no	no	A	
N-nitrosomorpholine; NMOR	59892	yes	yes	A	
N-Nitrosopiperidine	100754	no	yes	A	
N-nonylphenol	NA	yes	no	NA	
Nonabromobiphenyl	27753522	yes	no	NA	
Nonabromobiphenyl, 2,2',3,3',4,4',5,5',6-	69278622	yes	no	NA	
Nonabromobiphenyl, 2,2',3,3',4,4',5,6,6'-	119264629	yes	no	NA	
Nonabromobiphenyl, 2,2',3,3',4,5,5',6,6'-	119264630	yes	no	NA	
Nonabromodiphenyl ether	63936561	yes	no	NA	
Nonidet P-40	NA	yes	yes	NA	
Nonoxynol 10	26027383	yes	no	NA	
Nonylphenol (branched), 4-	84852153	yes	no	NA	
Nonylphenol diethoxylate, 4-	NA	yes	no	NA	
Nonylphenol ethoxylates	NA	yes	no	NA	
Nonylphenol monoethoxylate	27986363	yes	no	NA	
Nonylphenol, 2-	136834	yes	no	NA	

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Nonylphenol, 3-	139844	yes	no	NA	
Nonylphenol, 4-	25154523	yes	no	NA	
Nonylphenol, 4-	104405	yes	no	NA	
Nonylphenoxy acetic acid, 4-	3115499	yes	no	NA	
Nonylphenoxy-3,6,9,12-tetraoxatetradecan-1-ol, 14-	26264028	yes	no	NA	
Norethisterone, 19-	68224	yes	no	NA	
Norfloxacin	70458967	yes	no	NA	
N-Phenylacetamide	103844	yes	no	NA	
Octabromobiphenyl	27858077	yes	no	NA	
Octabromobiphenyl, 2,2',3,3',4,4',5,5'-	67889003	yes	no	NA	
Octabromobiphenyl, 2,2',3,3',4,4',6,6'-	119264594	yes	no	NA	
Octabromobiphenyl, 2,2',3,3',4,5',6,6'-	69887112	yes	no	NA	
Octabromobiphenyl, 2,2',3,3',5,5',6,6'-	59080410	yes	no	NA	
Octabromobiphenyl, 2,2',3,3'4,5',6,6'-	119264607	yes	no	NA	
Octabromobiphenyl, 2,2',3,4,4',5,6,6'-	119264618	yes	no	NA	
Octabromodibenzofuran, 1,2,3,4,6,7,8,9-	NA	yes	no	NA	
Octabromodibenzo-p-dioxin, 1,2,3,4,6,7,8,9-	NA	yes	no	NA	
Octabromodiphenyl ether	32536520	yes	yes	NA	
Octachloronaphthalene	2234131	yes	no	NA	
Octacosane n-	630-02-4	yes	no	C	
Octadecane n-	593-45-3	yes	no	C	
Octadecyltrimethylammonium chloride	112038	yes	no	NA	
Octylphenol	67554501	yes	no	NA	
Octylphenol diethoxylate, 4-	NA	yes	no	NA	
Octylphenol monoethoxylate, 4-	NA	yes	no	NA	
Octylphenol, 4-	1806264	yes	no	NA	
Osmium	7440042	yes	no	NA	
Oxytetracycline	79572	yes	yes	NA	
Palladium	7440053	yes	no	NA	
Parathion; Ethyl parathion	56382	no	yes	A	E
Paroxetine metabolite	NA	yes	no	NA	
Pentabromobiphenyl	56307790	yes	no	NA	
Pentabromobiphenyl, 2,2',3,4,6-	77910044	yes	no	NA	
Pentabromobiphenyl, 2,2',3,5',6-	88700054	yes	no	NA	
Pentabromobiphenyl, 2,2',4,4',5-	81397991	yes	no	NA	
Pentabromobiphenyl, 2,2',4,4',6-	97038976	yes	no	NA	

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Pentabromobiphenyl, 2,2',4,5,5'-	67888964	yes	no	NA	
Pentabromobiphenyl, 2,2',4,5',6-	59080396	yes	no	NA	
Pentabromobiphenyl, 2,2',4,5,6'-	80274926	yes	no	NA	
Pentabromobiphenyl, 2,2',4,6,6'-	97063757	yes	no	NA	
Pentabromobiphenyl, 2',3,4,4',5-	74114775	yes	no	NA	
Pentabromobiphenyl, 2,3,4,4',5-	96551701	yes	no	NA	
Pentabromobiphenyl, 2,3',4,4',5-	67888975	yes	no	NA	
Pentabromobiphenyl, 2,3',4,4',6-	86029643	yes	no	NA	
Pentabromobiphenyl, 2,3',4,5,5'-	80407701	yes	no	NA	
Pentabromobiphenyl, 2,3,4,5,6-	38421624	yes	no	NA	
Pentabromobiphenyl, 3,3',4,4',5-	84303468	yes	no	NA	
Pentabromobiphenyl, 3,3',4,5,5'-	81902332	yes	no	NA	
Pentabromodibenzofuran, 1,2,3,7,8-	NA	yes	no	NA	
Pentabromodibenzofuran, 2,3,4,7,8-	NA	yes	no	NA	
Pentabromodibenzo-p-dioxin, 1,2,3,7,8-	NA	yes	no	NA	
Pentabromodiphenyl ether	32534819	yes	yes	NA	E
Pentachlorobenzene	608935	yes	yes	A	
Pentachloroethane	76017	no	no	A	
Pentachloronaphthalene	1321648	yes	no	NA	
Pentachloronitrobenzene; PCNB	82688	yes	yes	C	E
Pentachlorophenol	87865	yes	yes	A	E
Pentamethyl-4,6-dinitrolindane, 1,1,3,3,5-	116665	yes	no	NA	
Pentamethylbenzene	700129	no	no	A	
Permethrin, cis-	54774457	yes	yes	NA	
Permethrin, trans-	51877748	yes	yes	NA	
Perylene	198550	yes	no	A	
Phantolide	15323350	yes	no	NA	
Phenacetin	62442	no	no	A	
Phenanthrene	85018	yes	no	C	
Phenazone	60800	yes	no	NA	
Phenol	108952	yes	yes	C	
Phenol, 2-methyl-4,6-dinitro; Dinitro-o-cresol; DNOC	534521	no	yes	A	
Phenothiazine	92842	no	no	A	
Phenoxymethylpenicyllim	87081	yes	no	NA	
Phenyl ether; Diphenyl ether	101-84-8	yes	yes	A	
Phenyl sulfide	139662	yes	no	NA	

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Phenylnaphthalene, 1-	605027	no	no	A	
Phenylnaphthalene, 2-	612942	yes	no	A	
Phorate	298022	yes	yes	A	
Phosmet	732116	yes	yes	A	
Phosphamidon	13171216	yes	no	A	E
Phosphoric acid, tri-o-tolyl ester	78-30-8	yes	no	C	
Phosphoric, triamide, hexamethyl	680319	yes	no	A	
Phthalates	88993	yes	no	NA	
Phthalic anhydride	85449	yes	yes	NA	
Phytane	638368	yes	no	NA	
Picoline, 2-	109068	yes	no	B	
Platinum	7440064	yes	no	NA	
Polybrominated biphenyls	67774327	yes	yes	NA	
Polychlorinated biphenyls; PCBs	1336-36-3	yes	yes	C	E
Polyethylene glycol nonylphenyl ether	9016459	yes	no	NA	
Polyethylene glycols	25322683	yes	no	NA	
Potassium	7440097	yes	no	NA	
Potassium oxide	12136457	yes	no	NA	
Praseodymium	7440100	yes	no	NA	
Pristane	1921706	yes	no	NA	
Progesterone	57830	yes	no	NA	
Pronamide	23950585	no	yes	A	
Propanil	709988	yes	yes	NA	E
Propen-1-ol, 2- ; Allyl alcohol	107186	no	yes	A	
Propenenitrile, 2-methyl, 2- ; Methacrylonitrile	126987	no	yes	A	
Propionic acid, 2-(4-chloro-2-methylphenoxy) ; MCPP	93652	yes	yes	NA	
Propranolol	525666	yes	no	NA	
Propyl mercaptan	107039	yes	no	NA	
Pyrene	129000	yes	yes	C	
Pyridine	110861	yes	yes	A	
Quinine sulphate	7778930	yes	no	NA	
Ranitidine	66357355	yes	no	NA	
Ranitidine hydrochloride	71130068	yes	no	NA	
Resorcinol	108463	no	no	A	
Rhenium	7440155	yes	no	NA	
Rhodium	7440166	yes	no	NA	

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Roxithromycin	80214831	yes	no	NA	
Rubidium	7440177	yes	no	NA	
Ruthenium	7440188	yes	no	NA	
Safrole	94597	no	yes	A	
Salicylic acid	69727	yes	no	NA	
Samarium	7440199	yes	no	NA	
Sarafloxacin	98105998	yes	no	NA	
Scandium	7440202	yes	no	NA	
Selenium and compounds*	7782492	yes	yes	C	
Silicon	7440213	yes	no	NA	
Silver	7440224	yes	yes	C	
Simazine	122349	yes	yes	NA	E
Skatole	83341	yes	no	NA	
Sodium	7440-23-5	yes	no	C	
Sodium hydroxide	1310-73-2	yes	yes	NA	
Sodium n-dodecylbenzene sulfonate	25155300	yes	no	NA	
Sodium valproate	1069665	yes	no	NA	
Squalene	7683649	no	no	A	
Stigmastanol	19466478	yes	no	NA	
Strontium	7440246	yes	yes	NA	
Styrene	100-42-5	yes	yes	C	E
Sulfachloropyridazine	80320	yes	no	NA	
Sulfadimethoxine	122112	yes	no	NA	
Sulfamerazine	127797	yes	no	NA	
Sulfamethazine	57681	yes	no	NA	
Sulfamethizole	144821	yes	no	NA	
Sulfamethoxazole	723466	yes	no	NA	
Sulfathiazole	72140	yes	no	NA	
Sulfur	7704349	yes	no	NA	
Sulfur dioxide	2025-88-4	no	yes	NA	
Sulfuric acid	7664939	yes	yes	NA	
Sulphasalazine	599791	yes	no	NA	
Tantalum	7440257	yes	no	NA	
Tellurium	13494809	yes	no	NA	
Terbataline	23031256	yes	no	NA	
Terbium	7440279	yes	no	NA	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Terbufos	13071799	yes	yes	A	
Terpineol, alpha-	8006-39-1	yes	no	C	
Tert-butyl-4-hydroxy anisole, 3-	25013165	yes	no	NA	
Testosterone	58220	yes	no	NA	
Tetrabromobiphenyl	40088457	yes	no	NA	
Tetrabromobiphenyl, 2,2',4,4'-	66115579	yes	no	NA	
Tetrabromobiphenyl, 2,2',4,5'-	60044248	yes	no	NA	
Tetrabromobiphenyl, 2,2',4,6'-	97038954	yes	no	NA	
Tetrabromobiphenyl, 2,2',5,5'-	59080374	yes	no	NA	
Tetrabromobiphenyl, 2,2',5,6'-	60044259	yes	no	NA	
Tetrabromobiphenyl, 2,2',6,6'-	97038965	yes	no	NA	
Tetrabromobiphenyl, 2,3,3',4-	97038998	yes	no	NA	
Tetrabromobiphenyl, 2,3',4,4'-	84303457	yes	no	NA	
Tetrabromobiphenyl, 2,3,4,5-	115245095	yes	no	NA	
Tetrabromobiphenyl, 2,3',4',5-	59080385	yes	no	NA	
Tetrabromobiphenyl, 2,3,4,6-	115245108	yes	no	NA	
Tetrabromobiphenyl, 2,4,4',6-	64258022	yes	no	NA	
Tetrabromobiphenyl, 3,3',4,4'-	77102820	yes	no	NA	
Tetrabromobiphenyl, 3,3',4,5'-	97038987	yes	no	NA	
Tetrabromobiphenyl, 3,3',5,5'-	16400503	yes	no	NA	
Tetrabromobiphenyl, 3,4,4',5-	59589923	yes	no	NA	
Tetrabromobisphenol A	79947	yes	no	NA	
Tetrabromodibenzofuran, 2,3,7,8-	NA	yes	no	NA	
Tetrabromodibenzo-p-dioxin, 2,3,7,8-	NA	yes	no	NA	
Tetrabromodiphenyl ether	40088479	yes	no	NA	E
Tetrachlorobenzene	12408105	yes	yes	NA	
Tetrachlorobenzene, 1,2,4,5-	95943	yes	yes	A	
Tetrachloroethane	25322207	yes	yes	NA	
Tetrachloroethane, 1,1,1,2-	630206	no	yes	A	
Tetrachloroethane, 1,1,2,2-	79345	yes	yes	A	
Tetrachloroethylene; Perchloroethylene	127184	yes	yes	C	E
Tetrachloronaphthalene	1335882	yes	no	NA	
Tetrachloronaphthalene, 1,2,3,4-	20020024	yes	no	NA	
Tetrachlorophenol	25167833	yes	yes	NA	
Tetrachlorophenol, 2,3,4,6-	58902	no	yes	A	
Tetrachlorvinphos	961115	yes	yes	A	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Tetracosane n-	646-31-1	yes	no	C	
Tetracycline	60548	yes	no	NA	
Tetradecane n-	629-59-4	yes	no	C	
Tetradecyltrimethylammonium salt	4574043	yes	no	NA	
Tetraethyldithiopyrophosphate; TEDP; Sulfotepp	3689245	yes	yes	A	
Tetraethylpyrophosphate	107-49-3	yes	no	C	
Tetramethylbutyl phenol, 4-1,1,3,3-	140669	no	no	NA	
Thallium	7440280	yes	yes	C	E
Thianaphthene	95158	no	no	A	
Thioacetamide	62555	no	yes	A	
Thioxanthe-9-one	492228	no	no	A	
Thorium	7440291	yes	no	NA	
Thulium	7440304	yes	no	NA	
Timolol	26839758	yes	no	NA	
Tin and compounds	Various	yes	yes	C	
Titanium	7440326	yes	no	C	
Titanium tetrachloride	7550450	yes	yes	NA	
Tolfenamic acid	13710195	yes	no	NA	
Toluene	108883	yes	yes	C	E
Toluene, 2,4-diamino	95807	no	yes	A	
Toluidine, 5-chloro, o-	95794	no	no	A	
Toluidine, o-	95534	no	yes	A	
Toxaphene	8001352	yes	yes	A	
Tri(2-chloroethyl) phosphate	115968	yes	no	NA	
Tri(dichlorisopropyl) phosphate	13674878	yes	no	NA	
Triacontane n-	638-68-6	yes	no	C	
Tribromobiphenyl	51202790	yes	no	NA	
Tribromobiphenyl, 2,2',5-	59080341	yes	no	NA	
Tribromobiphenyl, 2,3',5-	59080352	yes	no	NA	
Tribromobiphenyl, 2,4,4'-	6430906	yes	no	NA	
Tribromobiphenyl, 2,4',5-	59080363	yes	no	NA	
Tribromobiphenyl, 2,4,5-	115245073	yes	no	NA	
Tribromobiphenyl, 2,4',6-	64258033	yes	no	NA	
Tribromobiphenyl, 2,4,6-	59080330	yes	no	NA	
Tribromobiphenyl, 3,4,4'-	6683358	yes	no	NA	
Tribromobiphenyl, 3,4,5-	115245084	yes	no	NA	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Tribromobiphenyl, 3,4',5-	72416876	yes	no	NA	
Tribromodiphenyl ether	49690940	yes	no	NA	
Tribromomethane; Bromoform	75252	yes	yes	A	E
Tribromophenol, 2,4,6-	118796	yes	yes	NA	
Tributyl tin compounds	56573854	yes	yes	NA	E
Trichlorfon	52686	yes	yes	A	
Trichlorobenzene	12002481	yes	yes	NA	
Trichlorobenzene, 1,2,3-	87616	no	no	A	
Trichlorobenzene, 1,2,4-	120821	yes	yes	A	
Trichlorobenzene, 1,3,5-	108703	yes	no	NA	
Trichloroethane	25323891	yes	yes	NA	
Trichloroethane, 1,1,1-	71556	yes	yes	A	E
Trichloroethane, 1,1,2-	79005	yes	yes	A	
Trichloroethene	79016	yes	yes	B	E
Trichlorofluoromethane	75-69-4	yes	yes	C	
Trichloronaphthalene	1321659	yes	no	NA	
Trichlorophenol	25167822	yes	yes	NA	
Trichlorophenol, 2,3,6-	933-75-5	no	no	A	
Trichlorophenol, 2,4,5-	95954	no	yes	A	
Trichlorophenol, 2,4,6-	88062	yes	yes	A	
Trichlorophenoxy propionic acid, 2-2,4,5- ; Silvex	93721	yes	yes	C	
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93765	yes	yes	C	
Trichloropropane, 1,2,3-	96184	no	yes	A	
Triclosan	3380345	yes	yes	NA	
Triethylamine	121448	yes	yes	NA	
Trifluralin	1582098	yes	yes	C	
Trimethoprim	738705	yes	no	NA	
Trimethoxybenzene, 1,2,3-	634366	no	no	A	
Trimethyl phosphate	512561	yes	yes	A	
Trimethylamine	75503	yes	no	NA	
Trimethylnaphthalene, 2,3,6-	829265	yes	no	NA	
Triphenyl phosphate	115866	yes	no	NA	
Triphenylene	217594	no	no	A	
Tripropyleneglycol methyl ether	25498491	no	no	A	
Trithiane, 1,3,5-	291-21-4	no	no	A	
Tungsten	7440337	yes	no	NA	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments [I]
Tylosin	1401690	yes	no	NA	
Uranium	7440-61-1	yes	yes	NA	E
Vanadium	7440622	yes	yes	C	
Vinyl acetate	108054	yes	yes	A	E
Vinyl Chloride	75014	yes	yes	A	
Virginiamycin	21411530	yes	no	NA	
Volatile Organic Compounds	NA	yes	no	NA	
Warfarin	81812	yes	yes	NA	
Xylene, m-	108-38-3	yes	yes	C	
Xylene, o-	95476	yes	yes	NA	
Xylene, p-	106423	yes	yes	NA	
Xylene (o, p, m mixture)	1330207	yes	yes	C	
Ytterbium	7440644	yes	no	NA	
Yttrium	7440655	yes	no	C	
Zinc and compounds*	7440666	yes	yes	C	E
Zirconium	7440677	yes	no	NA	

CASRN = Chemical Abstracts Service Registry Number. * = Metals regulated in Round One. Column F: National & international literature search conducted for the period 1990-2002. Column G: Human health benchmarks from a number of databases. The HHBs have not necessarily been fully evaluated with regard to acceptability for use in this screening process. Column H: NSSS = 1989 National Sewage Sludge Survey; A = not detected in sewage sludge samples; B = detected in 1% of samples collected; C = detected in >1% of samples collected. Column I: D = Essential nutrient. E = Ongoing IRIS or OPP health assessment at October 1, 2003. E(NTP) = Ongoing NTP toxicological studies for Cr+6. E(NRC) = Ongoing NRC review of fluoride toxicological data, requested by EPA. NA = Not applicable or not available. Reference for NSSS data: EPA, 1990; 1996.

Table 2: Chemicals Reported in Sewage Sludge and Having Human Health Benchmarks from a Variety of Data Sources

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments[I]
Acenaphthene	83329	yes	yes	A	
Acetaldehyde	75070	yes	yes	NA	E
Acetone; 2-Propanone	67-64-1	yes	yes	C	
Acetophenone	98862	yes	yes	C	
Aldrin	309002	yes	yes	C	
Aluminum	7429905	yes	yes	C	
Ammonia	7664417	yes	yes	NA	
Aniline	62533	yes	yes	A	
Anthracene	120127	yes	yes	C	
Antimony and compounds	7440360	yes	yes	C	E
Aroclor 1016	12674112	yes	yes	A	E: PCBs
Aroclor 1254	11097691	yes	yes	C	E: PCBs
Arsenic and compounds*	7440-38-2	yes	yes	C	E
Atrazine	1912249	yes	yes	NA	E
Azinphos methyl	86500	yes	yes	C	
Barium	7440393	yes	yes	C	
Benzene	71432	yes	yes	A	
Benzenethiol	108985	yes	yes	A	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments[I]
Benzo[a]anthracene	56553	yes	yes	C	
Benzo[a]pyrene	50328	yes	yes	C	E
Benzo[b]fluoranthene	205992	yes	yes	C	
Benzo[j]fluoranthene	205823	yes	yes	NA	
Benzo[k]fluoranthene	207089	yes	yes	C	
Benzoic acid	65-85-0	yes	yes	C	
Beryllium	7440417	yes	yes	C	
Biphenyl, 1,1-	92524	yes	yes	B	
Bis(2-chloroethyl)ether	111444	yes	yes	A	
Bis(2-chloroisopropyl)ether	108601	yes	yes	A	
Bisphenol A	80057	yes	yes	NA	
Boron	7440428	yes	yes	C	E
Butanol, n- ; n-Butyl alcohol	71363	yes	yes	NA	
Butyl benzyl phthalate	85687	yes	yes	C	
Cadmium and compounds*	7440439	yes	yes	C	E
Calcium	7440-70-2	yes	yes	C	D
Captafol	2425061	yes	yes	A	
Captan	133062	yes	yes	A	
Carbaryl	63252	yes	yes	NA	
Carbon disulfide	75-15-0	yes	yes	C	
Carbon tetrachloride; Tetrachloromethane	56-23-5	yes	yes	C	E
Chlordane	57749	yes	yes	A	
Chlordane, cis-	5103719	yes	yes	NA	
Chlorine	7782505	yes	yes	NA	
Chloro-2-methyl-phenoxy acetic acid, 4- ; MCPA	94746	yes	yes	NA	E
Chloro-3-methylphenol, 4- ; p-Chloro-m-cresol; PCMC	59507	yes	yes	A	
Chloroaniline, 4-; p-Chloroaniline	106478	yes	yes	C	
Chloroanilines	27134265	yes	yes	NA	
Chlorobenzene; Phenyl chloride	108907	yes	yes	C	
Chlorobenzilate	510156	yes	yes	C	
Chloroform	67663	yes	yes	B	E
Chlorophenol	25167800	yes	yes	NA	
Chlorophenol, 2-	95578	yes	yes	A	
Chlorophenol, 4-	106489	yes	yes	NA	
Chloroprene; 2-Chloro-1,3-butadiene	126998	yes	yes	A	E
Chlorpyrifos	2921882	yes	yes	C	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments[I]
Chromium and compounds	7440-47-3	yes	yes	C	E (NTP)
Chrysene	218019	yes	yes	C	
Cobalt	7440484	yes	yes	C	E
Copper and compounds*	7440508	yes	yes	C	E
Coumaphos	56724	yes	yes	A	
Cresol, m- ; 3-Methylphenol	108394	yes	yes	NA	
Cresol, o- ; 2-Methylphenol	95-48-7	yes	yes	C	
Cresol, p- ; 4-Methylphenol	106445	yes	yes	C	
DDD, 4,4'-	72548	yes	yes	A	
DDE, 4,4'-	72559	yes	yes	B	
DDT ; p,p'-Dichlorodiphenyltrichloroethane	50293	yes	yes	C	
Decabromodiphenyl ether	1163195	yes	yes	NA	E
Demeton	8065483	yes	yes	A	
Di(2-ethylhexyl)adipate; DEHA	103231	yes	yes	NA	E
Di(2-ethylhexyl)phthalate; DEHP	117817	yes	yes	C	E
Diallate	2303164	yes	yes	A	
Diazinon	333415	yes	yes	C	
Dibenz[a,h]acridine	226368	yes	yes	NA	
Dibenz[a,h]anthracene	53703	yes	yes	A	
Dibenz[a,j]acridine	224420	yes	yes	NA	
Dibenzo[a,e]pyrene	192654	yes	yes	NA	
Dibenzo[a,h]pyrene	189640	yes	yes	NA	
Dibenzo[a,i]pyrene	189559	yes	yes	NA	
Dibenzo[a,l]pyrene	191300	yes	yes	NA	
Dibenzo[c,g]carbazole, 7H-	194592	yes	yes	NA	
Dibutyl phthalate	84742	yes	yes	C	E
Dichlorobenzene, 1,2-	95501	yes	yes	A	E
Dichlorobenzene, 1,3-	541731	yes	yes	A	E
Dichlorobenzene, 1,4-	106467	yes	yes	C	E
Dichlorobenzenes, total (mixed isomers)	25321226	yes	yes	NA	
Dichlorobenzidine, 3,3'	91941	yes	yes	A	
Dichloroethane, 1,2- ; Ethylene dichloride	107062	yes	yes	A	E
Dichloroethene, 1,1-	75-35-4	yes	yes	A	
Dichloroethene, 1,2-trans-	156-60-5	yes	yes	B	
Dichloromethane; Methylene chloride	75092	yes	yes	C	
Dichlorophenol, 2,4-	120832	yes	yes	A	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments[I]
Dichlorophenoxyacetic acid, 2,4- ; 2,4-D	94757	yes	yes	C	E
Dichlorvos; DDVP	62737	yes	yes	A	E
Dicrotophos; Bidrin	141662	yes	yes	A	
Dieldrin	60571	yes	yes	C	
Diethyl phthalate	84662	yes	yes	A	
Diethylstilbestrol	56531	yes	yes	NA	
Dimethoate	60515	yes	yes	B	E
Dimethylphenol, 2,4-; Xylenol	105679	yes	yes	A	
Dinitrophenol (mixed isomers)	25550587	yes	yes	NA	
Dinitrophenol, 2,4-	51285	yes	yes	A	
Dinitropyrene, 1,6-	42397648	yes	yes	NA	
Dinitropyrene, 1,8-	42397659	yes	yes	NA	
Dinitrotoluene, 2,4-	121142	yes	yes	A	
Dinitrotoluene, 2,6-	606202	yes	yes	A	
Di-N-octyl phthalate	117840	yes	yes	B	
Dinoseb	88857	yes	yes	NA	
Dioxane, 1,4-	123-91-1	yes	yes	C	
Disulfoton	298044	yes	yes	A	
Endosulfan	115297	yes	yes	NA	
Endosulfan I; alpha-Endosulfan	959988	yes	yes	B	
Endosulfan II; beta-Endosulphan	33213659	yes	yes	C	
Endrin	72208	yes	yes	C	
Ethion	563122	yes	yes	A	E
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104645	yes	yes	C	
Ethylbenzene	100414	yes	yes	C	E
Fenthion	55389	yes	yes	A	
Fluoranthene	206440	yes	yes	C	
Fluorene	86737	yes	yes	A	
Fluoride	16984488	yes	yes	C	E (NRC)
Heptachlor	76448	yes	yes	A	
Heptachlor epoxide	1024573	yes	yes	C	
Hexachlorobenzene	118741	yes	yes	A	
Hexachlorobutadiene	87683	yes	yes	A	E
Hexachlorocyclohexane, alpha-	319846	yes	yes	C	
Hexachlorocyclohexane, beta-	319857	yes	yes	C	
Hexachlorocyclopentadiene	77474	yes	yes	A	E

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments[I]
Indeno[1,2,3-cd]pyrene	193395	yes	yes	A	
Iodine	7553562	yes	yes	NA	
Isobutyl alcohol	78-83-1	yes	yes	C	
Lead and compounds*	7439921	yes	yes	C	
Lindane; gamma-Hexachlorocyclohexane	58899	yes	yes	A	
Linuron	330552	yes	yes	NA	
Magnesium	7439-95-4	yes	yes	C	D
Malathion	121755	yes	yes	A	E
Manganese	7439965	yes	yes	C	
Mercury and compounds*	Various	yes	yes	C	Includes MeHg
Methoxychlor	72435	yes	yes	A	E
Methyl chloride; Chloromethane	74873	yes	yes	A	
Methyl ethyl ketone; 2-Butanone	78-93-3	yes	yes	C	
Methyl isobutyl ketone; MIBK; Methyl-2-pentanone, 4-	108101	yes	yes	C	
Methyl parathion	298000	yes	yes	A	
Methylchrysene, 5-	3697243	yes	yes	NA	
Methylnaphthalene, 1-	90120	yes	yes	NA	
Mevinphos; Phosdrin	7786347	yes	yes	A	
Mirex	2385855	yes	yes	A	E
Molybdenum and compounds*	7439987	yes	yes	C	
Naled	300765	yes	yes	C	
Naloxone	465656	yes	yes	NA	
Naphthalene	91203	yes	yes	B	E
Nickel and compounds*	7440020	yes	yes	C	E
Nitrate	14797558	yes	yes	C	
Nitrite	14797-65-0	yes	yes	C	
Nitrobenzene	98953	yes	yes	A	E
Nitrofen (TOK)	NA	yes	yes	C	
Nitrofluorene, 2-	607578	yes	yes	NA	
Nitrophenol, 4-	100027	yes	yes	A	
Nitropyrene, 1-	5522430	yes	yes	NA	
Nitropyrene, 4-	57835924	yes	yes	NA	
N-Nitrosodiethylamine	55185	yes	yes	A	
N-nitrosodimethylamine (NDMA)	62759	yes	yes	A	
N-Nitrosodiphenylamine	86306	yes	yes	B	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments[I]
N-nitrosomorpholine; NMOR	59892	yes	yes	A	
Nonidet P-40	NA	yes	yes	NA	
Octabromodiphenyl ether	32536520	yes	yes	NA	
Oxytetracycline	79572	yes	yes	NA	
Pentabromodiphenyl ether	32534819	yes	yes	NA	E
Pentachlorobenzene	608935	yes	yes	A	
Pentachloronitrobenzene; PCNB	82688	yes	yes	C	E
Pentachlorophenol	87865	yes	yes	A	E
Permethrin, cis-	54774457	yes	yes	NA	
Permethrin, trans-	51877748	yes	yes	NA	
Phenol	108952	yes	yes	C	
Phenyl ether; Diphenyl ether	101-84-8	yes	yes	A	
Phorate	298022	yes	yes	A	
Phosmet	732116	yes	yes	A	
Phthalic anhydride	85449	yes	yes	NA	
Polybrominated biphenyls	67774327	yes	yes	NA	
Polychlorinated biphenyls; PCBs	1336-36-3	yes	yes	C	E
Propanil	709988	yes	yes	NA	E
Propionic acid, 2-(4-chloro-2-methylphenoxy) ; MCPP	93652	yes	yes	NA	
Pyrene	129000	yes	yes	C	
Pyridine	110861	yes	yes	A	
Selenium and compounds*	7782492	yes	yes	C	
Silver	7440224	yes	yes	C	
Simazine	122349	yes	yes	NA	E
Sodium hydroxide	1310-73-2	yes	yes	NA	
Strontium	7440246	yes	yes	NA	
Styrene	100-42-5	yes	yes	C	E
Sulfuric acid	7664939	yes	yes	NA	
Terbufos	13071799	yes	yes	A	
Tetrachlorobenzene	12408105	yes	yes	NA	
Tetrachlorobenzene, 1,2,4,5-	95943	yes	yes	A	
Tetrachloroethane	25322207	yes	yes	NA	
Tetrachloroethane, 1,1,2,2-	79345	yes	yes	A	
Tetrachloroethylene; Perchloroethylene	127184	yes	yes	C	E
Tetrachlorophenol	25167833	yes	yes	NA	
Tetrachlorvinphos	961115	yes	yes	A	

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments[I]
Tetraethyldithiopyrophosphate; TEDP; Sulfotepp	3689245	yes	yes	A	
Thallium	7440280	yes	yes	C	E
Tin and compounds	Various	yes	yes	C	
Titanium tetrachloride	7550450	yes	yes	NA	
Toluene	108883	yes	yes	C	E
Toxaphene	8001352	yes	yes	A	
Tribromomethane; Bromoform	75252	yes	yes	A	E
Tribromophenol, 2,4,6-	118796	yes	yes	NA	
Tributyl tin compounds	56573854	yes	yes	NA	E
Trichlorfon	52686	yes	yes	A	
Trichlorobenzene	12002481	yes	yes	NA	
Trichlorobenzene, 1,2,4-	120821	yes	yes	A	
Trichloroethane	25323891	yes	yes	NA	
Trichloroethane, 1,1,1-	71556	yes	yes	A	E
Trichloroethane, 1,1,2-	79005	yes	yes	A	
Trichloroethene	79016	yes	yes	B	E
Trichlorofluoromethane	75-69-4	yes	yes	C	
Trichlorophenol	25167822	yes	yes	NA	
Trichlorophenol, 2,4,6-	88062	yes	yes	A	
Trichlorophenoxy propionic acid, 2-2,4,5- ; Silvex	93721	yes	yes	C	
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93765	yes	yes	C	
Triclosan	3380345	yes	yes	NA	
Triethylamine	121448	yes	yes	NA	
Trifluralin	1582098	yes	yes	C	
Trimethyl phosphate	512561	yes	yes	A	
Uranium	7440-61-1	yes	yes	NA	E
Vanadium	7440622	yes	yes	C	
Vinyl acetate	108054	yes	yes	A	E
Vinyl Chloride	75014	yes	yes	A	
Warfarin	81812	yes	yes	NA	
Xylene, m-	108-38-3	yes	yes	C	
Xylene, o-	95476	yes	yes	NA	
Xylene, p-	106423	yes	yes	NA	
Xylenes (o, p, m mixture)	1330207	yes	yes	C	
Zinc and compounds*	7440666	yes	yes	C	E

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments[I]
* = Metals regulated in Round One. Column F: National & international literature search conducted for the period 1990-2002. Column G: Human health benchmarks from a number of databases; the HHBs have not necessarily been fully evaluated with regard to acceptability for use in this screening process. Column H: NSSS = 1989 National Sewage Sludge Survey; A = not detected; B = detected in 1% of samples; C = detected in >1% of samples collected. NA = Not applicable or not available; Reference for NSSS data: EPA, 1990; 1996.Column I: D = Essential nutrient; E = Ongoing EPA health assessment at October 1, 2003; E(NTP) = Ongoing NTP toxicological studies for Cr+6; E(NRC) = Ongoing NRC review of fluoride toxicity, requested by EPA.					

Table 3: Chemicals Regulated in Round One

Chemical	Comments
Arsenic	E
Cadmium	E
Copper	E
Lead	
Mercury	Includes MeHg
Molybdenum *	

Chemical	Comments
Nickel	E
Selenium	
Zinc	E

Molybdenum*: EPA will review criteria for molybdenum in land-applied treated sewage sludge. E = Ongoing Integrated Risk Information System (IRIS) assessment at October 1, 2003. EPA plans to include all nine metals in a targeted national survey to be initiated in FY 2005.

Table 4: Chemicals Previously Evaluated and Determined Not to be Hazardous in Sewage Sludge

Chemical	CASRN	Reported in Literature[F]	Human Health Benchmark[G]	Monitored in 1989 NSSS[H]	Comments[I]
Aldrin	309002	yes	IRIS 91	C	J (banned)
Calcium	7440-70-2	yes	IOM 99	C	D
Chlordane	57749	yes	IRIS 98	A	J (banned)
Chromium*	16065-83-1	yes	IRIS 98	C	Cr III predominates
DDD; p,p'-DDD	72548	yes	IRIS 88	A	J (banned)
DDE; p,p'-DDE	72559	yes	IRIS 88	B	J (banned)
DDT; p,p'-DDT	50293	yes	IRIS 88	C	J (banned)
Dieldrin	60571	yes	IRIS 91	C	J (banned)
Heptachlor	76-44-8	yes	OPP 92	A	J (severely restricted)
Heptachlor epoxide	1024-57-3	yes	OPP 92	C	J (severely restricted)
Hexachlorobenzene	118741	yes	IRIS 91	A	J (banned)
Lindane; gamma-Hexachlorocyclohexane	58899	yes	OPP 02	C	J (severely restricted)
Magnesium	7439-95-4	yes	IOM 99	C	D
Phthalic anhydride**	85449	yes	IRIS 88	NA	1/2 life considerations
Toxaphene	8001352	yes	IRIS 91	A	J (banned)

Column F: National & International literature search conducted for the period 1990-2002. Column G: IRIS or OPP human health benchmark & year of assessment. Column H: NSSS = National Sewage Sludge Survey; A = not detected in sewage sludge samples; B = detected in 1% of samples collected; C = detected in > 1% of samples collected; NA = not applicable. Column I: D = Essential nutrient. Tolerable upper intake levels (UL) established by the Institute of Medicine (IOM, 1999) for calcium and magnesium are 2.5 g/day & 0.35 g/day, respectively, indicating unlikely hazard from their presence in sewage sludge; J = Banned or severely restricted pesticide. Chromium*: The less toxic Cr III, rather than Cr VI, predominates in sewage sludge. Phthalic anhydride** was removed from consideration because of its extremely rapid degradation in soil for the required sewage sludge 30-day holding period.

Table 5: Chemicals Reported in U.S. Sewage Sludge from the Literature or the National Sewage Sludge Survey and Having Human Health Benchmarks from a Variety of Data Sources

Chemical	CASRN	HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Acenaphthene	83329	yes	n.d.	A	
Acetaldehyde	75070	yes		NA	E
Acetone; 2-Propanone	67-64-1	yes	yes	C	
Acetophenone	98862	yes		C	
Aluminum	7429905	yes	yes	C	
Ammonia	7664417	yes		NA	
Aniline	62533	yes	n.d.	A	
Anthracene	120127	yes	n.d.	C	
Antimony and compounds	7440360	yes	yes	C	E
Aroclor 1016	12674112	yes		A	E: PCBs
Aroclor 1254	11097691	yes		C	E: PCBs
Atrazine	1912249	yes		NA	E
Azinphos methyl	86500	yes		C	
Barium	7440393	yes	yes	C	
Benzene	71432	yes	n.d.	A	
Benzenethiol	108985	yes		A	
Benzo[a]anthracene	56553	yes	n.d.	C	
Benzo[a]pyrene	50328	yes	n.d.	C	E
Benzo[b]fluoranthene	205992	yes		C	
Benzo[j]fluoranthene	205823	yes		NA	
Benzo[k]fluoranthene	207089	yes		C	
Benzoic acid	65-85-0	yes	n.d.	C	
Beryllium	7440417	yes	yes	C	
Biphenyl, 1,1-	92524	yes		B	
Bis(2-chloroethyl)ether	111444	yes	n.d.	A	
Bis(2-chloroisopropyl)ether	108601	yes	n.d.	A	
Bisphenol A	80057	yes		NA	
Boron	7440428	yes	yes	C	E
Butanol, n- ; n-Butyl alcohol	71363	yes		NA	
Butyl benzyl phthalate	85687	yes	n.d.	C	
Captafol	2425061	yes		A	
Captan	133062	yes		A	

Chemical	CASRN	HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Carbaryl	63252	yes		NA	
Carbon disulfide	75-15-0	yes	n.d.	C	
Carbon tetrachloride; Tetrachloromethane	56-23-5	yes	n.d.	C	E
Chlordane, cis-	5103719	yes		NA	
Chlorine	7782505	yes		NA	
Chloro-2-methyl-phenoxy acetic acid, 4- ; MCPA	94746	yes		NA	E
Chloro-3-methylphenol, 4- ; p-Chloro-m-cresol; PCMC	59507	yes	n.d.	A	
Chloroaniline, 4-; p-Chloroaniline	106478	yes	n.d.	C	
Chloroanilines	27134265	yes		NA	
Chlorobenzene; Phenyl chloride	108907	yes	n.d.	C	
Chlorobenzilate	510156	yes		C	
Chloroform	67663	yes	yes	B	E
Chlorophenol	25167800	yes		NA	
Chlorophenol, 2-	95578	yes	n.d.	A	
Chlorophenol, 4-	106489	yes		NA	
Chloroprene; 2-Chloro-1,3-butadiene	126998	yes		A	E
Chlorpyrifos	2921882	yes	yes	C	
Chrysene	218019	yes	n.d.	C	
Cobalt	7440484	yes	yes	C	E
Coumaphos	56724	yes		A	
Cresol, m- ; 3-Methylphenol	108394	yes		NA	
Cresol, o- ; 2-Methylphenol	95-48-7	yes	n.d.	C	
Cresol, p- ; 4-Methylphenol	106445	yes	yes	C	
Decabromodiphenyl ether	1163195	yes	yes	NA	E
Demeton	8065483	yes		A	
Di(2-ethylhexyl)adipate; DEHA	103231	yes		NA	E
Di(2-ethylhexyl)phthalate; DEHP	117817	yes	yes	C	E
Diallate	2303164	yes		A	
Diazinon	333415	yes		C	
Dibenz[a,h]acridine	226368	yes		NA	
Dibenz[a,h]anthracene	53703	yes	n.d.	A	
Dibenz[a,j]acridine	224420	yes		NA	
Dibenzo[a,e]pyrene	192654	yes		NA	
Dibenzo[a,h]pyrene	189640	yes		NA	
Dibenzo[a,i]pyrene	189559	yes		NA	
Dibenzo[a,l]pyrene	191300	yes		NA	

Chemical	CASRN	HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Dibenzo[c,g]carbazole, 7H-	194592	yes		NA	
Dibutyl phthalate	84742	yes	n.d.	C	E
Dichlorobenzene, 1,2-	95501	yes	n.d.	A	E
Dichlorobenzene, 1,3-	541731	yes	n.d.	A	E
Dichlorobenzene, 1,4-	106467	yes	n.d.	C	E
Dichlorobenzenes, total (mixed isomers)	25321226	yes		NA	
Dichlorobenzidine, 3,3'	91941	yes	n.d.	A	
Dichloroethane, 1,2- ; Ethylene dichloride	107062	yes	n.d.	A	E
Dichloroethene, 1,1-	75-35-4	yes	n.d.	A	
Dichloroethene, 1,2-trans-	156-60-5	yes		B	
Dichloromethane; Methylene chloride	75092	yes	n.d.	C	
Dichlorophenol, 2,4-	120832	yes	n.d.	A	
Dichlorophenoxyacetic acid, 2,4- ; 2,4-D	94757	yes		C	E
Dichlorvos; DDVP	62737	yes		A	E
Dicrotophos; Bidrin	141662	yes		A	
Diethyl phthalate	84662	yes		A	
Diethylstilbestrol	56531	yes		NA	
Dimethoate	60515	yes		B	E
Dimethylphenol, 2,4-; Xylenol	105679	yes	n.d.	A	
Dinitrophenol (mixed isomers)	25550587	yes		NA	
Dinitrophenol, 2,4-	51285	yes	n.d.	A	
Dinitropyrene, 1,6-	42397648	yes		NA	
Dinitropyrene, 1,8-	42397659	yes		NA	
Dinitrotoluene, 2,4-	121142	yes	n.d.	A	
Dinitrotoluene, 2,6-	606202	yes	n.d.	A	
Di-N-octyl phthalate	117840	yes	n.d.	B	
Dinoseb	88857	yes		NA	
Dioxane, 1,4-	123-91-1	yes		C	
Disulfoton	298044	yes		A	
Endosulfan	115297	yes	n.d.	NA	
Endosulfan I; alpha-Endosulfan	959988	yes	n.d.	B	
Endosulfan II; beta-Endosulphan	33213659	yes	n.d.	C	
Endrin	72208	yes	n.d.	C	
Ethion	563122	yes		A	E
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104645	yes		C	
Ethylbenzene	100414	yes	n.d.	C	E

Chemical	CASRN	HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Fenthion	55389	yes		A	
Fluoranthene	206440	yes	yes	C	
Fluorene	86737	yes	n.d.	A	
Fluoride	16984488	yes		C	E (NRC)
Hexachlorobutadiene	87683	yes	n.d.	A	E
Hexachlorocyclohexane, alpha-	319846	yes	n.d.	C	
Hexachlorocyclohexane, beta-	319857	yes	n.d.	C	
Hexachlorocyclopentadiene	77474	yes	n.d.	A	E
Indeno[1,2,3-cd]pyrene	193395	yes	n.d.	A	
Iodine	7553562	yes		NA	
Isobutyl alcohol	78-83-1	yes		C	
Linuron	330552	yes		NA	
Malathion	121755	yes		A	E
Manganese	7439965	yes	yes	C	
Methoxychlor	72435	yes	n.d.	A	E
Methyl chloride; Chloromethane	74873	yes	n.d.	A	
Methyl ethyl ketone; 2-Butanone	78-93-3	yes	n.d.	C	
Methyl isobutyl ketone; MIBK; Methyl-2-pentanone, 4-	108101	yes	n.d.	C	
Methyl parathion	298000	yes		A	
Methylchrysene, 5-	3697243	yes		NA	
Methylnaphthalene, 1-	90120	yes	n.d.	NA	
Mevinphos; Phosdrin	7786347	yes		A	
Mirex	2385855	yes		A	E
Naled	300765	yes		C	
Naloxone	465656	yes		NA	
Naphthalene	91203	yes	n.d.	B	E
Nitrate	14797558	yes	yes	C	
Nitrite	14797-65-0	yes		C	
Nitrobenzene	98953	yes	n.d.	A	E
Nitrofen (TOK)	NA	yes		C	
Nitrofluorene, 2-	607578	yes		NA	
Nitrophenol, 4-	100027	yes	n.d.	A	
Nitropyrene, 1-	5522430	yes		NA	
Nitropyrene, 4-	57835924	yes		NA	
N-Nitrosodiethylamine	55185	yes		A	
N-nitrosodimethylamine (NDMA)	62759	yes	n.d.	A	

Chemical	CASRN	HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
N-Nitrosodiphenylamine	86306	yes	n.d.	B	
N-nitrosomorpholine; NMOR	59892	yes		A	
Nonidet P-40	NA	yes		NA	
Octabromodiphenyl ether	32536520	yes		NA	
Oxytetracycline	79572	yes		NA	
Pentabromodiphenyl ether	32534819	yes	yes	NA	E
Pentachlorobenzene	608935	yes		A	
Pentachloronitrobenzene; PCNB	82688	yes		C	E
Pentachlorophenol	87865	yes	n.d.	A	E
Permethrin, cis-	54774457	yes		NA	
Permethrin, trans-	51877748	yes		NA	
Phenol	108952	yes	yes	C	
Phenyl ether; Diphenyl ether	101-84-8	yes		A	
Phorate	298022	yes		A	
Phosmet	732116	yes		A	
Polybrominated biphenyls	67774327	yes		NA	
Polychlorinated biphenyls; PCBs	1336-36-3	yes	yes	C	E
Propanil	709988	yes		NA	E
Propionic acid, 2-(4-chloro-2-methylphenoxy) ; MCPP	93652	yes		NA	
Pyrene	129000	yes	yes	C	
Pyridine	110861	yes		A	
Silver	7440224	yes	yes	C	
Simazine	122349	yes		NA	E
Sodium hydroxide	1310-73-2	yes		NA	
Strontium	7440246	yes	yes	NA	
Styrene	100-42-5	yes	n.d.	C	E
Sulfuric acid	7664939	yes		NA	
Terbufos	13071799	yes		A	
Tetrachlorobenzene	12408105	yes		NA	
Tetrachlorobenzene, 1,2,4,5-	95943	yes		A	
Tetrachloroethane	25322207	yes		NA	
Tetrachloroethane, 1,1,2,2-	79345	yes	n.d.	A	
Tetrachloroethylene; Perchloroethylene	127184	yes	n.d.	C	E
Tetrachlorophenol	25167833	yes		NA	
Tetrachlorvinphos	961115	yes		A	
Tetraethyldithiopyrophosphate; TEDP; Sulfotepp	3689245	yes		A	

Chemical	CASRN	HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Thallium	7440280	yes	yes	C	E
Tin and compounds	Various	yes		C	
Titanium tetrachloride	7550450	yes		NA	
Toluene	108883	yes	yes	C	E
Tribromomethane; Bromoform	75252	yes	n.d.	A	E
Tribromophenol, 2,4,6-	118796	yes		NA	
Tributyl tin compounds	56573854	yes		NA	E
Trichlorfon	52686	yes		A	
Trichlorobenzene	12002481	yes		NA	
Trichlorobenzene, 1,2,4-	120821	yes		A	
Trichloroethane	25323891	yes	n.d.	NA	
Trichloroethane, 1,1,1-	71556	yes		A	E
Trichloroethane, 1,1,2-	79005	yes	n.d.	A	
Trichloroethene	79016	yes	n.d.	B	E
Trichlorofluoromethane	75-69-4	yes	n.d.	C	
Trichlorophenol	25167822	yes		NA	
Trichlorophenol, 2,4,6-	88062	yes	n.d.	A	
Trichlorophenoxy propionic acid, 2-2,4,5- ; Silvex	93721	yes		C	
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93765	yes		C	
Triclosan	3380345	yes		NA	
Triethylamine	121448	yes		NA	
Trifluralin	1582098	yes		C	
Trimethyl phosphate	512561	yes		A	
Uranium	7440-61-1	yes	yes	NA	E
Vanadium	7440622	yes	yes	C	
Vinyl acetate	108054	yes	n.d.	A	E
Vinyl Chloride	75014	yes	n.d.	A	
Warfarin	81812	yes		NA	
Xylene, m-	108-38-3	yes		C	
Xylene, o-	95476	yes		NA	
Xylene, p-	106423	yes		NA	
Xylenes (o, p, m mixtures)	1330207	yes	n.d.	C	

Chemical	CASRN	HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Column D: HHB = Human health benchmarks from a variety of databases. The HHBs have not necessarily been fully evaluated with regard to acceptability for use in this screening process. Column F: Literature search for concentration values in U.S. sewage sludge conducted for the period 1990-2002; yes = value reported; n.d. = not detected; blank = not mentioned in the literature. Column G: NSSS = National Sewage Sludge Survey; A = not detected in sewage sludge samples; B = detected in 1% of samples collected; C = detected in >1% of samples collected. NA = not applicable i.e., not monitored in NSSS. Column H: E = Ongoing IRIS or OPP health assessment at October 1, 2003. E(NRC) = Ongoing NRC review of fluoride toxicological data, requested by EPA.					

Table 6: Identifying Availability of IRIS or OPP Human Health Benchmarks for Chemicals Occurring in U.S. Sewage Sludge

Chemical	CASRN	IRIS or OPP HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Acetone; 2-Propanone	67-64-1	yes	yes	C	
Acetophenone	98862	yes		C	
Aluminum	7429905	no	yes	C	
Anthracene	120127	yes	n.d.	C	
Antimony and compounds	7440360	yes	yes	C	E
Aroclor 1254	11097691	yes		C	E: PCBs
Azinphos methyl	86500	yes		C	
Barium	7440393	yes	yes	C	
Benzo[a]anthracene	56553	no	n.d.	C	
Benzo[a]pyrene	50328	yes	n.d.	C	E
Benzo[b]fluoranthene	205992	no		C	
Benzo[k]fluoranthene	207089	no		C	
Benzoic acid	65-85-0	yes	n.d.	C	
Beryllium	7440417	yes	yes	C	
Biphenyl, 1,1-	92524	yes		B	
Boron	7440428	yes	yes	C	E
Butyl benzyl phthalate	85687	yes	n.d.	C	
Carbon disulfide	75-15-0	yes	n.d.	C	
Carbon tetrachloride; Tetrachloromethane	56-23-5	yes	n.d.	C	E
Chloroaniline, 4-; p-Chloroaniline	106478	yes	n.d.	C	
Chlorobenzene; Phenyl chloride	108907	yes	n.d.	C	
Chlorobenzilate	510156	yes		C	
Chloroform	67663	yes	yes	B	E
Chlorpyrifos	2921882	yes	yes	C	
Chrysene	218019	no	n.d.	C	
Cobalt	7440484	no	yes	C	E
Cresol, o- ; 2-Methylphenol	95-48-7	yes	n.d.	C	
Cresol, p- ; 4-Methylphenol	106445	no	yes	C	
Decabromodiphenyl ether	1163195	yes	yes	NA	E
Di(2-ethylhexyl)phthalate; DEHP	117817	yes	yes	C	E
Diazinon	333415	yes		C	
Dibutyl phthalate	84742	yes	n.d.	C	E
Dichlorobenzene, 1,4-	106467	yes	n.d.	C	E

Chemical	CASRN	IRIS or OPP HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Dichloroethene, 1,2-trans-	156-60-5	yes		B	
Dichloromethane; Methylene chloride	75092	yes	n.d.	C	
Dichlorophenoxyacetic acid, 2,4- ; 2,4-D	94757	yes		C	E
Dimethoate	60515	yes		B	E
Di-N-octyl phthalate	117840	no	n.d.	B	
Dioxane, 1,4-	123-91-1	yes		C	
Endosulfan I; alpha-Endosulfan	959988	no	n.d.	B	
Endosulfan II; beta-Endosulphan	33213659	no	n.d.	C	
Endrin	72208	yes	n.d.	C	
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104645	yes		C	
Ethylbenzene	100414	yes	n.d.	C	E
Fluoranthene	206440	yes	yes	C	
Fluoride	16984488	yes		C	E (NRC)
Hexachlorocyclohexane, alpha-	319846	yes	n.d.	C	
Hexachlorocyclohexane, beta-	319857	yes	n.d.	C	
Isobutyl alcohol	78-83-1	yes		C	
Manganese	7439965	yes	yes	C	
Methyl ethyl ketone; 2-Butanone	78-93-3	yes	n.d.	C	
Methyl isobutyl ketone; MIBK; Methyl-2-pentanone, 4-	108101	yes	n.d.	C	
Naled	300765	yes		C	
Naphthalene	91203	yes	n.d.	B	E
Nitrate	14797558	yes	yes	C	
Nitrite	14797-65-0	yes		C	
Nitrofen (TOK)	NA	no		C	
N-Nitrosodiphenylamine	86306	yes	n.d.	B	
Pentabromodiphenyl ether	32534819	yes	yes	NA	E
Pentachloronitrobenzene; PCNB	82688	no		C	E
Phenol	108952	yes	yes	C	
Polychlorinated biphenyls; PCBs	1336-36-3	yes	yes	C	E
Pyrene	129000	yes	yes	C	
Silver	7440224	yes	yes	C	
Strontium*	7440246	yes	yes	NA	
Styrene	100-42-5	yes	n.d.	C	E
Tetrachloroethylene; Perchloroethylene	127184	yes	n.d.	C	E
Thallium	7440280	yes	yes	C	E
Tin and compounds	Various	no		C	

Chemical	CASRN	IRIS or OPP HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Toluene	108883	yes	yes	C	E
Trichloroethene	79016	no	n.d.	B	E
Trichlorofluoromethane	75-69-4	yes	n.d.	C	
Trichlorophenoxy propionic acid, 2-2,4,5- ; Silvex	93721	yes		C	
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93765	yes		C	
Trifluralin	1582098	yes		C	
Uranium	7440-61-1	no	yes	NA	E
Vanadium	7440622	no	yes	C	
Xylene, m-	108-38-3	no		C	
Xylenes (o, p, m mixtures)	1330207	yes	n.d.	C	

Chemicals listed in this table have reported concentration values in U.S. sewage sludge from the literature search and/or NSSS. Column D = Human health benchmarks available (yes) or not available (no) from IRIS or OPP. Column F: Literature search for concentration values in U.S. sewage sludge conducted for the period 1990-2002; yes = concentration values reported; n.d. = not detected; blank = not mentioned in the literature. Column G: NSSS = National Sewage Sludge Survey; B = detected in 1% of samples collected; C = detected in >1% of samples collected; NA = not applicable i.e., not monitored in NSSS. Column H: E = Ongoing IRIS or OPP health assessment at October 1, 2003. E(NRC) = Ongoing NRC review of fluoride toxicological data, requested by EPA. *Strontium: Environmental properties data not available to conduct exposure analysis.

Table 7: Chemicals Occurring in U.S. Sewage Sludge and Having IRIS or OPP Human Health Benchmarks

Chemical	CASRN	IRIS or OPP HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Acetone; 2-Propanone	67-64-1	yes	yes	C	
Acetophenone	98862	yes		C	
Anthracene	120127	yes	n.d	C	
Antimony and compounds	7440360	yes	yes	C	E
Aroclor 1254	11097691	yes		C	E: PCBs
Azinphos methyl	86500	yes		C	
Barium	7440393	yes	yes	C	
Benzo[a]pyrene	50328	yes	n.d	C	E
Benzoic acid	65-85-0	yes	n.d	C	
Beryllium	7440417	yes	yes	C	
Biphenyl, 1,1-	92524	yes		B	
Boron	7440428	yes	yes	C	E
Butyl benzyl phthalate	85687	yes	n.d	C	
Carbon disulfide	75-15-0	yes	n.d	C	
Carbon tetrachloride; Tetrachloromethane	56-23-5	yes	n.d	C	E
Chloroaniline, 4-; p-Chloroaniline	106478	yes	n.d	C	
Chlorobenzene; Phenyl chloride	108907	yes	n.d	C	
Chlorobenzilate	510156	yes		C	
Chloroform	67663	yes	yes	B	E
Chlorpyrifos	2921882	yes	yes	C	
Cresol, o- ; 2-Methylphenol	95-48-7	yes	n.d	C	
Decabromodiphenyl ether	1163195	yes	yes	NA	E
Di(2-ethylhexyl)phthalate; DEHP	117817	yes	yes	C	E
Diazinon	333415	yes		C	
Dibutyl phthalate	84742	yes	n.d	C	E
Dichlorobenzene, 1,4-	106467	yes	n.d	C	E
Dichloroethene, 1,2-trans-	156-60-5	yes		B	
Dichloromethane; Methylene chloride	75092	yes	n.d	C	
Dichlorophenoxyacetic acid, 2,4- ; 2,4-D	94757	yes		C	E
Dimethoate	60515	yes		B	E
Dioxane, 1,4-	123-91-1	yes		C	
Endrin	72208	yes	n.d	C	
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104645	yes		C	

Chemical	CASRN	IRIS or OPP HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Ethylbenzene	100414	yes	n.d	C	E
Fluoranthene	206440	yes	yes	C	
Fluoride	16984488	yes		C	E (NRC)
Hexachlorocyclohexane, alpha-	319846	yes	n.d	C	
Hexachlorocyclohexane, beta-	319857	yes	n.d	C	
Isobutyl alcohol	78-83-1	yes		C	
Manganese	7439965	yes	yes	C	
Methyl ethyl ketone; 2-Butanone	78-93-3	yes	n.d	C	
Methyl isobutyl ketone; MIBK; Methyl-2-pentanone, 4-	108101	yes	n.d	C	
Naled	300765	yes		C	
Naphthalene	91203	yes	n.d	B	E
Nitrate	14797558	yes	yes	C	
Nitrite	14797-65-0	yes		C	
N-Nitrosodiphenylamine	86306	yes	n.d	B	
Pentabromodiphenyl ether	32534819	yes	yes	NA	E
Phenol	108952	yes	yes	C	
Polychlorinated biphenyls; PCBs	1336-36-3	yes	yes	C	E
Pyrene	129000	yes	yes	C	
Silver	7440224	yes	yes	C	
Styrene	100-42-5	yes	n.d	C	E
Tetrachloroethylene; Perchloroethylene	127184	yes	n.d	C	E
Thallium	7440280	yes	yes	C	E
Toluene	108883	yes	yes	C	E
Trichlorofluoromethane	75-69-4	yes	n.d	C	
Trichlorophenoxy propionic acid, 2-2,4,5- ; Silvex	93721	yes		C	
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93765	yes		C	
Trifluralin	1582098	yes		C	
Xylenes (o, p, m mixture)	1330207	yes	n.d	C	

Column D: Human health benchmarks (HHB) available from IRIS or OPP. Column F: Literature search for concentration values in U.S. sewage sludge conducted for the period 1990-2002; yes = values reported; n.d. = not detected; blank = not mentioned in the literature. Column G: NSSS = National Sewage Sludge Survey; B = detected in 1% of samples collected; C = detected in >1% of samples collected; NA = not applicable i.e., not monitored in NSSS. Column H: E = Ongoing IRIS or OPP health assessment at October 1, 2003; E(NRC) = Ongoing NRC review of fluoride toxicological data, requested by EPA.

Table 8: Chemicals Occurring in U.S. Sewage Sludge with Ongoing Health Assessments and Existing IRIS or OPP Human Health Benchmarks

Chemical	CASRN	IRIS or OPP Oral HHB[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]	Comments[H]
Antimony and compounds	7440360	yes	yes	C	E
Aroclor 1254	11097691	yes		C	E: PCBs
Benzo[a]pyrene	50328	yes	n.d	C	E
Boron	7440428	yes	yes	C	E
Carbon tetrachloride; Tetrachloromethane	56-23-5	yes	n.d	C	E
Chloroform	67663	yes	yes	B	E
Decabromodiphenyl ether	1163195	yes	yes	NA	E
Di(2-ethylhexyl)phthalate; DEHP	117817	yes	yes	C	E
Dibutyl phthalate	84742	yes	n.d	C	E
Dichlorobenzene, 1,4-	106467	no	n.d	C	E
Dichlorophenoxyacetic acid, 2,4- ; 2,4-D	94757	yes		C	E
Dimethoate	60515	yes		B	E
Ethylbenzene	100414	yes	n.d	C	E
Fluoride	16984488	yes		C	E (NRC)
Naphthalene	91203	yes	n.d	B	E
Pentabromodiphenyl ether	32534819	yes	yes	NA	E
Polychlorinated biphenyls; PCBs	1336-36-3	yes	yes	C	E
Styrene	100-42-5	yes	n.d	C	E
Tetrachloroethylene; Perchloroethylene	127184	yes	n.d	C	E
Thallium	7440280	yes	yes	C	E
Toluene	108883	yes	yes	C	E

Chemicals listed in this table have ongoing IRIS or OPP health assessments, reported concentration values in U.S. sewage sludge from the literature search and/or NSSS. Column D: Oral human health benchmarks available (yes) or not available (no) from IRIS or OPP. Column F: Literature search for concentration values in U.S. sewage sludge conducted for the period 1990-2002; yes = values reported; n.d = not detected; blank = not mentioned in the literature. Column G: NSSS = National Sewage Sludge Survey; B = detected in 1% of samples collected; C = detected in >1% of samples collected; NA = not applicable i.e., not monitored in NSSS. Column H: E = Ongoing IRIS or OPP health assessment at October 1, 2003; E(NRC) = Ongoing NRC review of fluoride toxicological data, requested by EPA.

Table 9: Candidate Chemicals for Exposure and Hazard Screening

Chemical	CASRN	IRIS or OPP Chronic HHB & Year[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]
Acetone; 2-Propanone	67-64-1	IRIS 03	yes	C
Acetophenone	98862	IRIS 91		C
Anthracene	120127	IRIS 91	n.d.	C
Azinphos methyl	86500	OPP 01		C
Barium	7440393	IRIS 99	yes	C
Benzoic acid	65-85-0	IRIS 91	n.d.	C
Beryllium	7440417	IRIS 98	yes	C
Biphenyl, 1,1-	92524	IRIS 91		B
Butyl benzyl phthalate	85687	IRIS 89	n.d.	C
Carbon disulfide	75-15-0	IRIS 95	n.d.	C
Chloroaniline, 4-; p-Chloroaniline	106478	IRIS 88	n.d.	C
Chlorobenzene; Phenyl chloride	108907	IRIS 90	n.d.	C
Chlorobenzilate	510156	IRIS 89		C
Chlorpyrifos	2921882	OPP 01	yes	C
Cresol, o- ; 2-Methylphenol	95-48-7	IRIS 92	n.d.	C
Diazinon	333415	OPP 02		C
Dichloroethene, 1,2-trans-	156-60-5	IRIS 88		B
Dichloromethane; Methylene chloride	75092	IRIS 91	n.d.	C
Dioxane, 1,4-	123-91-1	IRIS 88		C
Endrin	72208	IRIS 89	n.d.	C
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104645	IRIS 87		C
Fluoranthene	206440	IRIS 90	yes	C
Hexachlorocyclohexane, alpha-	319846	IRIS 91	n.d.	C
Hexachlorocyclohexane, beta-	319857	IRIS 91	n.d.	C
Isobutyl alcohol	78-83-1	IRIS 87		C
Manganese	7439965	IRIS 95	yes	C
Methyl ethyl ketone; 2-Butanone	78-93-3	IRIS 03	n.d.	C
Methyl isobutyl ketone; MIBK; Methyl-2-pentanone, 4-	108101	IRIS 03	n.d.	C
Naled	300765	OPP 02		C
Nitrate	14797558	IRIS 91	yes	C
Nitrite	14797-65-0	IRIS 87		C
N-Nitrosodiphenylamine	86306	IRIS 87	n.d.	B
Phenol	108952	IRIS 02	yes	C
Pyrene	129000	IRIS 91	yes	C

Chemical	CASRN	IRIS or OPP Chronic HHB & Year[D]	Literature Reports Concn Values in U.S. Sludge[F]	Monitored in 1989 NSSS[G]
Silver	7440224	IRIS 91	yes	C
Trichlorofluoromethane	75-69-4	IRIS 87	n.d.	C
Trichlorophenoxy propionic acid, 2-2,4,5- ; Silvex	93721	IRIS 88		C
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93765	IRIS 88		C
Trifluralin	1582098	OPP 95		C
Xylenes (o, p, m mixture)	1330207	IRIS 03	n.d.	C

Chemicals listed in this table have reported concentration values in U.S. sewage sludge from the literature search and/or NSSS. Column D: IRIS or OPP chronic human health benchmarks and assessment year. Column F: Literature search for concentration values in U.S. sewage sludge conducted for the period 1990-2002; yes = values reported; n.d. = not detected; blank = not mentioned in the literature. Column G: NSSS = National Sewage Sludge Survey; B = detected in 1% of samples collected; C = detected in >1% of samples collected.

Table 10A: Oral Human Health Benchmarks for Candidate Chemicals for Exposure and Hazard Screening

Chemical	CASRN	% detect 1989 NSSS	NSSS 95th perc. Concn mg/kg	IRIS/OPP Chronic HHB & Year	RfD	PAD	OSF	Dose for E-5	OCD
Acetone; 2-Propanone	67-64-1	58	116.00	IRIS 03	9.00e-01				9.00e-01
Acetophenone	98862	2	32.90	IRIS 91	1.00e-01				1.00e-01
Anthracene	120127	2	32.90	IRIS 91	3.00e-01				3.00e-01
Azinphos methyl	86500	2	0.31	OPP 01	1.49e-03	1.49e-03			1.49e-03
Barium	7440393	100	1730.00	IRIS 99	7.00e-02				7.00e-02
Benzoic acid	65-85-0	4	167.00	IRIS 91	4.00e+00				4.00e+00
Beryllium	7440-41-7	22	8.00	IRIS 98	2.00e-03				2.00e-03
Biphenyl, 1,1-	92524	1	33.30	IRIS 91	5.00e-02				5.00e-02
Butyl benzyl phthalate	85687	9	32.90	IRIS 89	2.00e-01				2.00e-01
Carbon disulfide	75-15-0	10	3.13	IRIS 95	1.00e-01				1.00e-01
Chloroaniline, 4-; p-Chloroaniline	106478	5	33.30	IRIS 88	4.00e-03				4.00e-03
Chlorobenzene; Phenyl chloride	108907	2	3.13	IRIS 90	2.00e-02				2.00e-02
Chlorobenzilate	510156	7	0.10	IRIS 89	2.00e-02				2.00e-02
Chlorpyrifos	2921882	3	0.16	OPP 01	3.00e-04	3.00e-05			3.00e-05
Cresol, o-; 2-Methylphenol	95-48-7	6	42.80	IRIS 92	5.00e-02				5.00e-02
Diazinon	333415	2	0.15	OPP 02	2.00e-04	2.00e-04			2.00e-04
Dichloroethene, 1,2-trans-	156-60-5	1	2.94	IRIS 88	2.00e-02				2.00e-02
Dichloromethane; Methylene chloride	75-09-2	42	31.30	IRIS 91	6.00e-02		7.50e-03	1.33e-03	1.33e-03
Dioxane, 1,4-	123-91-1	2	3.13	IRIS 88			1.10e-02	9.09e-04	9.09e-04
Endrin	72208	6	0.04	IRIS 89	3.00e-04				3.00e-04
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104645	2	0.12	IRIS 87	1.00e-05				1.00e-05
Fluoranthene	206440	5	32.90	IRIS 90	4.00e-02				4.00e-02
Hexachlorocyclohexane, alpha-	319846	2	0.02	IRIS 91			6.30e+00	1.59e-06	1.59e-06
Hexachlorocyclohexane, beta-	319857	6	0.04	IRIS 91			1.80e+00	5.56e-06	5.56e-06
Isobutyl alcohol	78-83-1	3	3.13	IRIS 87	3.00e-01				3.00e-01
Manganese (from drinking water) *	7439965	100	1620.00	IRIS 95	4.67e-02				4.67e-02
Methyl ethyl ketone; 2-Butanone	78-93-3	34	69.30	IRIS 03	6.00e-01				6.00e-01
Methyl isobutyl ketone (MIBK); Methyl-2-pentanone, 4-	108101	2	15.60	IRIS 03					NA
Naled	300765	2	0.84	OPP 02	2.00e-03	2.00e-03			2.00e-03
Nitrate (as Nitrate-nitrogen)	14797558	95	5020.00	IRIS 91	1.60e+00				1.60e+00
Nitrite (as Nitrate-nitrogen)	14797-65-0	83	462.00	IRIS 87	1.00e-01				1.00e-01
N-Nitrosodiphenylamine	86306	1	65.80	IRIS 87			4.90e-03	2.04e-03	2.04e-03
Phenol	108952	34	57.50	IRIS 02	3.00e-01				3.00e-01

Chemical	CASRN	% detect 1989 NSSS	NSSS 95th perc. Concn mg/kg	IRIS/OPP Chronic HHB & Year	RfD	PAD	OSF	Dose for E-5	OCD
Pyrene	129000	5	33.00	IRIS 91	3.00e-02				3.00e-02
Silver	7440224	84	128.00	IRIS 91	5.00e-03				5.00e-03
Trichlorofluoromethane	75-69-4	5	3.47	IRIS 87	3.00e-01				3.00e-01
Trichlorophenoxy propionic acid, 2-2,4,5-; Silvex	93-72-1	15	0.04	IRIS 88	8.00e-03				8.00e-03
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93765	29	0.05	IRIS 88	1.00e-02				1.00e-02
Trifluralin	1582098	3	0.16	OPP 95	2.40e-02		7.70e-03	1.30e-03	1.30e-03
Xylenes (mixture)	1330207	4	6.18	IRIS 03	2.00e-01				2.00e-01

NSSS = 1989 National Sewage Sludge Survey; Reference for NSSS data: EPA, 1996. HHB = Human health benchmark. RfD = Reference dose, mg/kg/day. PAD = Population adjusted dose, mg/kg/day. OSF = Oral slope factor, cancer risk per mg/kg/day. Dose for E-5 = Dose for a cancer risk of E-5, mg/kg/day. OCD = Oral critical dose, mg/kg/day = the smaller of the RfD, PAD or dose for E-5. NA = Not available. * RfD and OCD for Mn from food = 1.40E-1 mg/kg/day.

Table 10B: Inhalation Human Health Benchmarks for Candidate Chemicals for Exposure and Hazard Screening

Chemical	CASRN	% detect 1989 NSSS	NSSS 95th perc. Concn mg/kg	IRIS/ OPP Chronic HHB & Year	OCD	RfC	AUR	Concn for E-5	CC
Acetone; 2-Propanone	67-64-1	58	116.00	IRIS 03	9.00e-01				
Acetophenone	98862	2	32.90	IRIS 91	1.00e-01				
Anthracene	120127	2	32.90	IRIS 91	3.00e-01				
Azinphos methyl**	86500	2	0.31	OPP 01	1.49e-03	2.20e-03			2.20e-03
Barium	7440393	100	1730.00	IRIS 99	7.00e-02				
Benzoic acid	65-85-0	4	167.00	IRIS 91	4.00e+00				
Beryllium	7440-41-7	22	8.00	IRIS 98	2.00e-03	2.00e-05	2.40e-06	4.00e-06	4.00e-06
Biphenyl, 1,1-	92524	1	33.30	IRIS 91	5.00e-02				
Butyl benzyl phthalate	85687	9	32.90	IRIS 89	2.00e-01				
Carbon disulfide	75-15-0	10	3.13	IRIS 95	1.00e-01	7.00e-01			7.00e-01
Chloroaniline, 4-; p-Chloroaniline	106478	5	33.30	IRIS 88	4.00e-03				
Chlorobenzene; Phenyl chloride	108907	2	3.13	IRIS 90	2.00e-02				
Chlorobenzilate	510156	7	0.10	IRIS 89	2.00e-02				
Chlorpyrifos**	2921882	3	0.16	OPP 01	3.00e-05	5.00e-05			5.00e-05
Cresol, o-; 2-Methylphenol	95-48-7	6	42.80	IRIS 92	5.00e-02				
Diazinon**	333415	2	0.15	OPP 02	2.00e-04	6.00e-05			6.00e-05
Dichloroethene, 1,2-trans-	156-60-5	1	2.94	IRIS 88	2.00e-02				
Dichloromethane; Methylene chloride	75-09-2	42	31.30	IRIS 91	1.33e-03		4.70e-04	2.00e-02	2.00e-02
Dioxane, 1,4-	123-91-1	2	3.13	IRIS 88	9.09e-04				
Endrin	72208	6	0.04	IRIS 89	3.00e-04				
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104645	2	0.12	IRIS 87	1.00e-05				
Fluoranthene	206440	5	32.90	IRIS 90	4.00e-02				
Hexachlorocyclohexane, alpha-	319846	2	0.02	IRIS 91	1.59e-06		1.80e+00	6.00e-06	6.00e-06
Hexachlorocyclohexane, beta-	319857	6	0.04	IRIS 91	5.56e-06		5.30e-01	2.00e-05	2.00e-05
Isobutyl alcohol	78-83-1	3	3.13	IRIS 87	3.00e-01				
Manganese (from drinking water) *	7439965	100	1620.00	IRIS 95	4.67e-02	5.00e-05			5.00e-05
Methyl ethyl ketone; 2-Butanone	78-93-3	34	69.30	IRIS 03	6.00e-01	5.00e+00			5.00e+00
Methyl isobutyl ketone (MIBK); Methyl-2-pentanone, 4-	108101	2	15.60	IRIS 03	NA	3.00e+00			3.00e+00
Naled**	300765	2	0.84	OPP 02	2.00e-03	4.00e-04			4.00e-04
Nitrate (as nitrate-nitrogen)	14797558	95	5020.00	IRIS 91	1.60e+00				
Nitrite (as nitrate-nitrogen)	14797-65-0	83	462.00	IRIS 87	1.00e-01				
N-Nitrosodiphenylamine	86306	1	65.80	IRIS 87	2.04e-03				
Phenol	108952	34	57.50	IRIS 02	3.00e-01				
Pyrene	129000	5	33.00	IRIS 91	3.00e-02				
Silver	7440224	84	128.00	IRIS 91	5.00e-03				

Chemical	CASRN	% detect 1989 NSSS	NSSS 95th perc. Concn mg/kg	IRIS/ OPP Chronic HHB & Year	OCD	RfC	AUR	Concn for E-5	CC
Trichlorofluoromethane	75-69-4	5	3.47	IRIS 87	3.00e-01				
Trichlorophenoxy propionic acid, 2-2,4,5-; Silvex	93-72-1	15	0.04	IRIS 88	8.00e-03				
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93765	29	0.05	IRIS 88	1.00e-02				
Trifluralin	1582098	3	0.16	OPP 95	1.30e-03				
Xylenes (mixture)	1330207	4	6.18	IRIS 03	2.00e-01	1.00e-01			1.00e-01

NSSS = 1989 National Sewage Sludge Survey; Reference for NSSS data: EPA, 1996. OCD = Oral critical dose, mg/kg/day = the smaller of the reference dose (RfD), population adjusted dose (PAD) or dose for a cancer risk of E-5 (derived in Table 10.A.). RfC = Reference concentration, mg/m3. AUR = Air unit risk = cancer risk per mg/m3. Concn for E-5 = Air concentration for a risk of E-5, mg/m3. CC = Critical concentration, mg/m3 = the smaller of the RfC and concentration for E-5. * Manganese is more bioavailable from drinking water; RfD and OCD for Mn from food = 1.40E-1 mg/kg/day. ** OPP-derived inhalation human health benchmarks (OPP, 2003). NA = not available.

Table 11: Prioritization of Chemicals with Ongoing Health Assessments and IRIS or OPP Oral Human Health Benchmarks

Chemical	CASRN	Lit. or NSSS Avg Concn mg/kg	Ongoing	RfD	PAD	OSF	Dose for E-5	OCD	TADI	THQ = TADI/OCD
Dichlorobenzene, 1,4-	106-46-7	9.72	IRIS					NA	NA	NA
Benzo(a)pyrene	50328	9.74	IRIS			7.3e+00	1.4e-06	1.4e-06	8.2e-01	605995.5
PCBs; Aroclor (mixture)	1336-36-3	2.12	IRIS			2.0e+00	5.0e-06	5.0e-06	1.8e-01	35876.9
Di(2-ethylhexyl)phthalate; DEHP	117817	55.60	IRIS	2.0e-02		1.4e-02	7.1e-04	7.1e-04	4.7e+00	6589.1
Thallium	7440280	5.20	IRIS	8.0e-05				8.0e-05	4.4e-01	5500.0
Aroclor 1254	11097691	0.50	IRIS	2.0e-05				2.0e-05	4.2e-02	2119.6
Antimony and compounds	7440360	6.47	IRIS	4.0e-04				4.0e-04	5.5e-01	1368.7
Carbon tetrachloride; Tetrachloromethane	56-23-5	0.97	IRIS	7.0e-04		1.3e-01	7.6e-05	7.6e-05	8.2e-02	1078.8
Fluoride	16984488	126.00	NRC	1.2e-01				1.2e-01	1.1e+01	88.8
Decabromodiphenyl ether	1163195	4.89	IRIS	1.0e-02				1.0e-02	4.1e-01	41.4
Naphthalene	91203	9.69	IRIS	2.0e-02				2.0e-02	8.2e-01	41.0
Pentabromodiphenyl ether	32534819	0.72	IRIS	2.0e-03				2.0e-03	6.1e-02	30.7
Toluene	108883	41.30	IRIS	2.0e-01				2.0e-01	3.5e+00	17.5
Dimethoate	60515	0.06	OPP	5.0e-04	5.0e-04			5.0e-04	5.3e-03	10.6
Dibutyl phthalate	84742	11.20	IRIS	1.0e-01				1.0e-01	9.5e-01	9.5
Tetrachloroethylene; Perchloroethylene	127184	0.99	IRIS	1.0e-02				1.0e-02	8.4e-02	8.4
Chloroform	67663	0.99	IRIS	1.0e-02				1.0e-02	8.3e-02	8.3
Styrene	100-42-5	12.10	IRIS	2.0e-01				2.0e-01	1.0e+00	5.1
Ethylbenzene	100414	1.00	IRIS	1.0e-01				1.0e-01	8.4e-02	0.8
Dichlorophenoxyacetic acid, 2,4-; 2,4-D	94757	0.01	OPP	5.0e-03	5.0e-03			5.0e-03	8.5e-04	0.2
Boron	7440428	0.03	IRIS	9.0e-02				9.0e-02	2.9e-03	0.0

Lit. or NSSS Avg Concn, mg/kg = Average concentration from the 1990-2002 literature search or the 1989 National Sewage Sludge Survey (EPA, 1996). Ongoing = Ongoing health assessment by IRIS, OPP or NRC (review of fluoride toxicological data requested by EPA/OW). RfD = Reference dose, mg/kg/day. PAD = Population adjusted dose, mg/kg/day. OSF = Oral slope factor, risk per mg/kg/day. Dose for E-5 = Dose for cancer risk of E-5. OCD = Oral critical dose = The smaller of the RfD, PAD and dose for E-5. TADI = Theoretical average daily intake, mg/kg/day, assumes consumption of 1.1 kg/day of total diet (0.8 kg of food and 0.3 kg of drinking water) containing the average concentration of the chemical, by a 1-3 year old child weighing 13 kg, i.e. TADI = C_{avg} x (1.1/13). THQ = Theoretical Hazard Quotient = TADI/OCD; THQ greater than 75 are High Priority, THQ less than 75 are Low Priority. NA = Not available (oral human health benchmark not available for 1,4-dichlorobenzene).

Table 12: Theoretical Hazard Quotients for Chemicals Which Qualified for Exposure and Hazard Screening

Chemical	CASRN	% detect 1989 NSSS	NSSS Avg Concn, mg/kg	TADI	OCD	THQ = TADI/OCD
Methyl isobutyl ketone (MIBK)	108101	2	10.20	8.63e-01	NA	NA
Manganese (from water and soil) *	7439965	100	538.00	4.55e+01	4.67e-02	975.6
Silver	7440224	84	48.20	4.08e+00	5.00e-03	815.7
Barium	7440393	100	673.00	5.69e+01	7.00e-02	813.5
N-Nitrosodiphenylamine	86306	1	19.40	1.64e+00	2.04e-03	804.7
Hexachlorocyclohexane, alpha-	319846	2	0.01	1.10e-03	1.59e-06	693.1
Dichloromethane; Methylene chloride	75-09-2	42	8.56	7.24e-01	1.33e-03	544.6
Ethyl p-nitrophenyl phenylphosphorothioate; EPN; Santox	2104645	2	0.06	5.33e-03	1.00e-05	533.1
Hexachlorocyclohexane, beta-	319857	6	0.01	1.18e-03	5.56e-06	213.3
Chloroaniline, 4-	106478	5	9.84	8.33e-01	4.00e-03	208.2
Chlorpyrifos	2921882	3	0.06	5.50e-03	3.00e-05	183.3
Nitrite	14797-65-0	83	201.00	1.70e+01	1.00e-01	170.1
Biphenyl, 1,1-	92524	1	68.70	5.81e+00	5.00e-02	116.3
Dioxane, 1,4-	123-91-1	2	0.99	8.35e-02	9.09e-04	91.9
Beryllium	7440-41-7	22	1.84	1.56e-01	2.00e-03	77.8
Nitrate	14797558	95	1420.00	1.20e+02	1.60e+00	75.1
Pyrene	129000	5	9.95	8.42e-01	3.00e-02	28.1
Cresol, o-; 2-Methylphenol	95-48-7	6	16.50	1.40e+00	5.00e-02	27.9
Diazinon	333415	2	0.06	5.42e-03	2.00e-04	27.1
Fluoranthene	206440	5	9.95	8.42e-01	4.00e-02	21.0
Naled+A23	300765	2	0.42	3.59e-02	2.00e-03	17.9
Azinphos methyl	86500	2	0.16	1.34e-02	1.49e-03	9.0
Acetophenone	98862	2	9.72	8.22e-01	1.00e-01	8.2
Acetone; 2-Propanone	67-64-1	58	64.30	5.44e+00	9.00e-01	6.0
Phenol	108952	34	19.70	1.67e+00	3.00e-01	5.6
Trifluralin	1582098	3	0.07	5.58e-03	1.30e-03	4.3
Endrin	72208	6	0.02	1.27e-03	3.00e-04	4.2
Chlorobenzene; Phenyl chloride	108907	2	1.00	8.42e-02	2.00e-02	4.2
Butyl benzyl phthalate	85687	9	9.86	8.34e-01	2.00e-01	4.2
Dichloroethene, 1,2-trans-	156-60-5	1	0.98	8.25e-02	2.00e-02	4.1
Methyl ethyl ketone; 2-Butanone	78-93-3	34	25.50	2.16e+00	6.00e-01	3.6
Anthracene	120127	2	9.74	8.24e-01	3.00e-01	2.7

Chemical	CASRN	% detect 1989 NSSS	NSSS Avg Concn, mg/kg	TADI	OCD	THQ = TADI/OCD
Benzoic acid	65-85-0	4	53.10	4.49e+00	4.00e+00	1.1
Carbon disulfide	75-15-0	10	1.08	9.14e-02	1.00e-01	0.9
Xylenes (mixture)	1330207	3	0.97	8.21e-02	2.00e-01	0.4
Trichlorofluoromethane	75-69-4	5	1.00	8.46e-02	3.00e-01	0.3
Isobutyl alcohol	78-83-1	3	0.97	8.18e-02	3.00e-01	0.3
Trichlorophenoxyacetic acid, 2,4,5-; 2,4,5-T	93765	29	0.02	1.78e-03	1.00e-02	0.2
Chlorobenzilate	510156	7	0.03	2.54e-03	2.00e-02	0.1
Trichlorophenoxy propionic acid, 2-2,4,5-; Silvex	93-72-1	15	0.01	9.31e-04	8.00e-03	0.1

Avg Concn NSSS = Average concentration from the 1989 National Sewage Sludge Survey (EPA, 1996). TADI = Theoretical average daily intake, mg/kg/day, assumes consumption of 1.1 kg/day of total diet (0.8 kg of food and 0.3 kg of drinking water) containing the average concentration of the chemical, by a 1-3 year old child weighing 13 kg, i.e. TADI = C_{avg} x (1.1/13). OCD = Oral critical dose, mg/kg/day = the smaller of the reference dose, population adjusted dose, or dose for a cancer risk of E-5. THQ = Theoretical Hazard Quotient = TADI/OCD. NA = Not applicable. *Manganese: OCD for Mn from food = 1.40E-01. Chemicals failing the refined probabilistic oral exposure model are barium, beryllium, 4-chloroaniline, manganese, nitrate, nitrite and silver. As shown in this table, these chemicals have THQs equal to or greater than 75 using the TADI approach.

Appendix P

Ecological Benchmarks

Appendix P

Ecological Benchmarks

P1.0 Introduction

Ecological benchmarks used in the screening analysis are presented in Tables P-1 through P-45. To assess the potential for ecological risks from agricultural application of sewage sludge, the direct contact and ingestion pathways were assessed. For the direct contact exposure pathway, species assemblages (or communities) were assessed in soil, sediment, and surface water, where they were assumed to be exposed through direct contact with the contaminated medium. For the ingestion pathway, mammals and birds were assumed to ingest contaminated food and prey from the agricultural fields and the farm pond.

The screening criteria for ecological receptors are benchmarks expressed in terms of media concentration (e.g., mg/L for surface water, mg/kg for soil) for the direct contact pathway and in terms of dose (mg/kg-d) for the ingestion pathway. Because there is no single repository for approved ecological benchmarks analogous to the Integrated Risk Information System (IRIS) used for human health benchmarks, ecological benchmarks were derived from various EPA and other government reports, and from toxicological studies in the open literature.

Data quality objectives established to select benchmarks for use in the screening analysis included the following for ingestion benchmarks:

- Study should include test species, test species body weight, and study duration;
- Route of administration should be oral, not intraperitoneal injection; and
- Acceptable data sources include EPA, primary literature, or major publications.

For studies that met these three primary criteria, the lowest benchmark for ingestion exposures for each chemical/receptor combination was selected using a simple hierarchy:

1. Endpoints relevant to population-level impacts (e.g., reproductive fitness, mortality) were preferred over other endpoints (e.g., neurological effects).

2. Studies with exposure durations that were multigenerational or could be considered chronic or subchronic were preferred over studies conducted with acute exposure durations.

For direct contact benchmarks, environmental quality criteria were identified in existing EPA sources (e.g., national ambient water quality criteria) and other reputable sources of information, such as studies conducted at the Oak Ridge National Laboratories or published by the Canadian Council of Ministries of the Environment (CCME).

Tables P-1 through P-45 present the measurement endpoint, the study duration, and the reference for each benchmark used in the analysis. Benchmarks taken from the toxicological database provided by EPA's Environmental Fate and Effects Division (EFED) (U.S. EPA, 2003) include lethal endpoints (e.g., LC_{50} values). Risk results based on benchmarks based on lethality should be interpreted with caution because the impact on species populations associated with hazard quotients (HQs) that are below 1 may be severe. For example, an HQ of 0.1 that is based on an LC_{50} value may result in lethality to a significant percentage of the population (e.g., 10 percent). This result may be of much greater ecological significance than an HQ of 1.0 that is based on a low observed adverse effects level (LOAEL) for a reduction in reproductive fitness, which may only affect a small percentage of the population (see Section 3.0 for additional discussion).

P2.0 Ingestion Pathway Benchmarks

- *Assessment Endpoint: maintain viable mammalian and avian wildlife populations*. The attribute to be protected was the reproductive and developmental success of representative species.

- *Measure of Effect: a de minimis threshold for developmental and reproductive toxicity in mammalian and avian wildlife species*. The threshold was calculated as the geometric mean of the no observed adverse effects level (NOAEL) and LOAEL, frequently referred to as the maximum acceptable toxicant level (MATL). Implicit in this calculation is the assumption that the toxicological sensitivity is lognormal[1].

For mammals and birds, ecotoxicological data were evaluated to determine the most appropriate study with which to develop ecological benchmarks (in units of dose) to infer risk to the population level. Once the benchmark study was identified, a scaled benchmark was calculated for each receptor species. This method used an allometric scaling equation based on body weight to extrapolate test species doses to estimate wildlife species doses. For mammals, a scaling factor of 1/4 was used (Equation P-1). This is the default methodology EPA proposes for carcinogenicity assessments and reportable quantity documents to adjust animal data to an equivalent human dose (U.S. EPA, 1992).

For birds, research suggests that the cross-species scaling equation used for mammals is not appropriate (Mineau et al., 1996). Using a database that characterized acute toxicity of pesticides to avian receptors of various body weights, Mineau et al. (1996) concluded that applying mammalian scaling equations may not sufficiently predict protective doses for avian species. Mineau et al. further suggested that a scaling factor of 1 provided a better dose estimate for birds. Therefore, a scaling factor of 1 was applied for avian receptors (Equation P-2).

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[1] For benchmarks taken from the EFED database (U.S. EPA, 2003), sufficient data for calculating a MATL were not always available. In these cases, the reported effects concentration (e.g., LC_{50}, EC_{50}) was used as the benchmark. Tables P-1 through P-45 indicate the type of endpoint for each benchmark.

$$EB_w = MATL_t \times \left(\frac{bw_t}{bw_w} \right)^{1/4} \tag{P-1}$$

$$EB_w = MATL_t \times \left(\frac{bw_t}{bw_w} \right)^{0} \tag{P-2}$$

where

EB_w	=	scaled ecological benchmark for species *w* (mg/kg-d)
$MATL_t$	=	maximum acceptable toxicant concentration (mg/kg-d)
bw_t	=	body weight of the surrogate test species (kg)
bw_w	=	body weight of the representative wildlife species (kg).

P3.0 Direct Pathway Benchmarks

For the direct contact pathway, receptors and their respective benchmarks were selected by environmental medium (soil, surface water, and sediment). Benchmarks relevant to each medium are described below.

P3.1 Soil

- *Receptor: soil invertebrates*

- *Assessment Endpoint: maintain sustainable community structure and function.* The attributes to be protected were growth, survival, and reproductive success of species that represent key functional roles in the community.

- *Measure of Effect: concentration in soil based on ecotoxicity studies on endpoints that include lethality, fecundity, growth, and survival.* The benchmarks for the soil community were typically derived at a 95 percent protection level using both no effects and low effects data, as appropriate.

Benchmarks for soil invertebrates were identified for metals and organics in Efroymson et al. (1997a) and in CCME (2002). Efroymson et al. (1997a) provide benchmarks for earthworms based on lowest observed effects concentrations (LOECs).

P3.2 Surface Water

- *Receptors: aquatic community, aquatic plants, aquatic invertebrates, fish, and amphibians*

- *Assessment Endpoint: maintain sustainable community structure and function*. The attributes to be protected were growth, survival, and reproductive success of species that represent key functional roles in the community.

- *Measure of Effect: concentration in surface water based on ecotoxicity studies on endpoints that include lethality, fecundity, growth, and survival*. The benchmarks for the freshwater community were typically derived at a 95 percent protection level using both no effects and low effects data, as appropriate. When available, the Ambient Water Quality Criteria for chronic effects (U.S. EPA, 2002) were chosen as the freshwater chemical stressor concentration limits (CSCLs).

The receptors addressed in surface water reflect varying levels of organization. The aquatic community is understood to refer to all biota, both flora and fauna, living in the water column. Benchmarks for this receptor, such as the National Ambient Water Quality Criteria for aquatic life (U.S. EPA, 2002) are derived to protect the surface water community in general. Alternatively, benchmarks for aquatic plants, aquatic invertebrates, fish, and amphibians are derived based on studies specific to the particular taxon. The information in Tables P-1 though P-45 includes the target receptor for each benchmark. Risk results should be interpreted in light of each particular receptor taxon.

P3.3 Sediment

- *Receptor: sediment invertebrates*

- *Assessment Endpoint*: *maintain sustainable community structure and function*. The attributes of the benthic community to be protected included the growth, survival, and reproductive success of benthic biota.

- *Measure of Effect: concentration in sediment based on ecotoxicity studies on endpoints that include lethality, fecundity, growth, and survival*. The benchmarks for the sediment community were typically derived at a 95 percent protection level using both no effects and low effects data.

Sediment invertebrate benchmarks were identified from the CCME (2002) and Jones et al. (1997). The CCME document provides recommended sediment guidelines based on measured sediment and benthos concentrations. The Jones et al. (1997) document provides benchmarks estimated using EPA's equilibrium partitioning (EqP) equation (U.S. EPA, 1993). The EqP equation uses the partitioning relationship between sediment and surface water to predict a protective concentration for the benthic community. This method is appropriate only for nonionic organic constituents and requires the use of a relevant water quality criterion as its basis.

Table P-1. Ecological Benchmarks for Acetone (67-64-1)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
Black Bear		MATL	5.10E+01	21 days	Sample et al., 1996
Coyote		MATL	9.04E+01	21 days	Sample et al., 1996
Deer Mouse		MATL	4.57E+02	21 days	Sample et al., 1996
Eastern Cottontail		MATL	1.63E+02	21 days	Sample et al., 1996
Least Weasel		MATL	3.82E+02	21 days	Sample et al., 1996
Little Brown Bat		MATL	5.58E+02	21 days	Sample et al., 1996
Meadow Vole		MATL	4.52E+02	21 days	Sample et al., 1996
Mink		MATL	1.72E+02	21 days	Sample et al., 1996
Muskrat		MATL	1.78E+02	21 days	Sample et al., 1996
Prairie Vole		MATL	3.80E+02	21 days	Sample et al., 1996
Raccoon		MATL	1.11E+02	21 days	Sample et al., 1996
Red Fox		MATL	1.18E+02	21 days	Sample et al., 1996
White-Tailed Deer		MATL	5.96E+01	21 days	Sample et al., 1996
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	8.70E-03	365 days	Jones et al., 1997; U.S. EPA, 1993
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	1.50E+00	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.
Aquatic Invertebrates		ChV, P	1.10E+02	365 days	ECOTOX
Aquatic Plants		ChV, P	8.30E+01	365 days	ECOTOX
Fish		ChV, P	5.60E+02	365 days	ECOTOX

Table P-2. Ecological Benchmarks for Acetophenone (98-86-2)

Receptor	Effects	Endpoint	Value	ED	Reference
Water concentration benchmark (mg_chem/L_water)					
Aquatic Invertebrates		ChV, P	9.50E+00	365 days	ECOTOX
Aquatic Plants		ChV, P	1.10E+01	365 days	ECOTOX

Fish		ChV, P	2.60E+01	365 days	ECOTOX

Table P-3. Ecological Benchmarks for Anthracene (120-12-7)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	2.20E-01	365 days	Jones et al., 1997; U.S. EPA, 1993
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	7.30E-04	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Table P-4. Ecological Benchmarks for Azinphos Methyl (86-50-0)

Receptor	Effects	Endpoint	Value	ED	Reference
Water concentration benchmark (mg_chem/L_water)					
Amphibians		MATL	4.15E+00	4 days	ECOTOX
Aquatic Invertebrates		LOEC	2.00E-04	21 days	ECOTOX
Fish		MATC	2.40E-05	21 days	ECOTOX

Table P-5. Ecological Benchmarks for Barium and Compounds (7440-39-3)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
American Kestrel	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
American Robin	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
American Woodcock	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
Belted Kingfisher	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
Canada Goose	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
Great Blue Heron	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
Green Heron	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
Mallard Duck	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
Northern Bobwhite	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
Tree Swallow	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996
Western Meadowlark	Reproductive success	MATC	3.00E+01	21 days	Sample et al., 1996

Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota	Growth, reproductive success, and mortality	TEC	5.00E+02	365 days	CCME, 2002
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	4.00E-03	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Table P-6. Ecological Benchmarks for Benzoic Acid (65-85-0)

Receptor	Effects	Endpoint	Value	ED	Reference
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	4.20E-02	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Table P-7. Ecological Benchmarks for Beryllium and Compounds (7440-41-7)

Receptor	Effects	Endpoint	Value	ED	Reference
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	6.60E-04	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Table P-8. Ecological Benchmarks for Biphenyl, 1,1- (92-52-4)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	1.10E+00	365 days	Jones et al., 1997; U.S. EPA, 1993

Table P-9. Ecological Benchmarks for Butyl Benzyl Phthalate (85-68-7)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	1.10E+01	365 days	Jones et al., 1997; U.S. EPA, 1993
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	1.90E-02	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Table P-10. Ecological Benchmarks for Carbon Disulfide (75-15-0)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	8.50E-04	365 days	Jones et al., 1997; U.S. EPA, 1993
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	9.20E-04	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Table P-11. Ecological Benchmarks for Chloroaniline, 4- (106-47-8)

Receptor	Effects	Endpoint	Value	ED	Reference
Water concentration benchmark (mg_chem/L_water)					
Aquatic Invertebrates	REP	NOEC	1.00E-02	21 days	ECOTOX
Aquatic Plants	MOR	ChV, P	3.80E+00	365 days	ECOTOX
Fish	GRO	NOEC	2.00E-01	21 days	ECOTOX

Table P-12. Ecological Benchmarks for Chlorobenzene (108-90-7)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	4.10E-01	365 days	Jones et al., 1997; U.S. EPA, 1993
Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota	Mortality	ER-L	4.00E+01	10 days	Efroymson et al., 1997a
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	6.40E-02	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Table P-13. Ecological Benchmarks for Chlorobenzilate (510-15-6)

Receptor	Effects	Endpoint	Value	ED	Reference
Water concentration benchmark (mg_chem/L_water)					
Aquatic Invertebrates		ChV, P	2.00E-01	365 days	ECOTOX
Aquatic Plants		ChV, P	1.80E-01	365 days	ECOTOX
Fish		ChV, P	6.00E-02	365 days	ECOTOX

Table P-14. Ecological Benchmarks for Chlorpyrifos (2921-88-2)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
Black Bear		LD-50	3.45E+01	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Coyote		LD-50	6.10E+01	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Deer Mouse		LD-50	3.09E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Eastern Cottontail		LD-50	1.10E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Least Weasel		LD-50	2.58E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Little Brown Bat		LD-50	3.77E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Meadow Vole		LD-50	3.05E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Mink		LD-50	1.16E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Muskrat		LD-50	1.20E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Prairie Vole		LD-50	2.57E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Raccoon		LD-50	7.52E+01	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Red Fox		LD-50	7.96E+01	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
White-Tailed Deer		LD-50	4.02E+01	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		CCC	4.10E-05	365 days	EPA Nov. 2002
Aquatic Invertebrates		LC-50	5.00E-05	4 days	U.S. EPA, 2003. EFED database submitted to RTI.
Fish		LC-50	5.80E-03	4 days	U.S. EPA, 2003. EFED database submitted to RTI.

Table P-15. Ecological Benchmarks for Diazinon (333-41-5)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	2.00E-03	365 days	Jones et al., 1997; U.S. EPA, 1993
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	4.30E-05	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.
Fish		LC-50	1.36E-01	4 days	U.S. EPA, 2003. EFED database submitted to RTI.

Table P-16. Ecological Benchmarks for Dichloroethene, 1,2-trans- (156-60-5)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	4.00E-01	365 days	Jones et al., 1997; U.S. EPA, 1993
Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota	Growth, reproductive success, and mortality	TEC	1.00E-01	365 days	CCME, 2002
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	5.90E-01	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Table P-17. Ecological Benchmarks for Dichloromethane (75-09-2)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	3.70E-01	365 days	Jones et al., 1997; U.S. EPA, 1993
Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota	Growth, reproductive success, and mortality	TEC	1.00E-01	365 days	CCME, 2002
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community	Growth and reproductive success	LOEL	9.81E-02	365 days	CCME, 2002

Table P-18. Ecological Benchmarks for Dioxane, 1,4- (123-91-1)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
Black Bear	Reproductive effects	MATL	1.61E-01	365 days	Sample et al., 1996
Coyote	Reproductive effects	MATL	2.86E-01	365 days	Sample et al., 1996
Deer Mouse	Reproductive effects	MATL	1.45E+00	365 days	Sample et al., 1996
Eastern Cottontail	Reproductive effects	MATL	5.17E-01	365 days	Sample et al., 1996
Least Weasel	Reproductive effects	MATL	1.21E+00	365 days	Sample et al., 1996
Little Brown Bat	Reproductive effects	MATL	1.77E+00	365 days	Sample et al., 1996
Meadow Vole	Reproductive effects	MATL	1.43E+00	365 days	Sample et al., 1996
Mink	Reproductive effects	MATL	5.45E-01	365 days	Sample et al., 1996
Muskrat	Reproductive effects	MATL	5.63E-01	365 days	Sample et al., 1996
Prairie Vole	Reproductive effects	MATL	1.20E+00	365 days	Sample et al., 1996
Raccoon	Reproductive effects	MATL	3.52E-01	365 days	Sample et al., 1996
Red Fox	Reproductive effects	MATL	3.73E-01	365 days	Sample et al., 1996
White-Tailed Deer	Reproductive effects	MATL	1.88E-01	365 days	Sample et al., 1996

Table P-19. Ecological Benchmarks for Endrin (72-20-8)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
American Kestrel	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
American Robin	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
American Woodcock	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
Belted Kingfisher	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
Black Bear	Reproductive success	MATL	3.59E-02	21 days	Sample et al., 1996
Canada Goose	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
Coopers Hawk	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
Coyote	Reproductive success	MATL	6.36E-02	21 days	Sample et al., 1996
Deer Mouse	Reproductive success	MATL	3.22E-01	21 days	Sample et al., 1996
Eastern Cottontail	Reproductive success	MATL	1.15E-01	21 days	Sample et al., 1996
Great Blue Heron	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
Green Heron	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996

Least Weasel	Reproductive success	MATL	2.69E-01	21 days	Sample et al., 1996
Little Brown Bat	Reproductive success	MATL	3.93E-01	21 days	Sample et al., 1996
Mallard Duck	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
Meadow Vole	Reproductive success	MATL	3.18E-01	21 days	Sample et al., 1996
Mink	Reproductive success	MATL	1.21E-01	21 days	Sample et al., 1996
Muskrat	Reproductive success	MATL	1.25E-01	21 days	Sample et al., 1996
Northern Bobwhite	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
Prairie Vole	Reproductive success	MATL	2.67E-01	21 days	Sample et al., 1996
Raccoon	Reproductive success	MATL	7.84E-02	21 days	Sample et al., 1996
Red Fox	Reproductive success	MATL	8.30E-02	21 days	Sample et al., 1996
Red-Tailed Hawk	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
Tree Swallow	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
Western Meadowlark	Reproductive success	MATL	3.16E-02	21 days	Sample et al., 1996
White-Tailed Deer	Reproductive success	MATL	4.19E-02	21 days	Sample et al., 1996
Sediment concentration benchmark (mg_chem/kg_DW sediment)					
Sediment Biota	Growth and reproductive success	TEL	2.67E-03	365 days	CCME, 2002
Water concentration benchmark (mg_chem/L_water)					
Amphibians		LC-50	2.00E-03	4 days	CalEPA, 2003 (Cal/Ecotox). Http://www.oehha.org/cal_ecotox/reports.htm
Aquatic Community		CCC	3.60E-05	365 days	EPA Nov. 2002

Table P-20. Ecological Benchmarks for Fluoranthene (206-44-0)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota	Growth and reproductive success	TEL	1.11E-01	365 days	CCME, 2002
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		LOEL	4.00E-05	365 days	CCME, 2002

Table P-21. Ecological Benchmarks for Hexachlorocyclohexane, alpha- (319-84-6)

Receptor	Effects	Endpoint	Value	ED	Reference
Water concentration benchmark (mg_chem/L_water)					
Aquatic Invertebrates	REP	EC50	1.00E-01	21 days	ECOTOX
Fish	MOR	LC25	9.00E-01	21 days	ECOTOX

Table P-22. Ecological Benchmarks for Hexachlorocyclohexane, beta- (319-85-7)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
Black Bear	Growth	MATL	2.04E-01	21 days	Sample et al., 1996
Coyote	Growth	MATL	3.61E-01	21 days	Sample et al., 1996
Deer Mouse	Growth	MATL	1.83E+00	21 days	Sample et al., 1996
Eastern Cottontail	Growth	MATL	6.54E-01	21 days	Sample et al., 1996
Least Weasel	Growth	MATL	1.53E+00	21 days	Sample et al., 1996
Little Brown Bat	Growth	MATL	2.23E+00	21 days	Sample et al., 1996
Meadow Vole	Growth	MATL	1.81E+00	21 days	Sample et al., 1996
Mink	Growth	MATL	6.89E-01	21 days	Sample et al., 1996
Muskrat	Growth	MATL	7.12E-01	21 days	Sample et al., 1996
Prairie Vole	Growth	MATL	1.52E+00	21 days	Sample et al., 1996
Raccoon	Growth	MATL	4.45E-01	21 days	Sample et al., 1996
Red Fox	Growth	MATL	4.72E-01	21 days	Sample et al., 1996
White-Tailed Deer	Growth	MATL	2.38E-01	21 days	Sample et al., 1996
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	1.20E-01	365 days	Jones et al., 1997; U.S. EPA, 1993

Table P-23. Ecological Benchmarks for Manganese (7439-96-5)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
American Kestrel	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
American Robin	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
American Woodcock	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996

Belted Kingfisher	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
Black Bear	Reproductive success	MATL	3.61E+01	365 days	Sample et al., 1996
Canada Goose	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
Coyote	Reproductive success	MATL	6.38E+01	365 days	Sample et al., 1996
Deer Mouse	Reproductive success	MATL	3.23E+02	365 days	Sample et al., 1996
Eastern Cottontail	Reproductive success	MATL	1.15E+02	365 days	Sample et al., 1996
Great Blue Heron	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
Green Heron	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
Least Weasel	Reproductive success	MATL	2.70E+02	365 days	Sample et al., 1996
Little Brown Bat	Reproductive success	MATL	3.95E+02	365 days	Sample et al., 1996
Mallard Duck	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
Meadow Vole	Reproductive success	MATL	3.19E+02	365 days	Sample et al., 1996
Mink	Reproductive success	MATL	1.22E+02	365 days	Sample et al., 1996
Muskrat	Reproductive success	MATL	1.26E+02	365 days	Sample et al., 1996
Northern Bobwhite	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
Prairie Vole	Reproductive success	MATL	2.68E+02	365 days	Sample et al., 1996
Raccoon	Reproductive success	MATL	7.87E+01	365 days	Sample et al., 1996
Red Fox	Reproductive success	MATL	8.33E+01	365 days	Sample et al., 1996
Tree Swallow	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
Western Meadowlark	Growth and behavioral effects	NOAEL	9.77E+02	365 days	Sample et al., 1996
White-Tailed Deer	Reproductive success	MATL	4.21E+01	365 days	Sample et al., 1996
Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota	Respiration	ER-L	1.00E+02	21 days	Efroymson et al., 1997a
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	1.20E-01	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Table P-24. Ecological Benchmarks for Methyl ethyl ketone (78-93-3)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
Black Bear	Reproductive success	MATL	6.50E+02	365 days	Sample et al., 1996
Coyote	Reproductive success	MATL	1.15E+03	365 days	Sample et al., 1996

Deer Mouse	Reproductive success	MATL	5.82E+03	365 days	Sample et al., 1996
Eastern Cottontail	Reproductive success	MATL	2.08E+03	365 days	Sample et al., 1996
Least Weasel	Reproductive success	MATL	4.86E+03	365 days	Sample et al., 1996
Little Brown Bat	Reproductive success	MATL	7.11E+03	365 days	Sample et al., 1996
Meadow Vole	Reproductive success	MATL	5.75E+03	365 days	Sample et al., 1996
Mink	Reproductive success	MATL	2.19E+03	365 days	Sample et al., 1996
Muskrat	Reproductive success	MATL	2.26E+03	365 days	Sample et al., 1996
Prairie Vole	Reproductive success	MATL	4.83E+03	365 days	Sample et al., 1996
Raccoon	Reproductive success	MATL	1.42E+03	365 days	Sample et al., 1996
Red Fox	Reproductive success	MATL	1.50E+03	365 days	Sample et al., 1996
White-Tailed Deer	Reproductive success	MATL	7.58E+02	365 days	Sample et al., 1996
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	2.70E-01	365 days	Jones et al., 1997; U.S. EPA, 1993
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	1.40E+01	365 mg_	Calculated by Suter and Tsao 1996, following methods in EPA 1995.
Aquatic Invertebrates		ChV, P	5.20E+01	365 days	ECOTOX
Aquatic Plants		ChV, P	4.50E+01	365 days	ECOTOX
Fish		ChV, P	2.20E+02	365 days	ECOTOX

Table P-25. Ecological Benchmarks for Naled (300-76-5)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
Black Bear		LD-50	1.74E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Coyote		LD-50	3.08E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Deer Mouse		LD-50	1.56E+03	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Eastern Cottontail		LD-50	5.58E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Least Weasel		LD-50	1.30E+03	21 days	U.S. EPA, 2003. EFED database submitted to RTI.

Little Brown Bat		LD-50	1.90E+03	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Meadow Vole		LD-50	1.54E+03	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Mink		LD-50	5.88E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Muskrat		LD-50	6.07E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Prairie Vole		LD-50	1.30E+03	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Raccoon		LD-50	3.80E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Red Fox		LD-50	4.02E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
White-Tailed Deer		LD-50	2.03E+02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.
Water concentration benchmark (mg_chem/L_water)					
Aquatic Plants		EC-50	2.00E-02	4 days	U.S. EPA, 2003. EFED database submitted to RTI.
Fish		LOEC	1.50E-02	21 days	U.S. EPA, 2003. EFED database submitted to RTI.

Table P-26. Ecological Benchmarks for Nitrosodiphenylamine, N- (86-30-6)

Receptor	Effects	Endpoint	Value	ED	Reference
Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota		TEC	2.00E+01	21 days	Ecotox
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	2.10E-01	365 days	ECOTOX
Aquatic Invertebrates	MOR	ChV, P	9.00E-02	365 days	ECOTOX
Aquatic Plants		ChV, P	7.00E-01	365 days	ECOTOX
Fish	MOR	ChV, P	1.00E+00	365 days	ECOTOX

Table P-27. Ecological Benchmarks for Phenol (108-95-2)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	3.10E-02	365 days	Jones et al., 1997; U.S. EPA, 1993

Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota	Mortality	ER-L	3.00E+01	10 days	Efroymson et al., 1997a
Water concentration benchmark (mg_chem/L_water)					
Aquatic Invertebrates		CVhV, P	3.00E+00	365 days	ECOTOX
Aquatic Plants		ChV, P	9.70E+00	365 days	ECOTOX
Fish		ChV, P	1.90E-01	365 days	ECOTOX

Table P-28. Ecological Benchmarks for Pyrene (129-00-0)

Receptor	Effects	Endpoint	Value	ED	Reference
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota	Growth and reproductive success	TEL	5.30E-02	365 days	CCME, 2002
Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota	Growth, reproductive success, and mortality	TEC	1.00E-01	365 days	CCME, 2002
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		LOEL	2.50E-05	365 days	CCME 2000

Table P-29. Ecological Benchmarks for Silver and Compounds (7440-22-4)

Receptor	Effects	Endpoint	Value	ED	Reference
Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota	Growth, reproductive success, and mortality	TEC	2.00E+01	365 days	CCME, 2002
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community	Growth and reproductive success	LOEL	1.00E-04	365 days	CCME, 2002
Aquatic Invertebrates		EC-50	9.20E-03	1 days	U.S. EPA, 2003. EFED database submitted to RTI.
Fish		LC-50	3.62E-02	4 days	U.S. EPA, 2003. EFED database submitted to RTI.

Table P-30. Ecological Benchmarks for Total Nitrate Nitrogen (14797-55-8)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
Black Bear	Reproductive success	MATL	2.16E+02	365 days	Sample et al., 1996
Coyote	Reproductive success	MATL	3.83E+02	365 days	Sample et al., 1996
Deer Mouse	Reproductive success	MATL	1.94E+03	365 days	Sample et al., 1996

Eastern Cottontail	Reproductive success	MATL	6.93E+02	365 days	Sample et al., 1996
Least Weasel	Reproductive success	MATL	1.62E+03	365 days	Sample et al., 1996
Little Brown Bat	Reproductive success	MATL	2.37E+03	365 days	Sample et al., 1996
Meadow Vole	Reproductive success	MATL	1.91E+03	365 days	Sample et al., 1996
Mink	Reproductive success	MATL	7.30E+02	365 days	Sample et al., 1996
Muskrat	Reproductive success	MATL	7.54E+02	365 days	Sample et al., 1996
Prairie Vole	Reproductive success	MATL	1.61E+03	365 days	Sample et al., 1996
Raccoon	Reproductive success	MATL	4.72E+02	365 days	Sample et al., 1996
Red Fox	Reproductive success	MATL	5.00E+02	365 days	Sample et al., 1996
White-Tailed Deer	Reproductive success	MATL	2.53E+02	365 days	Sample et al., 1996

Table P-31. Ecological Benchmarks for Trichlorophenoxyacetic Acid, 2,4,5- (93-76-5)

Receptor	Effects	Endpoint	Value	ED	Reference
Water concentration benchmark (mg_chem/L_water)					
Aquatic Invertebrates	MOR	LC50	5.00E+00	4 days	ECOTOX
Fish	MOR	LC50	1.50E-01	4 days	ECOTOX

Table P-32. Ecological Benchmarks for Trifluralin (1582-09-8)

Receptor	Effects	Endpoint	Value	ED	Reference
Water concentration benchmark (mg_chem/L_water)					
Aquatic Invertebrates		MATC	4.80E-03	365 days	ECOTOX
Aquatic Plants		EC50	4.35E-02	21 days	ECOTOX

Table P-33. Ecological Benchmarks for Xylenes (1330-20-7)

Receptor	Effects	Endpoint	Value	ED	Reference
Dose benchmark (mg_chem/kg_BW/day)					
Black Bear	Reproductive success	MATL	2.89E-01	4 days	Sample et al., 1996
Coyote	Reproductive success	MATL	5.11E-01	4 days	Sample et al., 1996
Deer Mouse	Reproductive success	MATL	2.59E+00	4 days	Sample et al., 1996
Eastern Cottontail	Reproductive success	MATL	9.24E-01	4 days	Sample et al., 1996
Least Weasel	Reproductive success	MATL	2.16E+00	4 days	Sample et al., 1996
Little Brown Bat	Reproductive success	MATL	3.16E+00	4 days	Sample et al., 1996
Meadow Vole	Reproductive success	MATL	2.55E+00	4 days	Sample et al., 1996

Mink	Reproductive success	MATL	9.74E-01	4 days	Sample et al., 1996
Muskrat	Reproductive success	MATL	1.01E+00	4 days	Sample et al., 1996
Prairie Vole	Reproductive success	MATL	2.15E+00	4 days	Sample et al., 1996
Raccoon	Reproductive success	MATL	6.30E-01	4 days	Sample et al., 1996
Red Fox	Reproductive success	MATL	6.67E-01	4 days	Sample et al., 1996
White-Tailed Deer	Reproductive success	MATL	3.37E-01	4 days	Sample et al., 1996
Sediment concentration benchmark (mg_chem/kg_sediment)					
Sediment Biota		SCV	1.60E-01	365 days	Jones et al., 1997; U.S. EPA, 1993
Soil concentration benchmark (mg_chem/kg_soil)					
Soil Biota	Growth, reproductive success, and mortality	TEC	1.00E-01	365 days	CCME, 2002
Water concentration benchmark (mg_chem/L_water)					
Aquatic Community		SCV	1.30E-02	365 days	Calculated by Suter and Tsao 1996, following methods in EPA 1995.

Appendix Q

Detailed Human Health Results

Appendix Q

Attachment A:
Hazard Quotients - Sewage Sludge Lagoon

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Acetone

CAS: 67-64-1 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	4.84E-03	5.38E-03
Groundwater Adult	75	Drinking water	1.19E-02	1.32E-02
Groundwater Adult	90	Drinking water	2.47E-02	2.75E-02
Groundwater Adult	95	Drinking water	3.53E-02	3.92E-02
Groundwater Adult	99	Drinking water	6.49E-02	7.22E-02
Groundwater Child	50	Drinking water	1.03E-02	1.14E-02
Groundwater Child	75	Drinking water	2.70E-02	2.99E-02
Groundwater Child	90	Drinking water	5.69E-02	6.32E-02
Groundwater Child	95	Drinking water	8.51E-02	9.45E-02
Groundwater Child	99	Drinking water	1.66E-01	1.84E-01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Acetophenone

CAS: 98-86-2 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	2.75E-03	2.75E-02
Groundwater Adult	75	Drinking water	5.17E-03	5.17E-02
Groundwater Adult	90	Drinking water	8.52E-03	8.52E-02
Groundwater Adult	95	Drinking water	1.09E-02	1.09E-01
Groundwater Adult	99	Drinking water	1.61E-02	1.61E-01
Groundwater Child	50	Drinking water	5.92E-03	5.92E-02
Groundwater Child	75	Drinking water	1.22E-02	1.22E-01
Groundwater Child	90	Drinking water	2.00E-02	2.00E-01
Groundwater Child	95	Drinking water	2.62E-02	2.62E-01
Groundwater Child	99	Drinking water	4.14E-02	4.14E-01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Anthracene

CAS: 120-12-7 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	3.78E-06	1.26E-05
Groundwater Adult	75	Drinking water	5.95E-06	1.98E-05
Groundwater Adult	90	Drinking water	9.15E-06	3.05E-05
Groundwater Adult	95	Drinking water	1.15E-05	3.85E-05
Groundwater Adult	99	Drinking water	1.84E-05	6.12E-05
Groundwater Child	50	Drinking water	8.71E-06	2.90E-05
Groundwater Child	75	Drinking water	1.38E-05	4.60E-05
Groundwater Child	90	Drinking water	2.10E-05	7.01E-05
Groundwater Child	95	Drinking water	2.80E-05	9.33E-05
Groundwater Child	99	Drinking water	4.43E-05	1.48E-04

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Azinphos Methyl

CAS: 86-50-0 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	3.29E-08
	75	Shower	NA	5.31E-08
	90	Shower	NA	7.91E-08
	95	Shower	NA	1.01E-07
	99	Shower	NA	1.62E-07
Above-ground Adult	50	Ambient air	NA	4.12E-06
Above-ground Adult	75	Ambient air	NA	1.95E-05
Above-ground Adult	90	Ambient air	NA	5.26E-05
Above-ground Adult	95	Ambient air	NA	9.77E-05
Above-ground Adult	99	Ambient air	NA	2.31E-04
Above-ground Child	50	Ambient air	NA	4.12E-06
Above-ground Child	75	Ambient air	NA	1.95E-05
Above-ground Child	90	Ambient air	NA	5.26E-05
Above-ground Child	95	Ambient air	NA	9.77E-05
Above-ground Child	99	Ambient air	NA	2.31E-04
Groundwater Adult	50	Drinking water	5.80E-07	3.86E-04
Groundwater Adult	75	Drinking water	9.81E-07	6.54E-04
Groundwater Adult	90	Drinking water	1.51E-06	1.01E-03
Groundwater Adult	95	Drinking water	1.92E-06	1.28E-03
Groundwater Adult	99	Drinking water	2.95E-06	1.97E-03
Groundwater Child	50	Drinking water	1.31E-06	8.71E-04
Groundwater Child	75	Drinking water	2.24E-06	1.50E-03
Groundwater Child	90	Drinking water	3.52E-06	2.35E-03
Groundwater Child	95	Drinking water	4.61E-06	3.07E-03
Groundwater Child	99	Drinking water	7.85E-06	5.23E-03

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Barium

CAS: 7440-39-3 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	2.37E-03	3.38E-02
Groundwater Adult	75	Drinking water	2.10E-02	2.99E-01
Groundwater Adult	90	Drinking water	6.77E-02	9.66E-01
Groundwater Adult	95	Drinking water	1.05E-01	1.50E+00
Groundwater Adult	99	Drinking water	1.84E-01	2.62E+00
Groundwater Child	50	Drinking water	4.94E-03	7.05E-02
Groundwater Child	75	Drinking water	4.69E-02	6.71E-01
Groundwater Child	90	Drinking water	1.55E-01	2.21E+00
Groundwater Child	95	Drinking water	2.47E-01	3.53E+00
Groundwater Child	99	Drinking water	4.58E-01	6.54E+00

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Benzoic Acid

CAS: 65-85-0 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	2.78E-02	6.96E-03
Groundwater Adult	75	Drinking water	5.24E-02	1.31E-02
Groundwater Adult	90	Drinking water	8.36E-02	2.09E-02
Groundwater Adult	95	Drinking water	1.07E-01	2.68E-02
Groundwater Adult	99	Drinking water	1.54E-01	3.86E-02
Groundwater Child	50	Drinking water	6.13E-02	1.53E-02
Groundwater Child	75	Drinking water	1.22E-01	3.04E-02
Groundwater Child	90	Drinking water	1.97E-01	4.93E-02
Groundwater Child	95	Drinking water	2.59E-01	6.47E-02
Groundwater Child	99	Drinking water	4.07E-01	1.02E-01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Beryllium

CAS: 7440-41-7 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	3.58E-05	1.79E-02
Groundwater Adult	75	Drinking water	2.12E-04	1.06E-01
Groundwater Adult	90	Drinking water	5.89E-04	2.94E-01
Groundwater Adult	95	Drinking water	8.90E-04	4.45E-01
Groundwater Adult	99	Drinking water	1.71E-03	8.55E-01
Groundwater Child	50	Drinking water	7.85E-05	3.93E-02
Groundwater Child	75	Drinking water	4.68E-04	2.34E-01
Groundwater Child	90	Drinking water	1.41E-03	7.06E-01
Groundwater Child	95	Drinking water	2.06E-03	1.03E+00
Groundwater Child	99	Drinking water	3.87E-03	1.93E+00

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Biphenyl, 1,1-

CAS: 92-52-4 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	3.59E-06	7.18E-05
Groundwater Adult	75	Drinking water	6.04E-06	1.21E-04
Groundwater Adult	90	Drinking water	9.21E-06	1.84E-04
Groundwater Adult	95	Drinking water	1.22E-05	2.44E-04
Groundwater Adult	99	Drinking water	1.77E-05	3.53E-04
Groundwater Child	50	Drinking water	8.05E-06	1.61E-04
Groundwater Child	75	Drinking water	1.40E-05	2.79E-04
Groundwater Child	90	Drinking water	2.23E-05	4.46E-04
Groundwater Child	95	Drinking water	2.86E-05	5.73E-04
Groundwater Child	99	Drinking water	4.69E-05	9.39E-04

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Butyl Benzyl Phthalate

CAS: 85-68-7 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	2.03E-06	1.01E-05
Groundwater Adult	75	Drinking water	3.08E-06	1.54E-05
Groundwater Adult	90	Drinking water	4.45E-06	2.22E-05
Groundwater Adult	95	Drinking water	5.56E-06	2.78E-05
Groundwater Adult	99	Drinking water	8.04E-06	4.02E-05
Groundwater Child	50	Drinking water	4.67E-06	2.34E-05
Groundwater Child	75	Drinking water	7.19E-06	3.60E-05
Groundwater Child	90	Drinking water	1.05E-05	5.25E-05
Groundwater Child	95	Drinking water	1.35E-05	6.74E-05
Groundwater Child	99	Drinking water	1.89E-05	9.44E-05

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Carbon Disulfide

CAS: 75-15-0 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	1.60E-03
	75	Shower	NA	4.04E-03
	90	Shower	NA	7.37E-03
	95	Shower	NA	1.05E-02
	99	Shower	NA	1.97E-02
Above-ground Adult	50	Ambient air	NA	2.32E-07
Above-ground Adult	75	Ambient air	NA	1.86E-06
Above-ground Adult	90	Ambient air	NA	5.09E-06
Above-ground Adult	95	Ambient air	NA	9.95E-06
Above-ground Adult	99	Ambient air	NA	2.48E-05
Above-ground Child	50	Ambient air	NA	2.32E-07
Above-ground Child	75	Ambient air	NA	1.86E-06
Above-ground Child	90	Ambient air	NA	5.09E-06
Above-ground Child	95	Ambient air	NA	9.95E-06
Above-ground Child	99	Ambient air	NA	2.48E-05
Groundwater Adult	50	Drinking water	5.85E-05	5.85E-04
Groundwater Adult	75	Drinking water	1.15E-04	1.15E-03
Groundwater Adult	90	Drinking water	1.94E-04	1.94E-03
Groundwater Adult	95	Drinking water	2.64E-04	2.64E-03
Groundwater Adult	99	Drinking water	4.31E-04	4.31E-03
Groundwater Child	50	Drinking water	1.27E-04	1.27E-03
Groundwater Child	75	Drinking water	2.70E-04	2.70E-03
Groundwater Child	90	Drinking water	4.53E-04	4.53E-03
Groundwater Child	95	Drinking water	6.43E-04	6.43E-03
Groundwater Child	99	Drinking water	1.10E-03	1.10E-02

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Chloroaniline, 4-

CAS: 106-47-8 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	3.18E-03	7.94E-01
Groundwater Adult	75	Drinking water	5.43E-03	1.36E+00
Groundwater Adult	90	Drinking water	8.61E-03	2.15E+00
Groundwater Adult	95	Drinking water	1.08E-02	2.71E+00
Groundwater Adult	99	Drinking water	1.51E-02	3.77E+00
Groundwater Child	50	Drinking water	6.96E-03	1.74E+00
Groundwater Child	75	Drinking water	1.30E-02	3.25E+00
Groundwater Child	90	Drinking water	2.02E-02	5.04E+00
Groundwater Child	95	Drinking water	2.57E-02	6.42E+00
Groundwater Child	99	Drinking water	3.86E-02	9.65E+00

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Chlorobenzene

CAS: 108-90-7 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	2.54E-05	1.27E-03
Groundwater Adult	75	Drinking water	4.25E-05	2.12E-03
Groundwater Adult	90	Drinking water	6.49E-05	3.24E-03
Groundwater Adult	95	Drinking water	8.28E-05	4.14E-03
Groundwater Adult	99	Drinking water	1.14E-04	5.69E-03
Groundwater Child	50	Drinking water	5.67E-05	2.83E-03
Groundwater Child	75	Drinking water	9.99E-05	4.99E-03
Groundwater Child	90	Drinking water	1.53E-04	7.63E-03
Groundwater Child	95	Drinking water	1.91E-04	9.53E-03
Groundwater Child	99	Drinking water	2.88E-04	1.44E-02

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Chlorobenzilate

CAS: 510-15-6 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	7.78E-09	3.89E-07
Groundwater Adult	75	Drinking water	1.21E-08	6.06E-07
Groundwater Adult	90	Drinking water	1.73E-08	8.67E-07
Groundwater Adult	95	Drinking water	2.19E-08	1.09E-06
Groundwater Adult	99	Drinking water	3.20E-08	1.60E-06
Groundwater Child	50	Drinking water	1.78E-08	8.92E-07
Groundwater Child	75	Drinking water	2.79E-08	1.40E-06
Groundwater Child	90	Drinking water	4.16E-08	2.08E-06
Groundwater Child	95	Drinking water	5.36E-08	2.68E-06
Groundwater Child	99	Drinking water	7.62E-08	3.81E-06

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Chlorpyrifos

CAS: 2921-88-2 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	7.29E-06
	75	Shower	NA	1.07E-05
	90	Shower	NA	1.51E-05
	95	Shower	NA	1.84E-05
	99	Shower	NA	2.99E-05
Above-ground Adult	50	Ambient air	NA	1.52E-07
Above-ground Adult	75	Ambient air	NA	6.50E-07
Above-ground Adult	90	Ambient air	NA	1.58E-06
Above-ground Adult	95	Ambient air	NA	3.10E-06
Above-ground Adult	99	Ambient air	NA	7.54E-06
Above-ground Child	50	Ambient air	NA	1.52E-07
Above-ground Child	75	Ambient air	NA	6.50E-07
Above-ground Child	90	Ambient air	NA	1.58E-06
Above-ground Child	95	Ambient air	NA	3.10E-06
Above-ground Child	99	Ambient air	NA	7.54E-06
Groundwater Adult	50	Drinking water	2.53E-09	8.43E-05
Groundwater Adult	75	Drinking water	3.95E-09	1.32E-04
Groundwater Adult	90	Drinking water	5.69E-09	1.90E-04
Groundwater Adult	95	Drinking water	7.25E-09	2.42E-04
Groundwater Adult	99	Drinking water	1.02E-08	3.39E-04
Groundwater Child	50	Drinking water	5.81E-09	1.94E-04
Groundwater Child	75	Drinking water	9.13E-09	3.04E-04
Groundwater Child	90	Drinking water	1.36E-08	4.55E-04
Groundwater Child	95	Drinking water	1.77E-08	5.91E-04
Groundwater Child	99	Drinking water	2.74E-08	9.13E-04

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Cresol, o-

CAS: 95-48-7 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	1.18E-03	2.36E-02
Groundwater Adult	75	Drinking water	2.30E-03	4.61E-02
Groundwater Adult	90	Drinking water	3.77E-03	7.54E-02
Groundwater Adult	95	Drinking water	4.82E-03	9.63E-02
Groundwater Adult	99	Drinking water	7.22E-03	1.44E-01
Groundwater Child	50	Drinking water	2.53E-03	5.05E-02
Groundwater Child	75	Drinking water	5.35E-03	1.07E-01
Groundwater Child	90	Drinking water	8.84E-03	1.77E-01
Groundwater Child	95	Drinking water	1.17E-02	2.33E-01
Groundwater Child	99	Drinking water	1.84E-02	3.67E-01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Diazinon

CAS: 333-41-5 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	1.07E-04
	75	Shower	NA	1.68E-04
	90	Shower	NA	2.46E-04
	95	Shower	NA	2.95E-04
	99	Shower	NA	4.55E-04
Above-ground Adult	50	Ambient air	NA	1.38E-06
Above-ground Adult	75	Ambient air	NA	6.44E-06
Above-ground Adult	90	Ambient air	NA	1.67E-05
Above-ground Adult	95	Ambient air	NA	2.59E-05
Above-ground Adult	99	Ambient air	NA	5.52E-05
Above-ground Child	50	Ambient air	NA	1.38E-06
Above-ground Child	75	Ambient air	NA	6.44E-06
Above-ground Child	90	Ambient air	NA	1.67E-05
Above-ground Child	95	Ambient air	NA	2.59E-05
Above-ground Child	99	Ambient air	NA	5.52E-05
Groundwater Adult	50	Drinking water	1.36E-07	6.78E-04
Groundwater Adult	75	Drinking water	2.17E-07	1.09E-03
Groundwater Adult	90	Drinking water	3.37E-07	1.68E-03
Groundwater Adult	95	Drinking water	4.21E-07	2.11E-03
Groundwater Adult	99	Drinking water	6.11E-07	3.05E-03
Groundwater Child	50	Drinking water	3.05E-07	1.52E-03
Groundwater Child	75	Drinking water	5.12E-07	2.56E-03
Groundwater Child	90	Drinking water	7.74E-07	3.87E-03
Groundwater Child	95	Drinking water	1.01E-06	5.06E-03
Groundwater Child	99	Drinking water	1.56E-06	7.78E-03

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Dichloroethene, 1,2-trans-

CAS: 156-60-5 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	6.89E-05	3.44E-03
Groundwater Adult	75	Drinking water	1.42E-04	7.10E-03
Groundwater Adult	90	Drinking water	2.50E-04	1.25E-02
Groundwater Adult	95	Drinking water	3.41E-04	1.71E-02
Groundwater Adult	99	Drinking water	5.65E-04	2.82E-02
Groundwater Child	50	Drinking water	1.51E-04	7.56E-03
Groundwater Child	75	Drinking water	3.35E-04	1.68E-02
Groundwater Child	90	Drinking water	5.75E-04	2.88E-02
Groundwater Child	95	Drinking water	8.23E-04	4.12E-02
Groundwater Child	99	Drinking water	1.39E-03	6.94E-02

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Dichloromethane

CAS: 75-09-2 **Endpoint:** Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	6.08E-02
	75	Shower	NA	1.65E-01
	90	Shower	NA	3.79E-01
	95	Shower	NA	6.62E-01
	99	Shower	NA	1.91E+00
Above-ground Adult	50	Ambient air	NA	3.24E-05
Above-ground Adult	75	Ambient air	NA	1.59E-04
Above-ground Adult	90	Ambient air	NA	4.59E-04
Above-ground Adult	95	Ambient air	NA	8.19E-04
Above-ground Adult	99	Ambient air	NA	2.90E-03
Above-ground Child	50	Ambient air	NA	4.18E-05
Above-ground Child	75	Ambient air	NA	2.10E-04
Above-ground Child	90	Ambient air	NA	6.56E-04
Above-ground Child	95	Ambient air	NA	1.18E-03
Above-ground Child	99	Ambient air	NA	3.89E-03
Groundwater Adult	50	Drinking water	1.29E-05	9.67E-03
Groundwater Adult	75	Drinking water	2.86E-05	2.14E-02
Groundwater Adult	90	Drinking water	5.83E-05	4.37E-02
Groundwater Adult	95	Drinking water	8.18E-05	6.14E-02
Groundwater Adult	99	Drinking water	1.57E-04	1.18E-01
Groundwater Child	50	Drinking water	1.92E-05	1.44E-02
Groundwater Child	75	Drinking water	4.98E-05	3.73E-02
Groundwater Child	90	Drinking water	1.11E-04	8.30E-02
Groundwater Child	95	Drinking water	1.62E-04	1.22E-01
Groundwater Child	99	Drinking water	3.27E-04	2.45E-01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Dioxane, 1,4-

CAS: 123-91-1 **Endpoint:** Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	1.36E-05	1.49E-02
Groundwater Adult	75	Drinking water	2.61E-05	2.87E-02
Groundwater Adult	90	Drinking water	4.80E-05	5.28E-02
Groundwater Adult	95	Drinking water	7.30E-05	8.03E-02
Groundwater Adult	99	Drinking water	1.40E-04	1.53E-01
Groundwater Child	50	Drinking water	1.90E-05	2.09E-02
Groundwater Child	75	Drinking water	4.18E-05	4.59E-02
Groundwater Child	90	Drinking water	6.92E-05	7.60E-02
Groundwater Child	95	Drinking water	8.96E-05	9.84E-02
Groundwater Child	99	Drinking water	1.38E-04	1.52E-01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Endrin

CAS: 72-20-8 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	1.39E-09	4.63E-06
Groundwater Adult	75	Drinking water	2.08E-09	6.93E-06
Groundwater Adult	90	Drinking water	3.00E-09	1.00E-05
Groundwater Adult	95	Drinking water	3.62E-09	1.21E-05
Groundwater Adult	99	Drinking water	5.29E-09	1.76E-05
Groundwater Child	50	Drinking water	3.21E-09	1.07E-05
Groundwater Child	75	Drinking water	4.89E-09	1.63E-05
Groundwater Child	90	Drinking water	7.02E-09	2.34E-05
Groundwater Child	95	Drinking water	8.99E-09	3.00E-05
Groundwater Child	99	Drinking water	1.25E-08	4.18E-05

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Ethyl p-nitrophenyl Phenylphosphorothioate

CAS: 2104-64-5 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	4.18E-08	4.18E-03
Groundwater Adult	75	Drinking water	6.45E-08	6.45E-03
Groundwater Adult	90	Drinking water	9.63E-08	9.63E-03
Groundwater Adult	95	Drinking water	1.21E-07	1.21E-02
Groundwater Adult	99	Drinking water	1.80E-07	1.80E-02
Groundwater Child	50	Drinking water	9.48E-08	9.48E-03
Groundwater Child	75	Drinking water	1.51E-07	1.51E-02
Groundwater Child	90	Drinking water	2.25E-07	2.25E-02
Groundwater Child	95	Drinking water	2.95E-07	2.95E-02
Groundwater Child	99	Drinking water	4.27E-07	4.27E-02

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Fluoranthene

CAS: 206-44-0 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	1.16E-06	2.90E-05
Groundwater Adult	75	Drinking water	1.75E-06	4.37E-05
Groundwater Adult	90	Drinking water	2.51E-06	6.29E-05
Groundwater Adult	95	Drinking water	3.03E-06	7.56E-05
Groundwater Adult	99	Drinking water	4.49E-06	1.12E-04
Groundwater Child	50	Drinking water	2.68E-06	6.71E-05
Groundwater Child	75	Drinking water	4.10E-06	1.03E-04
Groundwater Child	90	Drinking water	5.95E-06	1.49E-04
Groundwater Child	95	Drinking water	7.53E-06	1.88E-04
Groundwater Child	99	Drinking water	1.06E-05	2.65E-04

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **Endpoint:** Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	2.15E-05
	75	Shower	NA	4.50E-05
	90	Shower	NA	9.57E-05
	95	Shower	NA	1.37E-04
	99	Shower	NA	2.63E-04
Above-ground Adult	50	Ambient air	NA	1.74E-06
Above-ground Adult	75	Ambient air	NA	7.06E-06
Above-ground Adult	90	Ambient air	NA	1.97E-05
Above-ground Adult	95	Ambient air	NA	3.47E-05
Above-ground Adult	99	Ambient air	NA	1.17E-04
Above-ground Child	50	Ambient air	NA	1.99E-06
Above-ground Child	75	Ambient air	NA	8.24E-06
Above-ground Child	90	Ambient air	NA	2.34E-05
Above-ground Child	95	Ambient air	NA	4.14E-05
Above-ground Child	99	Ambient air	NA	1.36E-04
Groundwater Adult	50	Drinking water	6.61E-11	4.17E-05
Groundwater Adult	75	Drinking water	1.13E-10	7.12E-05
Groundwater Adult	90	Drinking water	1.80E-10	1.14E-04
Groundwater Adult	95	Drinking water	2.33E-10	1.47E-04
Groundwater Adult	99	Drinking water	4.15E-10	2.62E-04
Groundwater Child	50	Drinking water	1.21E-10	7.59E-05
Groundwater Child	75	Drinking water	2.25E-10	1.42E-04
Groundwater Child	90	Drinking water	3.56E-10	2.24E-04
Groundwater Child	95	Drinking water	4.59E-10	2.89E-04
Groundwater Child	99	Drinking water	7.29E-10	4.59E-04

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Hexachlorocyclohexane, beta-

CAS: 319-85-7 **Endpoint:** Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	5.34E-06
	75	Shower	NA	1.08E-05
	90	Shower	NA	2.07E-05
	95	Shower	NA	3.04E-05
	99	Shower	NA	5.16E-05
Above-ground Adult	50	Ambient air	NA	4.59E-07
Above-ground Adult	75	Ambient air	NA	1.94E-06
Above-ground Adult	90	Ambient air	NA	5.23E-06
Above-ground Adult	95	Ambient air	NA	8.92E-06
Above-ground Adult	99	Ambient air	NA	2.51E-05
Above-ground Child	50	Ambient air	NA	5.97E-07
Above-ground Child	75	Ambient air	NA	2.52E-06
Above-ground Child	90	Ambient air	NA	6.49E-06
Above-ground Child	95	Ambient air	NA	1.14E-05
Above-ground Child	99	Ambient air	NA	2.91E-05
Groundwater Adult	50	Drinking water	6.90E-10	1.24E-04
Groundwater Adult	75	Drinking water	1.18E-09	2.13E-04
Groundwater Adult	90	Drinking water	2.03E-09	3.65E-04
Groundwater Adult	95	Drinking water	2.80E-09	5.04E-04
Groundwater Adult	99	Drinking water	6.09E-09	1.10E-03
Groundwater Child	50	Drinking water	1.20E-09	2.16E-04
Groundwater Child	75	Drinking water	2.18E-09	3.92E-04
Groundwater Child	90	Drinking water	3.51E-09	6.33E-04
Groundwater Child	95	Drinking water	4.50E-09	8.11E-04
Groundwater Child	99	Drinking water	6.83E-09	1.23E-03

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Isobutyl Alcohol

CAS: 78-83-1 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	3.56E-04	1.19E-03
Groundwater Adult	75	Drinking water	6.83E-04	2.28E-03
Groundwater Adult	90	Drinking water	1.14E-03	3.79E-03
Groundwater Adult	95	Drinking water	1.50E-03	5.01E-03
Groundwater Adult	99	Drinking water	2.42E-03	8.06E-03
Groundwater Child	50	Drinking water	7.57E-04	2.52E-03
Groundwater Child	75	Drinking water	1.60E-03	5.32E-03
Groundwater Child	90	Drinking water	2.72E-03	9.06E-03
Groundwater Child	95	Drinking water	3.74E-03	1.25E-02
Groundwater Child	99	Drinking water	6.22E-03	2.07E-02

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Manganese

CAS: 7439-96-5 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	1.80E-01	3.83E+00
Groundwater Adult	75	Drinking water	4.09E-01	8.70E+00
Groundwater Adult	90	Drinking water	9.38E-01	2.00E+01
Groundwater Adult	95	Drinking water	1.52E+00	3.23E+01
Groundwater Adult	99	Drinking water	2.77E+00	5.89E+01
Groundwater Child	50	Drinking water	3.97E-01	8.45E+00
Groundwater Child	75	Drinking water	9.46E-01	2.01E+01
Groundwater Child	90	Drinking water	2.21E+00	4.71E+01
Groundwater Child	95	Drinking water	3.59E+00	7.63E+01
Groundwater Child	99	Drinking water	6.93E+00	1.47E+02

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	1.03E-03
	75	Shower	NA	2.48E-03
	90	Shower	NA	4.95E-03
	95	Shower	NA	7.12E-03
	99	Shower	NA	1.24E-02
Above-ground Adult	50	Ambient air	NA	1.30E-06
Above-ground Adult	75	Ambient air	NA	1.05E-05
Above-ground Adult	90	Ambient air	NA	2.97E-05
Above-ground Adult	95	Ambient air	NA	4.98E-05
Above-ground Adult	99	Ambient air	NA	1.49E-04
Above-ground Child	50	Ambient air	NA	1.30E-06
Above-ground Child	75	Ambient air	NA	1.05E-05
Above-ground Child	90	Ambient air	NA	2.97E-05
Above-ground Child	95	Ambient air	NA	4.98E-05
Above-ground Child	99	Ambient air	NA	1.49E-04
Groundwater Adult	50	Drinking water	2.77E-03	4.62E-03
Groundwater Adult	75	Drinking water	6.94E-03	1.15E-02
Groundwater Adult	90	Drinking water	1.44E-02	2.40E-02
Groundwater Adult	95	Drinking water	2.07E-02	3.45E-02
Groundwater Adult	99	Drinking water	3.79E-02	6.33E-02
Groundwater Child	50	Drinking water	5.94E-03	9.90E-03
Groundwater Child	75	Drinking water	1.57E-02	2.61E-02
Groundwater Child	90	Drinking water	3.31E-02	5.51E-02
Groundwater Child	95	Drinking water	4.97E-02	8.27E-02
Groundwater Child	99	Drinking water	9.75E-02	1.62E-01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

MIBK

CAS: 108-10-1 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	1.47E-03
	75	Shower	NA	2.94E-03
	90	Shower	NA	5.08E-03
	95	Shower	NA	6.61E-03
	99	Shower	NA	1.07E-02
Above-ground Adult	50	Ambient air	NA	3.03E-07
Above-ground Adult	75	Ambient air	NA	2.15E-06
Above-ground Adult	90	Ambient air	NA	6.44E-06
Above-ground Adult	95	Ambient air	NA	1.02E-05
Above-ground Adult	99	Ambient air	NA	2.63E-05
Above-ground Child	50	Ambient air	NA	3.03E-07
Above-ground Child	75	Ambient air	NA	2.15E-06
Above-ground Child	90	Ambient air	NA	6.44E-06
Above-ground Child	95	Ambient air	NA	1.02E-05
Above-ground Child	99	Ambient air	NA	2.63E-05

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Naled

CAS: 300-76-5 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	3.33E-06
	75	Shower	NA	5.41E-06
	90	Shower	NA	8.47E-06
	95	Shower	NA	1.11E-05
	99	Shower	NA	2.13E-05
Above-ground Adult	50	Ambient air	NA	4.24E-09
Above-ground Adult	75	Ambient air	NA	3.08E-08
Above-ground Adult	90	Ambient air	NA	8.49E-08
Above-ground Adult	95	Ambient air	NA	1.39E-07
Above-ground Adult	99	Ambient air	NA	3.12E-07
Above-ground Child	50	Ambient air	NA	4.24E-09
Above-ground Child	75	Ambient air	NA	3.08E-08
Above-ground Child	90	Ambient air	NA	8.49E-08
Above-ground Child	95	Ambient air	NA	1.39E-07
Above-ground Child	99	Ambient air	NA	3.12E-07
Groundwater Adult	50	Drinking water	3.48E-07	1.74E-04
Groundwater Adult	50	Drinking water	3.48E-07	1.74E-04
Groundwater Adult	75	Drinking water	5.83E-07	2.92E-04
Groundwater Adult	75	Drinking water	5.83E-07	2.91E-04
Groundwater Adult	90	Drinking water	9.22E-07	4.61E-04
Groundwater Adult	90	Drinking water	9.21E-07	4.61E-04
Groundwater Adult	95	Drinking water	1.28E-06	6.39E-04
Groundwater Adult	95	Drinking water	1.28E-06	6.38E-04
Groundwater Adult	99	Drinking water	2.13E-06	1.07E-03
Groundwater Adult	99	Drinking water	2.13E-06	1.06E-03
Groundwater Child	50	Drinking water	7.91E-07	3.96E-04
Groundwater Child	50	Drinking water	7.91E-07	3.95E-04

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Naled

CAS: 300-76-5 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Child	75	Drinking water	1.35E-06	6.76E-04
Groundwater Child	75	Drinking water	1.35E-06	6.76E-04
Groundwater Child	90	Drinking water	2.25E-06	1.12E-03
Groundwater Child	90	Drinking water	2.25E-06	1.12E-03
Groundwater Child	95	Drinking water	3.20E-06	1.60E-03
Groundwater Child	95	Drinking water	3.20E-06	1.60E-03
Groundwater Child	99	Drinking water	5.60E-06	2.80E-03
Groundwater Child	99	Drinking water	5.60E-06	2.80E-03

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Nitrosodiphenylamine, N-

CAS: 86-30-6 **Endpoint:** Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	3.63E-06	1.82E-03
Groundwater Adult	75	Drinking water	6.41E-06	3.21E-03
Groundwater Adult	90	Drinking water	1.11E-05	5.55E-03
Groundwater Adult	95	Drinking water	1.49E-05	7.44E-03
Groundwater Adult	99	Drinking water	2.95E-05	1.48E-02
Groundwater Child	50	Drinking water	5.92E-06	2.96E-03
Groundwater Child	75	Drinking water	1.16E-05	5.80E-03
Groundwater Child	90	Drinking water	1.89E-05	9.44E-03
Groundwater Child	95	Drinking water	2.40E-05	1.20E-02
Groundwater Child	99	Drinking water	3.58E-05	1.79E-02

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Phenol

CAS: 108-95-2 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	4.42E-03	1.47E-02
Groundwater Adult	75	Drinking water	8.44E-03	2.81E-02
Groundwater Adult	90	Drinking water	1.38E-02	4.59E-02
Groundwater Adult	95	Drinking water	1.80E-02	5.99E-02
Groundwater Adult	99	Drinking water	2.64E-02	8.79E-02
Groundwater Child	50	Drinking water	9.57E-03	3.19E-02
Groundwater Child	75	Drinking water	1.99E-02	6.63E-02
Groundwater Child	90	Drinking water	3.29E-02	1.10E-01
Groundwater Child	95	Drinking water	4.33E-02	1.44E-01
Groundwater Child	99	Drinking water	6.98E-02	2.33E-01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Pyrene

CAS: 129-00-0 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	7.66E-07	2.55E-05
Groundwater Adult	75	Drinking water	1.19E-06	3.98E-05
Groundwater Adult	90	Drinking water	1.79E-06	5.98E-05
Groundwater Adult	95	Drinking water	2.29E-06	7.62E-05
Groundwater Adult	99	Drinking water	3.51E-06	1.17E-04
Groundwater Child	50	Drinking water	1.74E-06	5.81E-05
Groundwater Child	75	Drinking water	2.75E-06	9.16E-05
Groundwater Child	90	Drinking water	4.24E-06	1.41E-04
Groundwater Child	95	Drinking water	5.45E-06	1.82E-04
Groundwater Child	99	Drinking water	8.60E-06	2.87E-04

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Silver

CAS: 7440-22-4 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	1.19E-06	2.39E-04
Groundwater Adult	75	Drinking water	1.62E-05	3.25E-03
Groundwater Adult	90	Drinking water	6.08E-05	1.22E-02
Groundwater Adult	95	Drinking water	1.19E-04	2.37E-02
Groundwater Adult	99	Drinking water	2.94E-04	5.88E-02
Groundwater Child	50	Drinking water	2.61E-06	5.22E-04
Groundwater Child	75	Drinking water	3.69E-05	7.39E-03
Groundwater Child	90	Drinking water	1.23E-04	2.46E-02
Groundwater Child	95	Drinking water	2.46E-04	4.91E-02
Groundwater Child	99	Drinking water	6.88E-04	1.38E-01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Sodium Nitrite

CAS: 7632-00-0 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	5.89E-01	5.89E+00
Groundwater Adult	75	Drinking water	8.41E-01	8.41E+00
Groundwater Adult	90	Drinking water	1.17E+00	1.17E+01
Groundwater Adult	95	Drinking water	1.36E+00	1.36E+01
Groundwater Adult	99	Drinking water	1.86E+00	1.86E+01
Groundwater Child	50	Drinking water	1.34E+00	1.34E+01
Groundwater Child	75	Drinking water	1.99E+00	1.99E+01
Groundwater Child	90	Drinking water	2.78E+00	2.78E+01
Groundwater Child	95	Drinking water	3.39E+00	3.39E+01
Groundwater Child	99	Drinking water	4.30E+00	4.30E+01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Total Nitrate Nitrogen

CAS: 14797-55-8 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	6.40E+00	4.00E+00
Groundwater Adult	75	Drinking water	9.14E+00	5.71E+00
Groundwater Adult	90	Drinking water	1.27E+01	7.92E+00
Groundwater Adult	95	Drinking water	1.48E+01	9.23E+00
Groundwater Adult	99	Drinking water	2.02E+01	1.26E+01
Groundwater Child	50	Drinking water	1.45E+01	9.09E+00
Groundwater Child	75	Drinking water	2.16E+01	1.35E+01
Groundwater Child	90	Drinking water	3.02E+01	1.89E+01
Groundwater Child	95	Drinking water	3.68E+01	2.30E+01
Groundwater Child	99	Drinking water	4.67E+01	2.92E+01

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Trichlorofluoromethane

CAS: 75-69-4 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	7.41E-05	2.47E-04
Groundwater Adult	75	Drinking water	1.28E-04	4.25E-04
Groundwater Adult	90	Drinking water	1.97E-04	6.57E-04
Groundwater Adult	95	Drinking water	2.53E-04	8.43E-04
Groundwater Adult	99	Drinking water	3.80E-04	1.27E-03
Groundwater Child	50	Drinking water	1.66E-04	5.53E-04
Groundwater Child	75	Drinking water	2.99E-04	9.97E-04
Groundwater Child	90	Drinking water	4.61E-04	1.54E-03
Groundwater Child	95	Drinking water	6.02E-04	2.01E-03
Groundwater Child	99	Drinking water	9.29E-04	3.10E-03

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Trichlorophenoxy) Propionic Acid, 2-(2,4,5-

CAS: 93-72-1 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	1.92E-06	2.40E-04
Groundwater Adult	75	Drinking water	3.56E-06	4.45E-04
Groundwater Adult	90	Drinking water	5.65E-06	7.06E-04
Groundwater Adult	95	Drinking water	7.29E-06	9.12E-04
Groundwater Adult	99	Drinking water	1.02E-05	1.28E-03
Groundwater Child	50	Drinking water	4.13E-06	5.16E-04
Groundwater Child	75	Drinking water	8.29E-06	1.04E-03
Groundwater Child	90	Drinking water	1.32E-05	1.65E-03
Groundwater Child	95	Drinking water	1.69E-05	2.12E-03
Groundwater Child	99	Drinking water	2.67E-05	3.34E-03

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Trichlorophenoxyacetic Acid, 2,4,5-

CAS: 93-76-5 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	3.97E-06	3.97E-04
Groundwater Adult	75	Drinking water	7.56E-06	7.56E-04
Groundwater Adult	90	Drinking water	1.22E-05	1.22E-03
Groundwater Adult	95	Drinking water	1.59E-05	1.59E-03
Groundwater Adult	99	Drinking water	2.30E-05	2.30E-03
Groundwater Child	50	Drinking water	8.56E-06	8.56E-04
Groundwater Child	75	Drinking water	1.76E-05	1.76E-03
Groundwater Child	90	Drinking water	2.88E-05	2.88E-03
Groundwater Child	95	Drinking water	3.73E-05	3.73E-03
Groundwater Child	99	Drinking water	5.88E-05	5.88E-03

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Trifluralin

CAS: 1582-09-8 **Endpoint:** Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Groundwater Adult	50	Drinking water	9.80E-11	7.55E-08
Groundwater Adult	75	Drinking water	1.54E-10	1.19E-07
Groundwater Adult	90	Drinking water	2.30E-10	1.77E-07
Groundwater Adult	95	Drinking water	2.97E-10	2.29E-07
Groundwater Adult	99	Drinking water	4.64E-10	3.57E-07
Groundwater Child	50	Drinking water	1.67E-10	1.29E-07
Groundwater Child	75	Drinking water	2.75E-10	2.12E-07
Groundwater Child	90	Drinking water	4.13E-10	3.18E-07
Groundwater Child	95	Drinking water	5.11E-10	3.94E-07
Groundwater Child	99	Drinking water	7.40E-10	5.70E-07

Table Q-A-1. Risk Screening Hazard Quotients by Pathway in the Sewage Sludge Lagoon

Xylenes

CAS: 1330-20-7 **Endpoint:** Non-Cancer

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
	50	Shower	NA	4.57E-03
	75	Shower	NA	8.64E-03
	90	Shower	NA	1.42E-02
	95	Shower	NA	1.81E-02
	99	Shower	NA	2.90E-02
Above-ground Adult	50	Ambient air	NA	4.52E-06
Above-ground Adult	75	Ambient air	NA	2.37E-05
Above-ground Adult	90	Ambient air	NA	6.57E-05
Above-ground Adult	95	Ambient air	NA	1.03E-04
Above-ground Adult	99	Ambient air	NA	2.64E-04
Above-ground Child	50	Ambient air	NA	4.52E-06
Above-ground Child	75	Ambient air	NA	2.37E-05
Above-ground Child	90	Ambient air	NA	6.57E-05
Above-ground Child	95	Ambient air	NA	1.03E-04
Above-ground Child	99	Ambient air	NA	2.64E-04
Groundwater Adult	50	Drinking water	2.56E-05	1.28E-04
Groundwater Adult	75	Drinking water	4.10E-05	2.05E-04
Groundwater Adult	90	Drinking water	6.32E-05	3.16E-04
Groundwater Adult	95	Drinking water	7.71E-05	3.85E-04
Groundwater Adult	99	Drinking water	1.14E-04	5.70E-04
Groundwater Child	50	Drinking water	5.83E-05	2.92E-04
Groundwater Child	75	Drinking water	9.63E-05	4.81E-04
Groundwater Child	90	Drinking water	1.45E-04	7.27E-04
Groundwater Child	95	Drinking water	1.88E-04	9.39E-04
Groundwater Child	99	Drinking water	2.75E-04	1.37E-03

Appendix Q

Attachment B:
Cancer Hazard Quotients - Agricultural Application

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloromethane

CAS: 75-09-2 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	9.55E-14	7.36E-11
75	Soil	5.48E-13	4.23E-10
90	Soil	1.59E-12	1.22E-09
95	Soil	2.65E-12	2.04E-09
99	Soil	7.42E-12	5.70E-09
50	Root	1.08E-07	8.29E-05
75	Root	7.61E-07	5.85E-04
90	Root	4.54E-06	3.51E-03
95	Root	1.02E-05	7.86E-03
99	Root	4.10E-05	3.16E-02
50	Exposed Fruit	2.08E-07	1.60E-04
75	Exposed Fruit	7.32E-07	5.63E-04
90	Exposed Fruit	2.28E-06	1.76E-03
95	Exposed Fruit	4.13E-06	3.19E-03
99	Exposed Fruit	1.26E-05	9.70E-03
50	Exposed Vegetables	1.17E-07	8.98E-05
75	Exposed Vegetables	4.35E-07	3.35E-04
90	Exposed Vegetables	1.33E-06	1.03E-03
95	Exposed Vegetables	2.37E-06	1.82E-03
99	Exposed Vegetables	7.48E-06	5.76E-03
50	Protected Fruit	8.89E-08	6.85E-05
75	Protected Fruit	5.51E-07	4.26E-04
90	Protected Fruit	2.40E-06	1.84E-03
95	Protected Fruit	5.70E-06	4.38E-03
99	Protected Fruit	1.61E-05	1.24E-02
50	Protected Vegetables	5.95E-08	4.57E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloromethane

CAS: 75-09-2 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	3.60E-07	2.77E-04
90	Protected Vegetables	1.49E-06	1.15E-03
95	Protected Vegetables	3.09E-06	2.37E-03
99	Protected Vegetables	1.19E-05	9.14E-03
50	Fish	1.16E-10	8.95E-08
75	Fish	6.07E-10	4.66E-07
90	Fish	2.56E-09	1.97E-06
95	Fish	5.51E-09	4.26E-06
99	Fish	3.19E-08	2.45E-05
50	Beef	1.09E-11	8.39E-09
75	Beef	3.13E-11	2.41E-08
90	Beef	7.61E-11	5.85E-08
95	Beef	1.17E-10	9.05E-08
99	Beef	2.73E-10	2.10E-07
50	Milk	1.62E-09	1.25E-06
75	Milk	4.73E-09	3.63E-06
90	Milk	1.29E-08	9.89E-06
95	Milk	2.32E-08	1.78E-05
99	Milk	5.51E-08	4.23E-05
50	Ground Water	1.09E-07	8.36E-05
75	Ground Water	3.16E-07	2.44E-04
90	Ground Water	7.11E-07	5.48E-04
95	Ground Water	1.05E-06	8.04E-04
99	Ground Water	1.88E-06	1.44E-03
50	Surface Water	2.31E-06	1.78E-03
75	Surface Water	6.70E-06	5.16E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloromethane

CAS: 75-09-2 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
90	Surface Water	1.46E-05	1.12E-02
95	Surface Water	2.21E-05	1.70E-02
99	Surface Water	4.38E-05	3.38E-02
50	Total Ingestion	5.26E-06	4.04E-03
75	Total Ingestion	1.32E-05	1.01E-02
90	Total Ingestion	2.82E-05	2.17E-02
95	Total Ingestion	4.26E-05	3.29E-02
99	Total Ingestion	8.23E-05	6.32E-02

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloromethane

CAS: 75-09-2 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	6.13E-13	4.73E-10
75	Soil	3.26E-12	2.50E-09
90	Soil	9.05E-12	6.95E-09
95	Soil	1.39E-11	1.07E-08
99	Soil	3.88E-11	2.99E-08
50	Root	9.52E-08	7.32E-05
75	Root	6.85E-07	5.29E-04
90	Root	3.82E-06	2.95E-03
95	Root	9.64E-06	7.42E-03
99	Root	3.51E-05	2.70E-02
50	Exposed Fruit	2.17E-07	1.67E-04
75	Exposed Fruit	6.76E-07	5.20E-04
90	Exposed Fruit	2.05E-06	1.58E-03
95	Exposed Fruit	3.72E-06	2.87E-03
99	Exposed Fruit	8.54E-06	6.57E-03
50	Exposed Vegetables	1.15E-07	8.80E-05
75	Exposed Vegetables	3.60E-07	2.78E-04
90	Exposed Vegetables	1.09E-06	8.36E-04
95	Exposed Vegetables	1.93E-06	1.48E-03
99	Exposed Vegetables	4.73E-06	3.63E-03
50	Protected Fruit	1.49E-07	1.15E-04
75	Protected Fruit	9.64E-07	7.42E-04
90	Protected Fruit	3.85E-06	2.95E-03
95	Protected Fruit	7.39E-06	5.67E-03
99	Protected Fruit	1.78E-05	1.37E-02
50	Protected Vegetables	8.61E-08	6.64E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloromethane

CAS: 75-09-2 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	4.51E-07	3.47E-04
90	Protected Vegetables	1.74E-06	1.34E-03
95	Protected Vegetables	3.09E-06	2.38E-03
99	Protected Vegetables	7.86E-06	6.04E-03
50	Fish	3.79E-10	2.92E-07
75	Fish	2.08E-09	1.61E-06
90	Fish	7.70E-09	5.92E-06
95	Fish	1.62E-08	1.24E-05
99	Fish	7.32E-08	5.63E-05
50	Beef	1.43E-11	1.10E-08
75	Beef	4.01E-11	3.08E-08
90	Beef	9.17E-11	7.04E-08
95	Beef	1.52E-10	1.17E-07
99	Beef	3.26E-10	2.50E-07
50	Milk	4.23E-09	3.26E-06
75	Milk	1.26E-08	9.67E-06
90	Milk	3.35E-08	2.59E-05
95	Milk	5.82E-08	4.48E-05
99	Milk	1.19E-07	9.11E-05
50	Ground Water	2.25E-07	1.73E-04
75	Ground Water	5.38E-07	4.13E-04
90	Ground Water	9.95E-07	7.67E-04
95	Ground Water	1.34E-06	1.03E-03
99	Ground Water	2.27E-06	1.75E-03
50	Surface Water	4.23E-06	3.26E-03
75	Surface Water	9.89E-06	7.61E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloromethane

CAS: 75-09-2 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
90	Surface Water	1.98E-05	1.52E-02
95	Surface Water	2.96E-05	2.28E-02
99	Surface Water	5.92E-05	4.54E-02
50	Total Ingestion	7.70E-06	5.92E-03
75	Total Ingestion	1.66E-05	1.28E-02
90	Total Ingestion	3.16E-05	2.42E-02
95	Total Ingestion	4.48E-05	3.44E-02
99	Total Ingestion	8.54E-05	6.57E-02

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dioxane, 1,4-

CAS: 123-91-1 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	5.48E-13	6.01E-10
75	Soil	3.10E-12	3.41E-09
90	Soil	1.03E-11	1.14E-08
95	Soil	2.23E-11	2.45E-08
99	Soil	7.95E-11	8.76E-08
50	Root	2.17E-06	2.38E-03
75	Root	8.80E-06	9.64E-03
90	Root	2.79E-05	3.07E-02
95	Root	5.20E-05	5.70E-02
99	Root	1.82E-04	2.00E-01
50	Exposed Fruit	3.38E-07	3.72E-04
75	Exposed Fruit	1.08E-06	1.18E-03
90	Exposed Fruit	2.75E-06	3.02E-03
95	Exposed Fruit	4.54E-06	4.98E-03
99	Exposed Fruit	1.45E-05	1.59E-02
50	Exposed Vegetables	1.92E-07	2.11E-04
75	Exposed Vegetables	6.13E-07	6.76E-04
90	Exposed Vegetables	1.57E-06	1.72E-03
95	Exposed Vegetables	2.53E-06	2.78E-03
99	Exposed Vegetables	8.01E-06	8.83E-03
50	Protected Fruit	3.69E-07	4.07E-04
75	Protected Fruit	1.39E-06	1.52E-03
90	Protected Fruit	4.32E-06	4.76E-03
95	Protected Fruit	7.23E-06	7.92E-03
99	Protected Fruit	1.64E-05	1.80E-02
50	Protected Vegetables	2.44E-07	2.69E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dioxane, 1,4-

CAS: 123-91-1 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	7.73E-07	8.51E-04
90	Protected Vegetables	2.20E-06	2.41E-03
95	Protected Vegetables	3.94E-06	4.35E-03
99	Protected Vegetables	1.18E-05	1.29E-02
50	Fish	8.29E-11	9.11E-08
75	Fish	4.35E-10	4.76E-07
90	Fish	1.52E-09	1.67E-06
95	Fish	3.10E-09	3.41E-06
99	Fish	1.43E-08	1.57E-05
50	Beef	8.17E-12	8.98E-09
75	Beef	2.50E-11	2.75E-08
90	Beef	6.07E-11	6.67E-08
95	Beef	9.30E-11	1.02E-07
99	Beef	2.10E-10	2.31E-07
50	Milk	1.83E-09	2.01E-06
75	Milk	5.54E-09	6.07E-06
90	Milk	1.33E-08	1.46E-05
95	Milk	2.17E-08	2.38E-05
99	Milk	5.04E-08	5.54E-05
50	Ground Water	2.81E-07	3.09E-04
75	Ground Water	6.85E-07	7.51E-04
90	Ground Water	1.42E-06	1.56E-03
95	Ground Water	2.13E-06	2.34E-03
99	Ground Water	4.16E-06	4.57E-03
50	Surface Water	2.49E-07	2.74E-04
75	Surface Water	6.79E-07	7.48E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dioxane, 1,4-

CAS: 123-91-1 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
90	Surface Water	1.52E-06	1.67E-03
95	Surface Water	2.33E-06	2.56E-03
99	Surface Water	5.51E-06	6.07E-03
50	Total Ingestion	5.51E-06	6.04E-03
75	Total Ingestion	1.64E-05	1.80E-02
90	Total Ingestion	4.01E-05	4.38E-02
95	Total Ingestion	6.82E-05	7.51E-02
99	Total Ingestion	2.00E-04	2.20E-01

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dioxane, 1,4-

CAS: 123-91-1 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	4.01E-12	4.41E-09
75	Soil	1.82E-11	2.00E-08
90	Soil	5.79E-11	6.39E-08
95	Soil	1.29E-10	1.42E-07
99	Soil	3.88E-10	4.26E-07
50	Root	2.22E-06	2.44E-03
75	Root	8.92E-06	9.83E-03
90	Root	2.69E-05	2.96E-02
95	Root	5.35E-05	5.88E-02
99	Root	1.61E-04	1.77E-01
50	Exposed Fruit	3.69E-07	4.04E-04
75	Exposed Fruit	9.92E-07	1.09E-03
90	Exposed Fruit	2.34E-06	2.57E-03
95	Exposed Fruit	3.82E-06	4.23E-03
99	Exposed Fruit	7.73E-06	8.51E-03
50	Exposed Vegetables	1.89E-07	2.08E-04
75	Exposed Vegetables	5.45E-07	5.98E-04
90	Exposed Vegetables	1.26E-06	1.38E-03
95	Exposed Vegetables	1.99E-06	2.19E-03
99	Exposed Vegetables	4.32E-06	4.73E-03
50	Protected Fruit	7.92E-07	8.70E-04
75	Protected Fruit	2.30E-06	2.52E-03
90	Protected Fruit	5.23E-06	5.73E-03
95	Protected Fruit	8.42E-06	9.23E-03
99	Protected Fruit	1.71E-05	1.88E-02
50	Protected Vegetables	3.85E-07	4.23E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dioxane, 1,4-

CAS: 123-91-1 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	1.03E-06	1.13E-03
90	Protected Vegetables	2.20E-06	2.42E-03
95	Protected Vegetables	3.35E-06	3.69E-03
99	Protected Vegetables	7.61E-06	8.36E-03
50	Fish	2.75E-10	3.02E-07
75	Fish	1.25E-09	1.37E-06
90	Fish	4.29E-09	4.69E-06
95	Fish	8.64E-09	9.48E-06
99	Fish	3.22E-08	3.54E-05
50	Beef	1.11E-11	1.22E-08
75	Beef	3.19E-11	3.51E-08
90	Beef	7.42E-11	8.14E-08
95	Beef	1.19E-10	1.31E-07
99	Beef	2.64E-10	2.90E-07
50	Milk	5.23E-09	5.73E-06
75	Milk	1.50E-08	1.65E-05
90	Milk	3.51E-08	3.85E-05
95	Milk	5.51E-08	6.07E-05
99	Milk	1.03E-07	1.13E-04
50	Ground Water	5.20E-07	5.70E-04
75	Ground Water	1.15E-06	1.27E-03
90	Ground Water	2.00E-06	2.20E-03
95	Ground Water	2.80E-06	3.08E-03
99	Ground Water	5.13E-06	5.67E-03
50	Surface Water	4.51E-07	4.95E-04
75	Surface Water	1.03E-06	1.13E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dioxane, 1,4-

CAS: 123-91-1 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
90	Surface Water	2.15E-06	2.36E-03
95	Surface Water	3.16E-06	3.47E-03
99	Surface Water	6.73E-06	7.39E-03
50	Total Ingestion	6.76E-06	7.45E-03
75	Total Ingestion	1.65E-05	1.81E-02
90	Total Ingestion	3.98E-05	4.38E-02
95	Total Ingestion	6.70E-05	7.36E-02
99	Total Ingestion	1.83E-04	2.01E-01

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	6.76E-14	4.23E-08
75	Soil	1.51E-13	9.47E-08
90	Soil	2.73E-13	1.72E-07
95	Soil	3.82E-13	2.40E-07
99	Soil	5.94E-13	3.71E-07
50	Root	1.25E-10	7.80E-05
75	Root	3.62E-10	2.26E-04
90	Root	9.83E-10	6.15E-04
95	Root	1.59E-09	9.97E-04
99	Root	3.75E-09	2.35E-03
50	Exposed Fruit	4.29E-11	2.69E-05
75	Exposed Fruit	1.12E-10	7.01E-05
90	Exposed Fruit	2.58E-10	1.61E-04
95	Exposed Fruit	4.32E-10	2.71E-04
99	Exposed Fruit	9.40E-10	5.88E-04
50	Exposed Vegetables	2.40E-11	1.49E-05
75	Exposed Vegetables	6.44E-11	4.02E-05
90	Exposed Vegetables	1.49E-10	9.33E-05
95	Exposed Vegetables	2.62E-10	1.64E-04
99	Exposed Vegetables	5.79E-10	3.62E-04
50	Protected Fruit	4.47E-11	2.80E-05
75	Protected Fruit	1.46E-10	9.11E-05
90	Protected Fruit	3.66E-10	2.28E-04
95	Protected Fruit	5.63E-10	3.53E-04
99	Protected Fruit	1.11E-09	6.96E-04
50	Protected Vegetables	2.80E-11	1.75E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	7.59E-11	4.75E-05
90	Protected Vegetables	1.80E-10	1.13E-04
95	Protected Vegetables	3.05E-10	1.91E-04
99	Protected Vegetables	7.14E-10	4.45E-04
50	Fish	4.34E-11	2.71E-05
75	Fish	1.74E-10	1.09E-04
90	Fish	6.37E-10	3.98E-04
95	Fish	1.24E-09	7.75E-04
99	Fish	4.41E-09	2.76E-03
50	Beef	4.05E-13	2.53E-07
75	Beef	1.04E-12	6.46E-07
90	Beef	2.17E-12	1.36E-06
95	Beef	3.37E-12	2.11E-06
99	Beef	6.51E-12	4.07E-06
50	Milk	2.71E-12	1.70E-06
75	Milk	6.76E-12	4.23E-06
90	Milk	1.40E-11	8.72E-06
95	Milk	2.10E-11	1.31E-05
99	Milk	3.96E-11	2.49E-05
99	Ground Water	5.36E-22	3.34E-16
50	Surface Water	1.26E-10	7.86E-05
75	Surface Water	3.64E-10	2.28E-04
90	Surface Water	9.27E-10	5.79E-04
95	Surface Water	1.57E-09	9.81E-04
99	Surface Water	3.80E-09	2.37E-03
50	Total Ingestion	7.96E-10	4.97E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Total Ingestion	1.77E-09	1.11E-03
90	Total Ingestion	3.34E-09	2.10E-03
95	Total Ingestion	4.97E-09	3.12E-03
99	Total Ingestion	9.83E-09	6.15E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	4.84E-13	3.03E-07
75	Soil	8.72E-13	5.45E-07
90	Soil	1.28E-12	8.00E-07
95	Soil	1.54E-12	9.63E-07
99	Soil	2.00E-12	1.25E-06
50	Root	1.23E-10	7.68E-05
75	Root	3.80E-10	2.37E-04
90	Root	9.74E-10	6.08E-04
95	Root	1.66E-09	1.04E-03
99	Root	4.32E-09	2.71E-03
50	Exposed Fruit	4.84E-11	3.03E-05
75	Exposed Fruit	1.07E-10	6.67E-05
90	Exposed Fruit	1.93E-10	1.21E-04
95	Exposed Fruit	2.76E-10	1.73E-04
99	Exposed Fruit	4.90E-10	3.05E-04
50	Exposed Vegetables	2.51E-11	1.57E-05
75	Exposed Vegetables	5.92E-11	3.71E-05
90	Exposed Vegetables	1.12E-10	7.03E-05
95	Exposed Vegetables	1.59E-10	9.97E-05
99	Exposed Vegetables	2.62E-10	1.63E-04
50	Protected Fruit	9.38E-11	5.88E-05
75	Protected Fruit	2.31E-10	1.44E-04
90	Protected Fruit	4.43E-10	2.78E-04
95	Protected Fruit	5.85E-10	3.66E-04
99	Protected Fruit	8.48E-10	5.29E-04
50	Protected Vegetables	4.59E-11	2.87E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	9.76E-11	6.10E-05
90	Protected Vegetables	1.71E-10	1.07E-04
95	Protected Vegetables	2.40E-10	1.49E-04
99	Protected Vegetables	4.14E-10	2.60E-04
50	Fish	1.41E-10	8.79E-05
75	Fish	5.29E-10	3.30E-04
90	Fish	1.75E-09	1.09E-03
95	Fish	3.44E-09	2.14E-03
99	Fish	1.28E-08	7.98E-03
50	Beef	5.40E-13	3.37E-07
75	Beef	1.36E-12	8.48E-07
90	Beef	2.67E-12	1.67E-06
95	Beef	3.73E-12	2.33E-06
99	Beef	6.83E-12	4.25E-06
50	Milk	7.57E-12	4.75E-06
75	Milk	1.84E-11	1.15E-05
90	Milk	3.30E-11	2.07E-05
95	Milk	4.43E-11	2.78E-05
99	Milk	7.64E-11	4.77E-05
99	Ground Water	8.61E-22	5.38E-16
50	Surface Water	2.21E-10	1.38E-04
75	Surface Water	5.42E-10	3.39E-04
90	Surface Water	1.24E-09	7.77E-04
95	Surface Water	2.13E-09	1.33E-03
99	Surface Water	4.61E-09	2.89E-03
50	Total Ingestion	1.20E-09	7.53E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Total Ingestion	2.46E-09	1.54E-03
90	Total Ingestion	4.57E-09	2.85E-03
95	Total Ingestion	6.80E-09	4.25E-03
99	Total Ingestion	1.60E-08	9.99E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, beta-

CAS: 319-85-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	6.08E-13	1.09E-07
75	Soil	1.31E-12	2.34E-07
90	Soil	2.37E-12	4.23E-07
95	Soil	3.29E-12	5.87E-07
99	Soil	4.91E-12	8.80E-07
50	Root	6.01E-10	1.07E-04
75	Root	1.74E-09	3.11E-04
90	Root	4.78E-09	8.55E-04
95	Root	7.60E-09	1.36E-03
99	Root	1.81E-08	3.24E-03
50	Exposed Fruit	1.80E-10	3.22E-05
75	Exposed Fruit	4.65E-10	8.30E-05
90	Exposed Fruit	1.05E-09	1.88E-04
95	Exposed Fruit	1.80E-09	3.21E-04
99	Exposed Fruit	3.70E-09	6.61E-04
50	Exposed Vegetables	1.00E-10	1.78E-05
75	Exposed Vegetables	2.66E-10	4.76E-05
90	Exposed Vegetables	6.27E-10	1.12E-04
95	Exposed Vegetables	1.08E-09	1.93E-04
99	Exposed Vegetables	2.54E-09	4.53E-04
50	Protected Fruit	2.07E-10	3.69E-05
75	Protected Fruit	6.64E-10	1.19E-04
90	Protected Fruit	1.65E-09	2.95E-04
95	Protected Fruit	2.55E-09	4.55E-04
99	Protected Fruit	4.99E-09	8.88E-04
50	Protected Vegetables	1.28E-10	2.28E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, beta-

CAS: 319-85-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	3.41E-10	6.09E-05
90	Protected Vegetables	8.10E-10	1.44E-04
95	Protected Vegetables	1.37E-09	2.45E-04
99	Protected Vegetables	3.18E-09	5.68E-04
50	Fish	1.16E-10	2.08E-05
75	Fish	4.63E-10	8.28E-05
90	Fish	1.71E-09	3.06E-04
95	Fish	3.27E-09	5.84E-04
99	Fish	1.12E-08	1.99E-03
50	Beef	1.58E-12	2.82E-07
75	Beef	3.92E-12	7.00E-07
90	Beef	8.19E-12	1.46E-06
95	Beef	1.21E-11	2.17E-06
99	Beef	2.33E-11	4.17E-06
50	Milk	1.10E-11	1.97E-06
75	Milk	2.75E-11	4.91E-06
90	Milk	5.54E-11	9.88E-06
95	Milk	8.30E-11	1.49E-05
99	Milk	1.60E-10	2.86E-05
50	Surface Water	3.22E-10	5.75E-05
75	Surface Water	7.79E-10	1.39E-04
90	Surface Water	1.67E-09	2.98E-04
95	Surface Water	2.52E-09	4.51E-04
99	Surface Water	6.01E-09	1.07E-03
50	Total Ingestion	2.85E-09	5.08E-04
75	Total Ingestion	6.33E-09	1.13E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, beta-

CAS: 319-85-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
90	Total Ingestion	1.16E-08	2.08E-03
95	Total Ingestion	1.70E-08	3.04E-03
99	Total Ingestion	3.18E-08	5.69E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, beta-

CAS: 319-85-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	4.35E-12	7.76E-07
75	Soil	7.61E-12	1.36E-06
90	Soil	1.10E-11	1.96E-06
95	Soil	1.28E-11	2.29E-06
99	Soil	1.65E-11	2.95E-06
50	Root	5.90E-10	1.05E-04
75	Root	1.83E-09	3.27E-04
90	Root	4.66E-09	8.30E-04
95	Root	7.96E-09	1.42E-03
99	Root	2.12E-08	3.78E-03
50	Exposed Fruit	2.01E-10	3.59E-05
75	Exposed Fruit	4.44E-10	7.93E-05
90	Exposed Fruit	7.96E-10	1.42E-04
95	Exposed Fruit	1.15E-09	2.04E-04
99	Exposed Fruit	2.02E-09	3.61E-04
50	Exposed Vegetables	1.05E-10	1.87E-05
75	Exposed Vegetables	2.43E-10	4.34E-05
90	Exposed Vegetables	4.61E-10	8.22E-05
95	Exposed Vegetables	6.49E-10	1.16E-04
99	Exposed Vegetables	1.07E-09	1.90E-04
50	Protected Fruit	4.26E-10	7.60E-05
75	Protected Fruit	1.05E-09	1.87E-04
90	Protected Fruit	1.98E-09	3.54E-04
95	Protected Fruit	2.63E-09	4.70E-04
99	Protected Fruit	3.87E-09	6.91E-04
50	Protected Vegetables	2.07E-10	3.71E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, beta-

CAS: 319-85-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	4.38E-10	7.83E-05
90	Protected Vegetables	7.68E-10	1.37E-04
95	Protected Vegetables	1.07E-09	1.91E-04
99	Protected Vegetables	1.87E-09	3.33E-04
50	Fish	3.74E-10	6.67E-05
75	Fish	1.39E-09	2.49E-04
90	Fish	4.57E-09	8.17E-04
95	Fish	8.80E-09	1.57E-03
99	Fish	3.41E-08	6.09E-03
50	Beef	2.07E-12	3.70E-07
75	Beef	5.05E-12	9.05E-07
90	Beef	9.79E-12	1.75E-06
95	Beef	1.40E-11	2.51E-06
99	Beef	2.39E-11	4.27E-06
50	Milk	3.10E-11	5.54E-06
75	Milk	7.53E-11	1.34E-05
90	Milk	1.34E-10	2.38E-05
95	Milk	1.80E-10	3.22E-05
99	Milk	2.89E-10	5.16E-05
50	Surface Water	5.63E-10	1.00E-04
75	Surface Water	1.21E-09	2.17E-04
90	Surface Water	2.26E-09	4.03E-04
95	Surface Water	3.16E-09	5.65E-04
99	Surface Water	6.54E-09	1.17E-03
50	Total Ingestion	4.05E-09	7.24E-04
75	Total Ingestion	8.08E-09	1.44E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, beta-

CAS: 319-85-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
90	Total Ingestion	1.39E-08	2.50E-03
95	Total Ingestion	2.01E-08	3.59E-03
99	Total Ingestion	4.69E-08	8.38E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Nitrosodiphenylamine, N-

CAS: 86-30-6 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	1.07E-13	5.36E-11
75	Soil	2.65E-13	1.33E-10
90	Soil	6.97E-13	3.49E-10
95	Soil	1.65E-12	8.23E-10
99	Soil	1.22E-11	6.12E-09
50	Root	3.37E-07	1.68E-04
75	Root	9.94E-07	4.97E-04
90	Root	2.72E-06	1.36E-03
95	Root	4.44E-06	2.22E-03
99	Root	1.07E-05	5.32E-03
50	Exposed Fruit	3.78E-07	1.90E-04
75	Exposed Fruit	1.01E-06	5.07E-04
90	Exposed Fruit	2.32E-06	1.16E-03
95	Exposed Fruit	4.00E-06	2.00E-03
99	Exposed Fruit	8.49E-06	4.25E-03
50	Exposed Vegetables	2.15E-07	1.07E-04
75	Exposed Vegetables	5.82E-07	2.91E-04
90	Exposed Vegetables	1.32E-06	6.57E-04
95	Exposed Vegetables	2.32E-06	1.16E-03
99	Exposed Vegetables	5.46E-06	2.73E-03
50	Protected Fruit	2.25E-07	1.13E-04
75	Protected Fruit	7.37E-07	3.70E-04
90	Protected Fruit	1.88E-06	9.41E-04
95	Protected Fruit	2.88E-06	1.44E-03
99	Protected Fruit	5.63E-06	2.82E-03
50	Protected Vegetables	1.43E-07	7.11E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Nitrosodiphenylamine, N-

CAS: 86-30-6 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	3.86E-07	1.93E-04
90	Protected Vegetables	9.21E-07	4.60E-04
95	Protected Vegetables	1.55E-06	7.70E-04
99	Protected Vegetables	3.49E-06	1.75E-03
50	Fish	5.96E-10	2.98E-07
75	Fish	2.61E-09	1.30E-06
90	Fish	9.80E-09	4.91E-06
95	Fish	2.06E-08	1.03E-05
99	Fish	8.69E-08	4.34E-05
50	Beef	1.39E-09	6.97E-07
75	Beef	3.55E-09	1.77E-06
90	Beef	7.57E-09	3.78E-06
95	Beef	1.07E-08	5.38E-06
99	Beef	2.15E-08	1.07E-05
50	Milk	6.65E-09	3.32E-06
75	Milk	1.69E-08	8.42E-06
90	Milk	3.43E-08	1.72E-05
95	Milk	5.22E-08	2.61E-05
99	Milk	9.34E-08	4.68E-05
75	Ground Water	2.30E-11	1.15E-08
90	Ground Water	3.65E-09	1.82E-06
95	Ground Water	1.71E-08	8.55E-06
99	Ground Water	1.47E-07	7.37E-05
50	Surface Water	5.28E-06	2.65E-03
75	Surface Water	1.52E-05	7.63E-03
90	Surface Water	3.43E-05	1.72E-02

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Nitrosodiphenylamine, N-

CAS: 86-30-6 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
95	Surface Water	5.29E-05	2.65E-02
99	Surface Water	1.06E-04	5.30E-02
50	Total Ingestion	8.55E-06	4.29E-03
75	Total Ingestion	2.01E-05	1.00E-02
90	Total Ingestion	4.20E-05	2.10E-02
95	Total Ingestion	6.14E-05	3.07E-02
99	Total Ingestion	1.13E-04	5.62E-02

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Nitrosodiphenylamine, N-

CAS: 86-30-6 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	7.17E-13	3.59E-10
75	Soil	1.47E-12	7.37E-10
90	Soil	3.45E-12	1.73E-09
95	Soil	1.07E-11	5.35E-09
99	Soil	7.83E-11	3.93E-08
50	Root	3.30E-07	1.65E-04
75	Root	1.05E-06	5.26E-04
90	Root	2.68E-06	1.34E-03
95	Root	4.60E-06	2.30E-03
99	Root	1.24E-05	6.20E-03
50	Exposed Fruit	4.31E-07	2.15E-04
75	Exposed Fruit	9.48E-07	4.74E-04
90	Exposed Fruit	1.77E-06	8.82E-04
95	Exposed Fruit	2.45E-06	1.23E-03
99	Exposed Fruit	4.70E-06	2.35E-03
50	Exposed Vegetables	2.24E-07	1.12E-04
75	Exposed Vegetables	5.30E-07	2.65E-04
90	Exposed Vegetables	1.02E-06	5.11E-04
95	Exposed Vegetables	1.43E-06	7.17E-04
99	Exposed Vegetables	2.55E-06	1.27E-03
50	Protected Fruit	4.74E-07	2.37E-04
75	Protected Fruit	1.19E-06	5.95E-04
90	Protected Fruit	2.26E-06	1.13E-03
95	Protected Fruit	3.04E-06	1.52E-03
99	Protected Fruit	4.53E-06	2.26E-03
50	Protected Vegetables	2.35E-07	1.18E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Nitrosodiphenylamine, N-

CAS: 86-30-6 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	4.98E-07	2.49E-04
90	Protected Vegetables	8.75E-07	4.38E-04
95	Protected Vegetables	1.22E-06	6.13E-04
99	Protected Vegetables	2.09E-06	1.05E-03
50	Fish	2.04E-09	1.02E-06
75	Fish	8.36E-09	4.19E-06
90	Fish	2.83E-08	1.41E-05
95	Fish	5.96E-08	2.98E-05
99	Fish	2.76E-07	1.38E-04
50	Beef	1.88E-09	9.41E-07
75	Beef	4.50E-09	2.25E-06
90	Beef	9.15E-09	4.57E-06
95	Beef	1.29E-08	6.45E-06
99	Beef	2.22E-08	1.11E-05
50	Milk	1.89E-08	9.41E-06
75	Milk	4.51E-08	2.26E-05
90	Milk	8.16E-08	4.08E-05
95	Milk	1.14E-07	5.70E-05
99	Milk	1.88E-07	9.41E-05
75	Ground Water	5.25E-11	2.63E-08
90	Ground Water	7.24E-09	3.61E-06
95	Ground Water	2.88E-08	1.44E-05
99	Ground Water	2.45E-07	1.23E-04
50	Surface Water	9.54E-06	4.77E-03
75	Surface Water	2.26E-05	1.13E-02
90	Surface Water	4.50E-05	2.25E-02

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Nitrosodiphenylamine, N-

CAS: 86-30-6 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
95	Surface Water	6.91E-05	3.45E-02
99	Surface Water	1.34E-04	6.65E-02
50	Total Ingestion	1.32E-05	6.57E-03
75	Total Ingestion	2.75E-05	1.38E-02
90	Total Ingestion	5.00E-05	2.50E-02
95	Total Ingestion	7.44E-05	3.71E-02
99	Total Ingestion	1.39E-04	6.97E-02

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trifluralin

CAS: 1582-09-8 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	2.77E-13	2.14E-10
75	Soil	6.31E-13	4.85E-10
90	Soil	1.13E-12	8.73E-10
95	Soil	1.54E-12	1.18E-09
99	Soil	2.28E-12	1.75E-09
50	Root	2.99E-10	2.29E-07
75	Root	8.71E-10	6.70E-07
90	Root	2.39E-09	1.83E-06
95	Root	3.83E-09	2.95E-06
99	Root	9.18E-09	7.05E-06
50	Exposed Fruit	3.04E-11	2.34E-08
75	Exposed Fruit	7.92E-11	6.09E-08
90	Exposed Fruit	1.81E-10	1.40E-07
95	Exposed Fruit	3.10E-10	2.39E-07
99	Exposed Fruit	6.45E-10	4.96E-07
50	Exposed Vegetables	1.70E-11	1.31E-08
75	Exposed Vegetables	4.56E-11	3.50E-08
90	Exposed Vegetables	1.08E-10	8.29E-08
95	Exposed Vegetables	1.89E-10	1.45E-07
99	Exposed Vegetables	4.46E-10	3.44E-07
50	Protected Fruit	3.56E-11	2.74E-08
75	Protected Fruit	1.16E-10	8.96E-08
90	Protected Fruit	2.90E-10	2.23E-07
95	Protected Fruit	4.45E-10	3.43E-07
99	Protected Fruit	8.73E-10	6.71E-07
50	Protected Vegetables	2.26E-11	1.74E-08

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trifluralin

CAS: 1582-09-8 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	5.98E-11	4.60E-08
90	Protected Vegetables	1.42E-10	1.09E-07
95	Protected Vegetables	2.42E-10	1.86E-07
99	Protected Vegetables	5.64E-10	4.34E-07
50	Fish	4.51E-10	3.47E-07
75	Fish	1.97E-09	1.51E-06
90	Fish	7.01E-09	5.39E-06
95	Fish	1.42E-08	1.09E-05
99	Fish	4.85E-08	3.74E-05
50	Beef	1.70E-11	1.32E-08
75	Beef	4.23E-11	3.25E-08
90	Beef	8.93E-11	6.87E-08
95	Beef	1.29E-10	9.92E-08
99	Beef	2.51E-10	1.94E-07
50	Milk	9.64E-11	7.41E-08
75	Milk	2.39E-10	1.84E-07
90	Milk	4.85E-10	3.74E-07
95	Milk	7.22E-10	5.55E-07
99	Milk	1.38E-09	1.06E-06
50	Surface Water	2.25E-10	1.74E-07
75	Surface Water	6.65E-10	5.11E-07
90	Surface Water	1.58E-09	1.21E-06
95	Surface Water	2.65E-09	2.05E-06
99	Surface Water	6.68E-09	5.15E-06
50	Total Ingestion	2.15E-09	1.66E-06
75	Total Ingestion	5.13E-09	3.94E-06

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trifluralin

CAS: 1582-09-8 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
90	Total Ingestion	1.22E-08	9.42E-06
95	Total Ingestion	1.92E-08	1.47E-05
99	Total Ingestion	5.10E-08	3.92E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trifluralin

CAS: 1582-09-8 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
50	Soil	2.03E-12	1.55E-09
75	Soil	3.69E-12	2.84E-09
90	Soil	5.19E-12	4.00E-09
95	Soil	6.04E-12	4.65E-09
99	Soil	7.73E-12	5.95E-09
50	Root	2.91E-10	2.25E-07
75	Root	9.15E-10	7.02E-07
90	Root	2.36E-09	1.81E-06
95	Root	3.98E-09	3.07E-06
99	Root	1.07E-08	8.23E-06
50	Exposed Fruit	3.43E-11	2.64E-08
75	Exposed Fruit	7.69E-11	5.91E-08
90	Exposed Fruit	1.37E-10	1.06E-07
95	Exposed Fruit	1.95E-10	1.51E-07
99	Exposed Fruit	3.55E-10	2.73E-07
50	Exposed Vegetables	1.80E-11	1.39E-08
75	Exposed Vegetables	4.17E-11	3.21E-08
90	Exposed Vegetables	8.01E-11	6.17E-08
95	Exposed Vegetables	1.11E-10	8.51E-08
99	Exposed Vegetables	1.84E-10	1.42E-07
50	Protected Fruit	7.38E-11	5.67E-08
75	Protected Fruit	1.84E-10	1.42E-07
90	Protected Fruit	3.49E-10	2.68E-07
95	Protected Fruit	4.67E-10	3.60E-07
99	Protected Fruit	6.88E-10	5.30E-07
50	Protected Vegetables	3.66E-11	2.82E-08

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trifluralin

CAS: 1582-09-8 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
75	Protected Vegetables	7.70E-11	5.94E-08
90	Protected Vegetables	1.35E-10	1.04E-07
95	Protected Vegetables	1.89E-10	1.46E-07
99	Protected Vegetables	3.24E-10	2.50E-07
50	Fish	1.46E-09	1.12E-06
75	Fish	5.70E-09	4.39E-06
90	Fish	1.86E-08	1.44E-05
95	Fish	3.78E-08	2.91E-05
99	Fish	1.45E-07	1.11E-04
50	Beef	2.23E-11	1.72E-08
75	Beef	5.39E-11	4.15E-08
90	Beef	1.06E-10	8.17E-08
95	Beef	1.52E-10	1.17E-07
99	Beef	2.60E-10	2.00E-07
50	Milk	2.70E-10	2.08E-07
75	Milk	6.53E-10	5.02E-07
90	Milk	1.15E-09	8.87E-07
95	Milk	1.58E-09	1.22E-06
99	Milk	2.53E-09	1.94E-06
50	Surface Water	3.94E-10	3.02E-07
75	Surface Water	9.70E-10	7.47E-07
90	Surface Water	2.17E-09	1.67E-06
95	Surface Water	3.57E-09	2.74E-06
99	Surface Water	8.01E-09	6.17E-06
50	Total Ingestion	4.20E-09	3.22E-06
75	Total Ingestion	9.86E-09	7.60E-06

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trifluralin

CAS: 1582-09-8 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kw/d)	Pathway HQ
90	Total Ingestion	2.37E-08	1.83E-05
95	Total Ingestion	4.25E-08	3.27E-05
99	Total Ingestion	1.47E-07	1.13E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Beryllium

CAS: 7440-41-7 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	2.61E-04
75	Air	NA	6.48E-04
90	Air	NA	1.33E-03
95	Air	NA	1.79E-03
99	Air	NA	3.28E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Beryllium

CAS: 7440-41-7 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	2.93E-04
75	Air	NA	7.25E-04
90	Air	NA	1.41E-03
95	Air	NA	1.93E-03
99	Air	NA	3.46E-03

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloromethane

CAS: 75-09-2 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	1.60E-04
75	Air	NA	2.43E-04
90	Air	NA	3.22E-04
95	Air	NA	3.79E-04
99	Air	NA	4.95E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloromethane

CAS: 75-09-2 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	1.98E-04
75	Air	NA	2.69E-04
90	Air	NA	3.44E-04
95	Air	NA	3.94E-04
99	Air	NA	5.29E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	1.64E-05
75	Air	NA	4.20E-05
90	Air	NA	7.93E-05
95	Air	NA	1.11E-04
99	Air	NA	2.22E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	2.26E-05
75	Air	NA	5.06E-05
90	Air	NA	9.02E-05
95	Air	NA	1.31E-04
99	Air	NA	2.40E-04

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, beta-

CAS: 319-85-7 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	4.82E-06
75	Air	NA	1.37E-05
90	Air	NA	2.85E-05
95	Air	NA	4.28E-05
99	Air	NA	9.38E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, beta-

CAS: 319-85-7 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	6.56E-06
75	Air	NA	1.72E-05
90	Air	NA	3.38E-05
95	Air	NA	4.89E-05
99	Air	NA	9.79E-05

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloromethane

CAS: 75-09-2 **PathwayCategory:** Inhalation

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Shower	NA	1.84E-03
75	Shower	NA	3.57E-03
90	Shower	NA	5.98E-03
95	Shower	NA	8.01E-03
99	Shower	NA	1.33E-02

Table Q-B-1. Cancer Risk Screening Hazard Quotients in the Agricultural Application

Hexachlorocyclohexane, alpha-

CAS: 319-84-6 **PathwayCategory:** Inhalation

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
99	Shower	NA	6.80E-16

Appendix Q

Attachment C:
Non-Cancer Hazard Quotients - Agricultural Application

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Acetone

CAS: 67-64-1 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	4.56E-13	5.07E-13
75	Soil	9.30E-12	1.03E-11
90	Soil	4.60E-11	5.11E-11
95	Soil	1.03E-10	1.15E-10
99	Soil	2.94E-10	3.27E-10
50	Root	1.98E-05	2.20E-05
75	Root	1.24E-04	1.38E-04
90	Root	7.09E-04	7.88E-04
95	Root	1.96E-03	2.18E-03
99	Root	8.09E-03	8.99E-03
50	Exposed Fruit	1.90E-05	2.12E-05
75	Exposed Fruit	8.62E-05	9.57E-05
90	Exposed Fruit	3.49E-04	3.88E-04
95	Exposed Fruit	7.37E-04	8.19E-04
99	Exposed Fruit	2.48E-03	2.75E-03
50	Exposed Vegetables	1.07E-05	1.19E-05
75	Exposed Vegetables	5.18E-05	5.75E-05
90	Exposed Vegetables	1.94E-04	2.15E-04
95	Exposed Vegetables	4.21E-04	4.67E-04
99	Exposed Vegetables	1.43E-03	1.59E-03
50	Protected Fruit	1.91E-05	2.12E-05
75	Protected Fruit	1.06E-04	1.18E-04
90	Protected Fruit	4.58E-04	5.08E-04
95	Protected Fruit	9.98E-04	1.11E-03
99	Protected Fruit	3.11E-03	3.45E-03
50	Protected Vegetables	1.20E-05	1.33E-05
75	Protected Vegetables	6.62E-05	7.35E-05
90	Protected Vegetables	2.81E-04	3.12E-04
95	Protected Vegetables	5.67E-04	6.30E-04
99	Protected Vegetables	1.83E-03	2.04E-03
50	Fish	1.43E-09	1.58E-09
75	Fish	1.20E-08	1.34E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Acetone

CAS: 67-64-1 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	5.04E-08	5.60E-08
95	Fish	1.28E-07	1.42E-07
99	Fish	5.29E-07	5.88E-07
50	Beef	5.81E-10	6.45E-10
75	Beef	2.25E-09	2.50E-09
90	Beef	8.40E-09	9.34E-09
95	Beef	1.63E-08	1.81E-08
99	Beef	4.09E-08	4.54E-08
50	Milk	1.17E-07	1.30E-07
75	Milk	4.63E-07	5.15E-07
90	Milk	1.94E-06	2.16E-06
95	Milk	3.81E-06	4.24E-06
99	Milk	9.08E-06	1.01E-05
50	Ground Water	7.03E-08	7.81E-08
75	Ground Water	5.66E-07	6.29E-07
90	Ground Water	3.71E-06	4.12E-06
95	Ground Water	6.44E-06	7.15E-06
99	Ground Water	1.48E-05	1.64E-05
50	Surface Water	5.06E-05	5.62E-05
75	Surface Water	1.14E-04	1.26E-04
90	Surface Water	2.35E-04	2.61E-04
95	Surface Water	3.45E-04	3.84E-04
99	Surface Water	6.53E-04	7.26E-04
50	Total Ingestion	2.58E-04	2.87E-04
75	Total Ingestion	7.23E-04	8.03E-04
90	Total Ingestion	2.97E-03	3.30E-03
95	Total Ingestion	5.41E-03	6.01E-03
99	Total Ingestion	1.34E-02	1.49E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Acetone

CAS: 67-64-1 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	4.36E-12	4.84E-12
75	Soil	8.94E-11	9.94E-11
90	Soil	5.05E-10	5.61E-10
95	Soil	1.06E-09	1.17E-09
99	Soil	3.30E-09	3.66E-09
50	Root	3.05E-05	3.39E-05
75	Root	1.95E-04	2.16E-04
90	Root	1.20E-03	1.33E-03
95	Root	2.78E-03	3.09E-03
99	Root	1.10E-02	1.23E-02
50	Exposed Fruit	3.12E-05	3.47E-05
75	Exposed Fruit	1.39E-04	1.55E-04
90	Exposed Fruit	5.59E-04	6.21E-04
95	Exposed Fruit	9.32E-04	1.04E-03
99	Exposed Fruit	2.23E-03	2.47E-03
50	Exposed Vegetables	1.70E-05	1.89E-05
75	Exposed Vegetables	7.53E-05	8.37E-05
90	Exposed Vegetables	2.70E-04	3.00E-04
95	Exposed Vegetables	5.67E-04	6.30E-04
99	Exposed Vegetables	1.36E-03	1.52E-03
50	Protected Fruit	6.05E-05	6.73E-05
75	Protected Fruit	2.80E-04	3.11E-04
90	Protected Fruit	1.19E-03	1.33E-03
95	Protected Fruit	2.34E-03	2.60E-03
99	Protected Fruit	6.85E-03	7.61E-03
50	Protected Vegetables	3.02E-05	3.36E-05
75	Protected Vegetables	1.45E-04	1.61E-04
90	Protected Vegetables	5.54E-04	6.15E-04
95	Protected Vegetables	9.22E-04	1.02E-03
99	Protected Vegetables	2.23E-03	2.47E-03
50	Fish	9.66E-09	1.07E-08
75	Fish	6.50E-08	7.22E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Acetone

CAS: 67-64-1 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	2.58E-07	2.86E-07
95	Fish	5.99E-07	6.65E-07
99	Fish	2.85E-06	3.17E-06
50	Beef	1.22E-09	1.35E-09
75	Beef	4.78E-09	5.31E-09
90	Beef	1.71E-08	1.90E-08
95	Beef	3.03E-08	3.36E-08
99	Beef	7.29E-08	8.10E-08
50	Milk	4.91E-07	5.46E-07
75	Milk	1.96E-06	2.18E-06
90	Milk	8.38E-06	9.32E-06
95	Milk	1.56E-05	1.73E-05
99	Milk	3.48E-05	3.87E-05
50	Ground Water	2.15E-07	2.39E-07
75	Ground Water	1.81E-06	2.01E-06
90	Ground Water	1.01E-05	1.13E-05
95	Ground Water	1.90E-05	2.11E-05
99	Ground Water	3.81E-05	4.24E-05
50	Surface Water	1.40E-04	1.56E-04
75	Surface Water	2.97E-04	3.30E-04
90	Surface Water	5.69E-04	6.32E-04
95	Surface Water	8.21E-04	9.12E-04
99	Surface Water	1.61E-03	1.78E-03
50	Total Ingestion	5.43E-04	6.03E-04
75	Total Ingestion	1.51E-03	1.68E-03
90	Total Ingestion	4.78E-03	5.31E-03
95	Total Ingestion	8.17E-03	9.08E-03
99	Total Ingestion	1.75E-02	1.94E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Acetophenone

CAS: 98-86-2 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.33E-11	1.33E-10
75	Soil	8.10E-11	8.10E-10
90	Soil	2.21E-10	2.21E-09
95	Soil	3.52E-10	3.52E-09
99	Soil	7.00E-10	7.00E-09
50	Root	1.80E-06	1.80E-05
75	Root	7.12E-06	7.12E-05
90	Root	2.61E-05	2.61E-04
95	Root	5.58E-05	5.58E-04
99	Root	2.19E-04	2.19E-03
50	Exposed Fruit	1.36E-06	1.36E-05
75	Exposed Fruit	4.49E-06	4.49E-05
90	Exposed Fruit	1.32E-05	1.32E-04
95	Exposed Fruit	2.37E-05	2.37E-04
99	Exposed Fruit	6.39E-05	6.39E-04
50	Exposed Vegetables	8.02E-07	8.02E-06
75	Exposed Vegetables	2.71E-06	2.71E-05
90	Exposed Vegetables	7.05E-06	7.05E-05
95	Exposed Vegetables	1.30E-05	1.30E-04
99	Exposed Vegetables	3.71E-05	3.71E-04
50	Protected Fruit	1.66E-06	1.66E-05
75	Protected Fruit	6.13E-06	6.13E-05
90	Protected Fruit	1.75E-05	1.75E-04
95	Protected Fruit	3.06E-05	3.06E-04
99	Protected Fruit	7.41E-05	7.41E-04
50	Protected Vegetables	9.42E-07	9.42E-06
75	Protected Vegetables	3.51E-06	3.51E-05
90	Protected Vegetables	9.67E-06	9.67E-05
95	Protected Vegetables	1.66E-05	1.66E-04
99	Protected Vegetables	5.00E-05	5.00E-04
50	Fish	5.75E-10	5.75E-09
75	Fish	3.05E-09	3.05E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Acetophenone

CAS: 98-86-2 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.11E-08	1.11E-07
95	Fish	2.21E-08	2.21E-07
99	Fish	6.60E-08	6.60E-07
50	Beef	6.99E-11	6.99E-10
75	Beef	2.19E-10	2.19E-09
90	Beef	5.89E-10	5.89E-09
95	Beef	1.00E-09	1.00E-08
99	Beef	2.31E-09	2.31E-08
50	Milk	8.03E-09	8.03E-08
75	Milk	2.39E-08	2.39E-07
90	Milk	6.66E-08	6.66E-07
95	Milk	1.14E-07	1.14E-06
99	Milk	2.27E-07	2.27E-06
75	Ground Water	1.38E-14	1.38E-13
90	Ground Water	8.09E-11	8.09E-10
95	Ground Water	1.08E-09	1.08E-08
99	Ground Water	3.28E-08	3.28E-07
50	Surface Water	1.34E-06	1.34E-05
75	Surface Water	4.14E-06	4.14E-05
90	Surface Water	1.10E-05	1.10E-04
95	Surface Water	2.02E-05	2.02E-04
99	Surface Water	5.78E-05	5.78E-04
50	Total Ingestion	1.54E-05	1.54E-04
75	Total Ingestion	3.89E-05	3.89E-04
90	Total Ingestion	9.33E-05	9.33E-04
95	Total Ingestion	1.51E-04	1.51E-03
99	Total Ingestion	3.33E-04	3.33E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Acetophenone

CAS: 98-86-2 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.49E-10	1.49E-09
75	Soil	8.51E-10	8.51E-09
90	Soil	2.03E-09	2.03E-08
95	Soil	3.27E-09	3.27E-08
99	Soil	7.45E-09	7.45E-08
50	Root	2.78E-06	2.78E-05
75	Root	1.11E-05	1.11E-04
90	Root	4.17E-05	4.17E-04
95	Root	8.39E-05	8.39E-04
99	Root	3.09E-04	3.09E-03
50	Exposed Fruit	2.38E-06	2.38E-05
75	Exposed Fruit	6.66E-06	6.66E-05
90	Exposed Fruit	1.67E-05	1.67E-04
95	Exposed Fruit	2.72E-05	2.72E-04
99	Exposed Fruit	5.92E-05	5.92E-04
50	Exposed Vegetables	1.16E-06	1.16E-05
75	Exposed Vegetables	3.94E-06	3.94E-05
90	Exposed Vegetables	1.01E-05	1.01E-04
95	Exposed Vegetables	1.68E-05	1.68E-04
99	Exposed Vegetables	3.75E-05	3.75E-04
50	Protected Fruit	4.73E-06	4.73E-05
75	Protected Fruit	1.53E-05	1.53E-04
90	Protected Fruit	3.95E-05	3.95E-04
95	Protected Fruit	6.87E-05	6.87E-04
99	Protected Fruit	1.83E-04	1.83E-03
50	Protected Vegetables	2.48E-06	2.48E-05
75	Protected Vegetables	6.96E-06	6.96E-05
90	Protected Vegetables	1.77E-05	1.77E-04
95	Protected Vegetables	2.66E-05	2.66E-04
99	Protected Vegetables	5.57E-05	5.57E-04
50	Fish	3.57E-09	3.57E-08
75	Fish	1.61E-08	1.61E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Acetophenone

CAS: 98-86-2 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	5.78E-08	5.78E-07
95	Fish	1.06E-07	1.06E-06
99	Fish	3.59E-07	3.59E-06
50	Beef	1.49E-10	1.49E-09
75	Beef	4.68E-10	4.68E-09
90	Beef	1.11E-09	1.11E-08
95	Beef	1.96E-09	1.96E-08
99	Beef	4.04E-09	4.04E-08
50	Milk	3.26E-08	3.26E-07
75	Milk	1.02E-07	1.02E-06
90	Milk	2.75E-07	2.75E-06
95	Milk	4.58E-07	4.58E-06
99	Milk	9.81E-07	9.81E-06
75	Ground Water	3.53E-14	3.53E-13
90	Ground Water	3.10E-10	3.10E-09
95	Ground Water	2.75E-09	2.75E-08
99	Ground Water	1.07E-07	1.07E-06
50	Surface Water	3.93E-06	3.93E-05
75	Surface Water	1.11E-05	1.11E-04
90	Surface Water	2.84E-05	2.84E-04
95	Surface Water	5.47E-05	5.47E-04
99	Surface Water	1.46E-04	1.46E-03
50	Total Ingestion	3.06E-05	3.06E-04
75	Total Ingestion	7.65E-05	7.65E-04
90	Total Ingestion	1.56E-04	1.56E-03
95	Total Ingestion	2.43E-04	2.43E-03
99	Total Ingestion	5.01E-04	5.01E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Anthracene

CAS: 120-12-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.88E-08	9.61E-08
75	Soil	4.28E-08	1.43E-07
90	Soil	5.56E-08	1.86E-07
95	Soil	6.32E-08	2.10E-07
99	Soil	7.63E-08	2.55E-07
50	Root	4.41E-06	1.46E-05
75	Root	1.15E-05	3.85E-05
90	Root	2.69E-05	8.98E-05
95	Root	4.38E-05	1.46E-04
99	Root	1.16E-04	3.88E-04
50	Exposed Fruit	8.75E-07	2.91E-06
75	Exposed Fruit	2.00E-06	6.68E-06
90	Exposed Fruit	4.08E-06	1.36E-05
95	Exposed Fruit	6.51E-06	2.17E-05
99	Exposed Fruit	1.23E-05	4.08E-05
50	Exposed Vegetables	4.80E-07	1.60E-06
75	Exposed Vegetables	1.15E-06	3.85E-06
90	Exposed Vegetables	2.57E-06	8.59E-06
95	Exposed Vegetables	3.55E-06	1.18E-05
99	Exposed Vegetables	7.27E-06	2.42E-05
50	Protected Fruit	1.09E-06	3.62E-06
75	Protected Fruit	3.08E-06	1.03E-05
90	Protected Fruit	6.09E-06	2.03E-05
95	Protected Fruit	8.72E-06	2.91E-05
99	Protected Fruit	1.50E-05	5.00E-05
50	Protected Vegetables	6.22E-07	2.07E-06
75	Protected Vegetables	1.48E-06	4.94E-06
90	Protected Vegetables	3.29E-06	1.10E-05
95	Protected Vegetables	4.97E-06	1.65E-05
99	Protected Vegetables	9.48E-06	3.16E-05
50	Fish	1.11E-06	3.72E-06
75	Fish	4.18E-06	1.39E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Anthracene

CAS: 120-12-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.23E-05	4.11E-05
95	Fish	2.17E-05	7.24E-05
99	Fish	7.14E-05	2.38E-04
50	Beef	4.80E-08	1.61E-07
75	Beef	1.01E-07	3.36E-07
90	Beef	1.91E-07	6.35E-07
95	Beef	2.62E-07	8.75E-07
99	Beef	5.03E-07	1.68E-06
50	Milk	3.42E-07	1.14E-06
75	Milk	7.30E-07	2.43E-06
90	Milk	1.28E-06	4.28E-06
95	Milk	1.68E-06	5.59E-06
99	Milk	2.42E-06	8.06E-06
50	Surface Water	9.94E-07	3.32E-06
75	Surface Water	2.05E-06	6.84E-06
90	Surface Water	3.62E-06	1.21E-05
95	Surface Water	4.80E-06	1.60E-05
99	Surface Water	8.13E-06	2.71E-05
50	Total Ingestion	1.78E-05	5.92E-05
75	Total Ingestion	3.10E-05	1.03E-04
90	Total Ingestion	5.20E-05	1.73E-04
95	Total Ingestion	7.21E-05	2.40E-04
99	Total Ingestion	1.58E-04	5.26E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Anthracene

CAS: 120-12-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.82E-07	9.41E-07
75	Soil	3.82E-07	1.27E-06
90	Soil	4.84E-07	1.61E-06
95	Soil	5.33E-07	1.77E-06
99	Soil	6.51E-07	2.17E-06
50	Root	6.81E-06	2.27E-05
75	Root	1.91E-05	6.35E-05
90	Root	4.57E-05	1.52E-04
95	Root	7.99E-05	2.66E-04
99	Root	2.18E-04	7.27E-04
50	Exposed Fruit	1.53E-06	5.10E-06
75	Exposed Fruit	2.78E-06	9.24E-06
90	Exposed Fruit	4.44E-06	1.48E-05
95	Exposed Fruit	6.02E-06	2.00E-05
99	Exposed Fruit	9.44E-06	3.15E-05
50	Exposed Vegetables	7.57E-07	2.52E-06
75	Exposed Vegetables	1.59E-06	5.30E-06
90	Exposed Vegetables	2.86E-06	9.51E-06
95	Exposed Vegetables	3.82E-06	1.27E-05
99	Exposed Vegetables	5.95E-06	1.99E-05
50	Protected Fruit	3.22E-06	1.07E-05
75	Protected Fruit	6.94E-06	2.31E-05
90	Protected Fruit	1.25E-05	4.18E-05
95	Protected Fruit	1.70E-05	5.66E-05
99	Protected Fruit	2.36E-05	7.86E-05
50	Protected Vegetables	1.56E-06	5.20E-06
75	Protected Vegetables	2.71E-06	9.05E-06
90	Protected Vegetables	4.54E-06	1.51E-05
95	Protected Vegetables	6.19E-06	2.06E-05
99	Protected Vegetables	1.16E-05	3.88E-05
50	Fish	6.09E-06	2.03E-05
75	Fish	2.11E-05	7.04E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Anthracene

CAS: 120-12-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	6.02E-05	2.01E-04
95	Fish	1.14E-04	3.78E-04
99	Fish	3.39E-04	1.14E-03
50	Beef	1.01E-07	3.39E-07
75	Beef	1.89E-07	6.28E-07
90	Beef	3.45E-07	1.16E-06
95	Beef	4.70E-07	1.56E-06
99	Beef	8.98E-07	3.00E-06
50	Milk	1.38E-06	4.61E-06
75	Milk	3.01E-06	1.00E-05
90	Milk	4.87E-06	1.62E-05
95	Milk	6.55E-06	2.18E-05
99	Milk	1.09E-05	3.65E-05
50	Surface Water	2.81E-06	9.38E-06
75	Surface Water	5.33E-06	1.78E-05
90	Surface Water	8.82E-06	2.94E-05
95	Surface Water	1.14E-05	3.78E-05
99	Surface Water	1.90E-05	6.35E-05
50	Total Ingestion	3.88E-05	1.29E-04
75	Total Ingestion	6.94E-05	2.31E-04
90	Total Ingestion	1.30E-04	4.31E-04
95	Total Ingestion	1.97E-04	6.55E-04
99	Total Ingestion	4.38E-04	1.45E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Azinphos Methyl

CAS: 86-50-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.76E-15	1.84E-12
75	Soil	1.56E-14	1.04E-11
90	Soil	1.41E-13	9.39E-11
95	Soil	3.08E-13	2.05E-10
99	Soil	1.68E-12	1.12E-09
50	Root	1.52E-08	1.01E-05
75	Root	4.26E-08	2.84E-05
90	Root	1.03E-07	6.84E-05
95	Root	1.78E-07	1.19E-04
99	Root	5.05E-07	3.37E-04
50	Exposed Fruit	2.01E-08	1.34E-05
75	Exposed Fruit	5.00E-08	3.33E-05
90	Exposed Fruit	1.09E-07	7.24E-05
95	Exposed Fruit	1.74E-07	1.16E-04
99	Exposed Fruit	3.81E-07	2.54E-04
50	Exposed Vegetables	1.12E-08	7.45E-06
75	Exposed Vegetables	2.79E-08	1.86E-05
90	Exposed Vegetables	6.59E-08	4.39E-05
95	Exposed Vegetables	9.66E-08	6.44E-05
99	Exposed Vegetables	1.95E-07	1.30E-04
50	Protected Fruit	1.52E-08	1.02E-05
75	Protected Fruit	4.95E-08	3.30E-05
90	Protected Fruit	1.06E-07	7.05E-05
95	Protected Fruit	1.59E-07	1.06E-04
99	Protected Fruit	2.61E-07	1.74E-04
50	Protected Vegetables	9.32E-09	6.21E-06
75	Protected Vegetables	2.44E-08	1.63E-05
90	Protected Vegetables	5.69E-08	3.80E-05
95	Protected Vegetables	9.00E-08	6.00E-05
99	Protected Vegetables	1.86E-07	1.24E-04
50	Fish	6.66E-12	4.44E-09
75	Fish	3.52E-11	2.35E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Azinphos Methyl

CAS: 86-50-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.80E-10	1.20E-07
95	Fish	4.75E-10	3.17E-07
99	Fish	1.97E-09	1.32E-06
50	Beef	2.27E-11	1.51E-08
75	Beef	5.06E-11	3.37E-08
90	Beef	9.72E-11	6.48E-08
95	Beef	1.42E-10	9.44E-08
99	Beef	2.79E-10	1.86E-07
50	Milk	1.49E-10	9.95E-08
75	Milk	3.42E-10	2.28E-07
90	Milk	6.60E-10	4.40E-07
95	Milk	8.87E-10	5.92E-07
99	Milk	1.32E-09	8.79E-07
75	Ground Water	2.75E-11	1.83E-08
90	Ground Water	7.55E-10	5.03E-07
95	Ground Water	2.44E-09	1.63E-06
99	Ground Water	8.92E-09	5.94E-06
50	Surface Water	1.78E-07	1.18E-04
75	Surface Water	4.73E-07	3.15E-04
90	Surface Water	9.95E-07	6.63E-04
95	Surface Water	1.51E-06	1.00E-03
99	Surface Water	2.88E-06	1.92E-03
50	Total Ingestion	3.70E-07	2.47E-04
75	Total Ingestion	7.16E-07	4.77E-04
90	Total Ingestion	1.26E-06	8.43E-04
95	Total Ingestion	1.80E-06	1.20E-03
99	Total Ingestion	3.25E-06	2.16E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Azinphos Methyl

CAS: 86-50-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.61E-14	1.74E-11
75	Soil	1.61E-13	1.07E-10
90	Soil	1.41E-12	9.38E-10
95	Soil	3.03E-12	2.02E-09
99	Soil	1.71E-11	1.14E-08
50	Root	2.28E-08	1.52E-05
75	Root	7.03E-08	4.68E-05
90	Root	1.71E-07	1.14E-04
95	Root	3.12E-07	2.08E-04
99	Root	8.44E-07	5.63E-04
50	Exposed Fruit	3.59E-08	2.40E-05
75	Exposed Fruit	7.30E-08	4.87E-05
90	Exposed Fruit	1.22E-07	8.12E-05
95	Exposed Fruit	1.67E-07	1.11E-04
99	Exposed Fruit	2.72E-07	1.82E-04
50	Exposed Vegetables	1.76E-08	1.18E-05
75	Exposed Vegetables	4.02E-08	2.68E-05
90	Exposed Vegetables	7.73E-08	5.16E-05
95	Exposed Vegetables	1.05E-07	7.03E-05
99	Exposed Vegetables	1.73E-07	1.15E-04
50	Protected Fruit	4.77E-08	3.18E-05
75	Protected Fruit	1.14E-07	7.59E-05
90	Protected Fruit	2.20E-07	1.46E-04
95	Protected Fruit	3.15E-07	2.10E-04
99	Protected Fruit	4.78E-07	3.19E-04
50	Protected Vegetables	2.51E-08	1.67E-05
75	Protected Vegetables	4.52E-08	3.01E-05
90	Protected Vegetables	8.06E-08	5.37E-05
95	Protected Vegetables	1.13E-07	7.53E-05
99	Protected Vegetables	2.19E-07	1.46E-04
50	Fish	3.73E-11	2.49E-08
75	Fish	1.93E-10	1.29E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Azinphos Methyl

CAS: 86-50-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	9.61E-10	6.41E-07
95	Fish	2.67E-09	1.78E-06
99	Fish	1.13E-08	7.53E-06
50	Beef	4.75E-11	3.17E-08
75	Beef	9.75E-11	6.50E-08
90	Beef	1.82E-10	1.22E-07
95	Beef	2.54E-10	1.69E-07
99	Beef	5.06E-10	3.38E-07
50	Milk	6.25E-10	4.17E-07
75	Milk	1.40E-09	9.36E-07
90	Milk	2.58E-09	1.72E-06
95	Milk	3.61E-09	2.41E-06
99	Milk	6.31E-09	4.20E-06
75	Ground Water	1.22E-10	8.17E-08
90	Ground Water	2.86E-09	1.90E-06
95	Ground Water	6.64E-09	4.42E-06
99	Ground Water	1.66E-08	1.11E-05
50	Surface Water	5.11E-07	3.41E-04
75	Surface Water	1.27E-06	8.45E-04
90	Surface Water	2.45E-06	1.63E-03
95	Surface Water	3.61E-06	2.40E-03
99	Surface Water	6.78E-06	4.52E-03
50	Total Ingestion	8.21E-07	5.47E-04
75	Total Ingestion	1.60E-06	1.06E-03
90	Total Ingestion	2.85E-06	1.90E-03
95	Total Ingestion	3.93E-06	2.62E-03
99	Total Ingestion	7.31E-06	4.88E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Barium

CAS: 7440-39-3 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.00E-05	2.85E-04
75	Soil	3.00E-05	4.28E-04
90	Soil	4.15E-05	5.92E-04
95	Soil	4.94E-05	7.06E-04
99	Soil	6.70E-05	9.57E-04
50	Root	5.24E-04	7.49E-03
75	Root	1.15E-03	1.64E-02
90	Root	2.25E-03	3.22E-02
95	Root	3.31E-03	4.73E-02
99	Root	6.31E-03	9.01E-02
50	Exposed Fruit	8.57E-05	1.22E-03
75	Exposed Fruit	1.91E-04	2.72E-03
90	Exposed Fruit	3.92E-04	5.60E-03
95	Exposed Fruit	6.12E-04	8.75E-03
99	Exposed Fruit	1.15E-03	1.65E-02
50	Exposed Vegetables	4.73E-04	6.75E-03
75	Exposed Vegetables	1.05E-03	1.50E-02
90	Exposed Vegetables	2.24E-03	3.20E-02
95	Exposed Vegetables	3.37E-03	4.82E-02
99	Exposed Vegetables	6.41E-03	9.16E-02
50	Protected Fruit	1.18E-04	1.68E-03
75	Protected Fruit	2.83E-04	4.04E-03
90	Protected Fruit	5.52E-04	7.88E-03
95	Protected Fruit	8.19E-04	1.17E-02
99	Protected Fruit	1.45E-03	2.08E-02
50	Protected Vegetables	6.42E-05	9.17E-04
75	Protected Vegetables	1.44E-04	2.06E-03
90	Protected Vegetables	2.90E-04	4.14E-03
95	Protected Vegetables	4.50E-04	6.42E-03
99	Protected Vegetables	9.42E-04	1.35E-02
50	Fish	7.62E-06	1.09E-04
75	Fish	3.13E-05	4.48E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Barium

CAS: 7440-39-3 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.01E-04	1.45E-03
95	Fish	1.92E-04	2.74E-03
99	Fish	5.61E-04	8.01E-03
50	Beef	6.90E-06	9.85E-05
75	Beef	1.39E-05	1.99E-04
90	Beef	2.48E-05	3.55E-04
95	Beef	3.44E-05	4.92E-04
99	Beef	6.09E-05	8.71E-04
50	Milk	3.87E-04	5.53E-03
75	Milk	7.71E-04	1.10E-02
90	Milk	1.33E-03	1.90E-02
95	Milk	1.72E-03	2.45E-02
99	Milk	2.98E-03	4.25E-02
95	Ground Water	1.00E-17	1.44E-16
99	Ground Water	1.69E-12	2.42E-11
50	Surface Water	7.14E-04	1.02E-02
75	Surface Water	1.84E-03	2.63E-02
90	Surface Water	3.93E-03	5.61E-02
95	Surface Water	5.98E-03	8.54E-02
99	Surface Water	1.23E-02	1.76E-01
50	Total Ingestion	3.69E-03	5.27E-02
75	Total Ingestion	6.03E-03	8.61E-02
90	Total Ingestion	9.14E-03	1.31E-01
95	Total Ingestion	1.19E-02	1.70E-01
99	Total Ingestion	1.86E-02	2.65E-01

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Barium

CAS: 7440-39-3 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.34E-04	1.91E-03
75	Soil	2.16E-04	3.08E-03
90	Soil	3.12E-04	4.45E-03
95	Soil	3.80E-04	5.43E-03
99	Soil	5.19E-04	7.41E-03
50	Root	5.44E-04	7.78E-03
75	Root	1.34E-03	1.92E-02
90	Root	2.93E-03	4.19E-02
95	Root	4.92E-03	7.03E-02
99	Root	1.21E-02	1.73E-01
50	Exposed Fruit	1.01E-04	1.45E-03
75	Exposed Fruit	2.01E-04	2.87E-03
90	Exposed Fruit	3.45E-04	4.93E-03
95	Exposed Fruit	4.59E-04	6.56E-03
99	Exposed Fruit	8.39E-04	1.20E-02
50	Exposed Vegetables	4.85E-04	6.93E-03
75	Exposed Vegetables	1.05E-03	1.50E-02
90	Exposed Vegetables	2.01E-03	2.87E-02
95	Exposed Vegetables	2.84E-03	4.05E-02
99	Exposed Vegetables	5.18E-03	7.40E-02
50	Protected Fruit	2.04E-04	2.92E-03
75	Protected Fruit	4.57E-04	6.53E-03
90	Protected Fruit	8.42E-04	1.20E-02
95	Protected Fruit	1.14E-03	1.63E-02
99	Protected Fruit	1.89E-03	2.70E-02
50	Protected Vegetables	1.00E-04	1.43E-03
75	Protected Vegetables	1.88E-04	2.69E-03
90	Protected Vegetables	3.23E-04	4.61E-03
95	Protected Vegetables	4.69E-04	6.69E-03
99	Protected Vegetables	9.34E-04	1.33E-02
50	Fish	2.92E-05	4.17E-04
75	Fish	1.13E-04	1.61E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Barium

CAS: 7440-39-3 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	3.81E-04	5.44E-03
95	Fish	7.39E-04	1.06E-02
99	Fish	2.20E-03	3.15E-02
50	Beef	1.04E-05	1.48E-04
75	Beef	2.03E-05	2.90E-04
90	Beef	3.74E-05	5.35E-04
95	Beef	5.27E-05	7.52E-04
99	Beef	1.02E-04	1.46E-03
50	Milk	1.03E-03	1.47E-02
75	Milk	2.14E-03	3.06E-02
90	Milk	3.98E-03	5.69E-02
95	Milk	5.55E-03	7.93E-02
99	Milk	9.50E-03	1.36E-01
95	Ground Water	1.46E-17	2.09E-16
99	Ground Water	3.03E-12	4.32E-11
50	Surface Water	1.46E-03	2.09E-02
75	Surface Water	3.68E-03	5.25E-02
90	Surface Water	7.85E-03	1.12E-01
95	Surface Water	1.23E-02	1.76E-01
99	Surface Water	2.63E-02	3.76E-01
50	Total Ingestion	5.89E-03	8.41E-02
75	Total Ingestion	1.03E-02	1.46E-01
90	Total Ingestion	1.65E-02	2.36E-01
95	Total Ingestion	2.17E-02	3.11E-01
99	Total Ingestion	3.68E-02	5.26E-01

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Benzoic Acid

CAS: 65-85-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.20E-11	5.51E-12
75	Soil	1.85E-10	4.63E-11
90	Soil	6.73E-10	1.69E-10
95	Soil	1.30E-09	3.26E-10
99	Soil	2.82E-09	7.03E-10
50	Root	2.25E-04	5.66E-05
75	Root	8.85E-04	2.20E-04
90	Root	3.11E-03	7.75E-04
95	Root	7.20E-03	1.80E-03
99	Root	2.97E-02	7.43E-03
50	Exposed Fruit	4.74E-06	1.19E-06
75	Exposed Fruit	1.45E-05	3.62E-06
90	Exposed Fruit	4.11E-05	1.03E-05
95	Exposed Fruit	7.65E-05	1.92E-05
99	Exposed Fruit	2.27E-04	5.68E-05
50	Exposed Vegetables	2.69E-06	6.71E-07
75	Exposed Vegetables	8.73E-06	2.19E-06
90	Exposed Vegetables	2.17E-05	5.44E-06
95	Exposed Vegetables	4.48E-05	1.12E-05
99	Exposed Vegetables	1.36E-04	3.39E-05
50	Protected Fruit	5.64E-06	1.41E-06
75	Protected Fruit	2.05E-05	5.14E-06
90	Protected Fruit	5.61E-05	1.40E-05
95	Protected Fruit	9.29E-05	2.32E-05
99	Protected Fruit	2.82E-04	7.05E-05
50	Protected Vegetables	3.37E-06	8.45E-07
75	Protected Vegetables	1.13E-05	2.82E-06
90	Protected Vegetables	3.16E-05	7.88E-06
95	Protected Vegetables	5.76E-05	1.44E-05
99	Protected Vegetables	1.74E-04	4.33E-05
50	Fish	5.58E-08	1.39E-08
75	Fish	2.79E-07	6.96E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Benzoic Acid

CAS: 65-85-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.04E-06	2.61E-07
95	Fish	2.00E-06	5.01E-07
99	Fish	6.26E-06	1.56E-06
50	Beef	3.89E-10	9.75E-11
75	Beef	1.11E-09	2.77E-10
90	Beef	2.92E-09	7.31E-10
95	Beef	5.26E-09	1.31E-09
99	Beef	1.31E-08	3.27E-09
50	Milk	2.77E-08	6.91E-09
75	Milk	7.77E-08	1.94E-08
90	Milk	2.00E-07	4.99E-08
95	Milk	3.59E-07	8.97E-08
99	Milk	8.18E-07	2.04E-07
50	Ground Water	4.29E-11	1.07E-11
75	Ground Water	2.71E-09	6.76E-10
90	Ground Water	6.78E-08	1.69E-08
95	Ground Water	2.44E-07	6.11E-08
99	Ground Water	9.07E-07	2.27E-07
50	Surface Water	8.55E-06	2.14E-06
75	Surface Water	2.45E-05	6.13E-06
90	Surface Water	5.68E-05	1.42E-05
95	Surface Water	8.75E-05	2.19E-05
99	Surface Water	2.54E-04	6.33E-05
50	Total Ingestion	3.07E-04	7.70E-05
75	Total Ingestion	9.85E-04	2.45E-04
90	Total Ingestion	3.34E-03	8.37E-04
95	Total Ingestion	7.40E-03	1.85E-03
99	Total Ingestion	2.99E-02	7.48E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Benzoic Acid

CAS: 65-85-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.22E-10	5.54E-11
75	Soil	1.92E-09	4.79E-10
90	Soil	7.18E-09	1.79E-09
95	Soil	1.23E-08	3.07E-09
99	Soil	2.67E-08	6.68E-09
50	Root	3.71E-04	9.25E-05
75	Root	1.39E-03	3.47E-04
90	Root	5.14E-03	1.28E-03
95	Root	1.09E-02	2.74E-03
99	Root	3.91E-02	9.79E-03
50	Exposed Fruit	8.28E-06	2.07E-06
75	Exposed Fruit	2.15E-05	5.39E-06
90	Exposed Fruit	5.34E-05	1.33E-05
95	Exposed Fruit	8.57E-05	2.14E-05
99	Exposed Fruit	2.07E-04	5.19E-05
50	Exposed Vegetables	4.01E-06	1.00E-06
75	Exposed Vegetables	1.18E-05	2.96E-06
90	Exposed Vegetables	2.89E-05	7.21E-06
95	Exposed Vegetables	5.24E-05	1.31E-05
99	Exposed Vegetables	1.22E-04	3.04E-05
50	Protected Fruit	1.67E-05	4.16E-06
75	Protected Fruit	4.71E-05	1.18E-05
90	Protected Fruit	1.18E-04	2.94E-05
95	Protected Fruit	2.15E-04	5.39E-05
99	Protected Fruit	6.16E-04	1.54E-04
50	Protected Vegetables	8.27E-06	2.07E-06
75	Protected Vegetables	2.17E-05	5.43E-06
90	Protected Vegetables	5.43E-05	1.36E-05
95	Protected Vegetables	8.43E-05	2.10E-05
99	Protected Vegetables	2.04E-04	5.08E-05
50	Fish	3.37E-07	8.42E-08
75	Fish	1.52E-06	3.81E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Benzoic Acid

CAS: 65-85-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	5.39E-06	1.35E-06
95	Fish	9.54E-06	2.39E-06
99	Fish	3.34E-05	8.37E-06
50	Beef	8.13E-10	2.04E-10
75	Beef	2.32E-09	5.79E-10
90	Beef	5.69E-09	1.42E-09
95	Beef	9.69E-09	2.42E-09
99	Beef	2.19E-08	5.44E-09
50	Milk	1.18E-07	2.94E-08
75	Milk	3.12E-07	7.83E-08
90	Milk	8.40E-07	2.10E-07
95	Milk	1.46E-06	3.64E-07
99	Milk	3.09E-06	7.75E-07
50	Ground Water	1.36E-10	3.41E-11
75	Ground Water	7.55E-09	1.89E-09
90	Ground Water	1.99E-07	4.96E-08
95	Ground Water	6.15E-07	1.54E-07
99	Ground Water	2.15E-06	5.39E-07
50	Surface Water	2.39E-05	5.98E-06
75	Surface Water	6.65E-05	1.66E-05
90	Surface Water	1.43E-04	3.59E-05
95	Surface Water	2.27E-04	5.68E-05
99	Surface Water	5.73E-04	1.43E-04
50	Total Ingestion	5.23E-04	1.30E-04
75	Total Ingestion	1.57E-03	3.92E-04
90	Total Ingestion	5.43E-03	1.36E-03
95	Total Ingestion	1.16E-02	2.89E-03
99	Total Ingestion	3.99E-02	1.00E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Beryllium

CAS: 7440-41-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	8.86E-08	4.43E-05
75	Soil	1.33E-07	6.66E-05
90	Soil	1.81E-07	9.06E-05
95	Soil	2.16E-07	1.08E-04
99	Soil	2.97E-07	1.49E-04
50	Root	1.52E-07	7.62E-05
75	Root	3.34E-07	1.67E-04
90	Root	6.69E-07	3.34E-04
95	Root	9.73E-07	4.87E-04
99	Root	1.90E-06	9.50E-04
50	Exposed Fruit	4.58E-08	2.29E-05
75	Exposed Fruit	1.03E-07	5.14E-05
90	Exposed Fruit	2.26E-07	1.13E-04
95	Exposed Fruit	3.33E-07	1.67E-04
99	Exposed Fruit	6.52E-07	3.26E-04
50	Exposed Vegetables	1.45E-07	7.25E-05
75	Exposed Vegetables	3.14E-07	1.57E-04
90	Exposed Vegetables	6.79E-07	3.40E-04
95	Exposed Vegetables	1.03E-06	5.15E-04
99	Exposed Vegetables	1.89E-06	9.46E-04
50	Protected Fruit	5.13E-08	2.57E-05
75	Protected Fruit	1.26E-07	6.28E-05
90	Protected Fruit	2.42E-07	1.21E-04
95	Protected Fruit	3.49E-07	1.75E-04
99	Protected Fruit	6.59E-07	3.30E-04
50	Protected Vegetables	2.85E-08	1.43E-05
75	Protected Vegetables	6.28E-08	3.14E-05
90	Protected Vegetables	1.27E-07	6.34E-05
95	Protected Vegetables	1.96E-07	9.78E-05
99	Protected Vegetables	4.27E-07	2.14E-04
50	Fish	2.94E-07	1.47E-04
75	Fish	1.11E-06	5.55E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Beryllium

CAS: 7440-41-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	3.31E-06	1.65E-03
95	Fish	6.93E-06	3.46E-03
99	Fish	2.08E-05	1.04E-02
50	Beef	5.22E-08	2.61E-05
75	Beef	1.07E-07	5.34E-05
90	Beef	1.91E-07	9.55E-05
95	Beef	2.67E-07	1.33E-04
99	Beef	4.66E-07	2.33E-04
50	Milk	7.38E-10	3.69E-07
75	Milk	1.52E-09	7.62E-07
90	Milk	2.59E-09	1.29E-06
95	Milk	3.39E-09	1.70E-06
99	Milk	5.68E-09	2.84E-06
75	Ground Water	3.77E-19	1.89E-16
90	Ground Water	1.92E-11	9.58E-09
95	Ground Water	1.05E-09	5.24E-07
99	Ground Water	5.77E-08	2.89E-05
50	Surface Water	4.77E-06	2.39E-03
75	Surface Water	1.18E-05	5.91E-03
90	Surface Water	2.43E-05	1.21E-02
95	Surface Water	3.77E-05	1.88E-02
99	Surface Water	7.30E-05	3.65E-02
50	Total Ingestion	6.66E-06	3.33E-03
75	Total Ingestion	1.50E-05	7.48E-03
90	Total Ingestion	2.98E-05	1.49E-02
95	Total Ingestion	4.57E-05	2.28E-02
99	Total Ingestion	8.44E-05	4.22E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Beryllium

CAS: 7440-41-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	5.78E-07	2.89E-04
75	Soil	9.37E-07	4.69E-04
90	Soil	1.38E-06	6.91E-04
95	Soil	1.66E-06	8.30E-04
99	Soil	2.22E-06	1.11E-03
50	Root	1.62E-07	8.11E-05
75	Root	3.98E-07	1.99E-04
90	Root	8.63E-07	4.32E-04
95	Root	1.47E-06	7.33E-04
99	Root	3.46E-06	1.73E-03
50	Exposed Fruit	5.64E-08	2.82E-05
75	Exposed Fruit	1.12E-07	5.58E-05
90	Exposed Fruit	1.98E-07	9.88E-05
95	Exposed Fruit	2.80E-07	1.40E-04
99	Exposed Fruit	5.61E-07	2.81E-04
50	Exposed Vegetables	1.52E-07	7.61E-05
75	Exposed Vegetables	3.27E-07	1.63E-04
90	Exposed Vegetables	6.05E-07	3.03E-04
95	Exposed Vegetables	8.68E-07	4.34E-04
99	Exposed Vegetables	1.56E-06	7.81E-04
50	Protected Fruit	9.12E-08	4.56E-05
75	Protected Fruit	2.02E-07	1.01E-04
90	Protected Fruit	3.69E-07	1.84E-04
95	Protected Fruit	4.99E-07	2.50E-04
99	Protected Fruit	8.34E-07	4.17E-04
50	Protected Vegetables	4.49E-08	2.24E-05
75	Protected Vegetables	8.27E-08	4.13E-05
90	Protected Vegetables	1.46E-07	7.28E-05
95	Protected Vegetables	2.05E-07	1.02E-04
99	Protected Vegetables	4.19E-07	2.10E-04
50	Fish	1.11E-06	5.56E-04
75	Fish	4.01E-06	2.00E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Beryllium

CAS: 7440-41-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.29E-05	6.46E-03
95	Fish	2.58E-05	1.29E-02
99	Fish	8.28E-05	4.14E-02
50	Beef	8.15E-08	4.08E-05
75	Beef	1.61E-07	8.04E-05
90	Beef	2.99E-07	1.50E-04
95	Beef	4.24E-07	2.12E-04
99	Beef	7.97E-07	3.98E-04
50	Milk	2.08E-09	1.04E-06
75	Milk	4.46E-09	2.23E-06
90	Milk	8.17E-09	4.09E-06
95	Milk	1.11E-08	5.55E-06
99	Milk	1.93E-08	9.65E-06
75	Ground Water	8.18E-19	4.09E-16
90	Ground Water	2.86E-11	1.43E-08
95	Ground Water	2.09E-09	1.05E-06
99	Ground Water	8.16E-08	4.08E-05
50	Surface Water	9.55E-06	4.78E-03
75	Surface Water	2.42E-05	1.21E-02
90	Surface Water	5.28E-05	2.64E-02
95	Surface Water	7.35E-05	3.68E-02
99	Surface Water	1.40E-04	7.00E-02
50	Total Ingestion	1.44E-05	7.19E-03
75	Total Ingestion	3.35E-05	1.68E-02
90	Total Ingestion	6.73E-05	3.36E-02
95	Total Ingestion	1.02E-04	5.12E-02
99	Total Ingestion	1.90E-04	9.51E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Biphenyl, 1,1-

CAS: 92-52-4 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	6.60E-17	1.32E-15
75	Soil	1.22E-16	2.43E-15
90	Soil	1.74E-16	3.49E-15
95	Soil	2.06E-16	4.13E-15
99	Soil	2.65E-16	5.30E-15
50	Root	1.06E-06	2.13E-05
75	Root	2.84E-06	5.68E-05
90	Root	6.82E-06	1.36E-04
95	Root	1.13E-05	2.27E-04
99	Root	3.03E-05	6.05E-04
50	Exposed Fruit	3.44E-07	6.88E-06
75	Exposed Fruit	8.22E-07	1.64E-05
90	Exposed Fruit	1.69E-06	3.38E-05
95	Exposed Fruit	2.67E-06	5.35E-05
99	Exposed Fruit	5.35E-06	1.07E-04
50	Exposed Vegetables	1.86E-07	3.73E-06
75	Exposed Vegetables	4.74E-07	9.47E-06
90	Exposed Vegetables	1.08E-06	2.16E-05
95	Exposed Vegetables	1.45E-06	2.91E-05
99	Exposed Vegetables	3.17E-06	6.34E-05
50	Protected Fruit	4.11E-07	8.22E-06
75	Protected Fruit	1.23E-06	2.45E-05
90	Protected Fruit	2.50E-06	5.01E-05
95	Protected Fruit	3.79E-06	7.58E-05
99	Protected Fruit	6.02E-06	1.20E-04
50	Protected Vegetables	2.41E-07	4.82E-06
75	Protected Vegetables	5.95E-07	1.19E-05
90	Protected Vegetables	1.33E-06	2.66E-05
95	Protected Vegetables	2.08E-06	4.17E-05
99	Protected Vegetables	4.04E-06	8.08E-05
50	Fish	9.23E-09	1.85E-07
75	Fish	5.53E-08	1.11E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Biphenyl, 1,1-

CAS: 92-52-4 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	2.21E-07	4.41E-06
95	Fish	4.43E-07	8.86E-06
99	Fish	1.48E-06	2.95E-05
50	Beef	4.15E-09	8.30E-08
75	Beef	9.17E-09	1.83E-07
90	Beef	1.81E-08	3.63E-07
95	Beef	2.50E-08	5.00E-07
99	Beef	5.41E-08	1.08E-06
50	Milk	3.10E-08	6.20E-07
75	Milk	7.04E-08	1.41E-06
90	Milk	1.30E-07	2.60E-06
95	Milk	1.71E-07	3.41E-06
99	Milk	2.47E-07	4.94E-06
50	Surface Water	2.25E-08	4.51E-07
75	Surface Water	7.66E-08	1.53E-06
90	Surface Water	2.41E-07	4.81E-06
95	Surface Water	1.14E-06	2.29E-05
99	Surface Water	2.16E-05	4.32E-04
50	Total Ingestion	4.14E-06	8.28E-05
75	Total Ingestion	7.58E-06	1.52E-04
90	Total Ingestion	1.32E-05	2.64E-04
95	Total Ingestion	1.91E-05	3.82E-04
99	Total Ingestion	4.12E-05	8.25E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Biphenyl, 1,1-

CAS: 92-52-4 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	7.06E-16	1.41E-14
75	Soil	1.12E-15	2.23E-14
90	Soil	1.50E-15	3.00E-14
95	Soil	1.76E-15	3.52E-14
99	Soil	2.25E-15	4.51E-14
50	Root	1.60E-06	3.21E-05
75	Root	4.70E-06	9.40E-05
90	Root	1.17E-05	2.34E-04
95	Root	2.04E-05	4.09E-04
99	Root	5.46E-05	1.09E-03
50	Exposed Fruit	6.03E-07	1.21E-05
75	Exposed Fruit	1.14E-06	2.29E-05
90	Exposed Fruit	1.93E-06	3.86E-05
95	Exposed Fruit	2.55E-06	5.11E-05
99	Exposed Fruit	4.08E-06	8.16E-05
50	Exposed Vegetables	2.96E-07	5.91E-06
75	Exposed Vegetables	6.62E-07	1.32E-05
90	Exposed Vegetables	1.21E-06	2.43E-05
95	Exposed Vegetables	1.67E-06	3.33E-05
99	Exposed Vegetables	2.67E-06	5.34E-05
50	Protected Fruit	1.26E-06	2.52E-05
75	Protected Fruit	2.79E-06	5.59E-05
90	Protected Fruit	5.14E-06	1.03E-04
95	Protected Fruit	7.11E-06	1.42E-04
99	Protected Fruit	1.03E-05	2.06E-04
50	Protected Vegetables	6.22E-07	1.24E-05
75	Protected Vegetables	1.10E-06	2.20E-05
90	Protected Vegetables	1.88E-06	3.76E-05
95	Protected Vegetables	2.54E-06	5.07E-05
99	Protected Vegetables	5.05E-06	1.01E-04
50	Fish	5.87E-08	1.17E-06
75	Fish	3.28E-07	6.56E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Biphenyl, 1,1-

CAS: 92-52-4 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.13E-06	2.26E-05
95	Fish	2.15E-06	4.30E-05
99	Fish	7.40E-06	1.48E-04
50	Beef	8.93E-09	1.79E-07
75	Beef	1.75E-08	3.50E-07
90	Beef	3.22E-08	6.43E-07
95	Beef	4.59E-08	9.18E-07
99	Beef	9.20E-08	1.84E-06
50	Milk	1.32E-07	2.64E-06
75	Milk	2.93E-07	5.86E-06
90	Milk	5.01E-07	1.00E-05
95	Milk	6.74E-07	1.35E-05
99	Milk	1.13E-06	2.27E-05
50	Surface Water	6.94E-08	1.39E-06
75	Surface Water	2.04E-07	4.08E-06
90	Surface Water	6.33E-07	1.27E-05
95	Surface Water	2.91E-06	5.82E-05
99	Surface Water	5.07E-05	1.01E-03
50	Total Ingestion	7.38E-06	1.48E-04
75	Total Ingestion	1.28E-05	2.56E-04
90	Total Ingestion	2.27E-05	4.55E-04
95	Total Ingestion	3.61E-05	7.21E-04
99	Total Ingestion	8.78E-05	1.76E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Butyl Benzyl Phthalate

CAS: 85-68-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	6.71E-17	3.36E-16
75	Soil	1.25E-16	6.28E-16
90	Soil	1.76E-16	8.82E-16
95	Soil	2.05E-16	1.03E-15
99	Soil	2.66E-16	1.33E-15
50	Root	1.28E-06	6.42E-06
75	Root	3.42E-06	1.72E-05
90	Root	8.26E-06	4.11E-05
95	Root	1.37E-05	6.84E-05
99	Root	3.65E-05	1.83E-04
50	Exposed Fruit	1.09E-07	5.43E-07
75	Exposed Fruit	2.59E-07	1.30E-06
90	Exposed Fruit	5.36E-07	2.67E-06
95	Exposed Fruit	8.42E-07	4.21E-06
99	Exposed Fruit	1.70E-06	8.49E-06
50	Exposed Vegetables	5.89E-08	2.94E-07
75	Exposed Vegetables	1.51E-07	7.57E-07
90	Exposed Vegetables	3.39E-07	1.69E-06
95	Exposed Vegetables	4.57E-07	2.29E-06
99	Exposed Vegetables	9.71E-07	4.84E-06
50	Protected Fruit	1.26E-07	6.28E-07
75	Protected Fruit	3.75E-07	1.88E-06
90	Protected Fruit	7.67E-07	3.85E-06
95	Protected Fruit	1.16E-06	5.79E-06
99	Protected Fruit	1.84E-06	9.21E-06
50	Protected Vegetables	7.37E-08	3.68E-07
75	Protected Vegetables	1.82E-07	9.11E-07
90	Protected Vegetables	4.08E-07	2.03E-06
95	Protected Vegetables	6.38E-07	3.19E-06
99	Protected Vegetables	1.24E-06	6.19E-06
50	Fish	1.18E-08	5.89E-08
75	Fish	6.97E-08	3.49E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Butyl Benzyl Phthalate

CAS: 85-68-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	2.71E-07	1.35E-06
95	Fish	5.72E-07	2.87E-06
99	Fish	1.87E-06	9.38E-06
50	Beef	1.42E-08	7.14E-08
75	Beef	3.14E-08	1.57E-07
90	Beef	5.89E-08	2.94E-07
95	Beef	8.36E-08	4.18E-07
99	Beef	1.61E-07	8.06E-07
50	Milk	9.05E-08	4.54E-07
75	Milk	2.03E-07	1.02E-06
90	Milk	3.68E-07	1.84E-06
95	Milk	4.90E-07	2.45E-06
99	Milk	7.04E-07	3.52E-06
50	Surface Water	8.49E-08	4.24E-07
75	Surface Water	2.79E-07	1.39E-06
90	Surface Water	8.23E-07	4.11E-06
95	Surface Water	1.34E-06	6.68E-06
99	Surface Water	3.36E-06	1.68E-05
50	Total Ingestion	2.83E-06	1.41E-05
75	Total Ingestion	5.43E-06	2.72E-05
90	Total Ingestion	1.04E-05	5.17E-05
95	Total Ingestion	1.61E-05	8.03E-05
99	Total Ingestion	3.82E-05	1.91E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Butyl Benzyl Phthalate

CAS: 85-68-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	7.17E-16	3.59E-15
75	Soil	1.15E-15	5.76E-15
90	Soil	1.53E-15	7.63E-15
95	Soil	1.77E-15	8.85E-15
99	Soil	2.22E-15	1.11E-14
50	Root	1.94E-06	9.67E-06
75	Root	5.69E-06	2.84E-05
90	Root	1.41E-05	7.07E-05
95	Root	2.47E-05	1.23E-04
99	Root	6.58E-05	3.29E-04
50	Exposed Fruit	1.94E-07	9.71E-07
75	Exposed Fruit	3.62E-07	1.80E-06
90	Exposed Fruit	6.09E-07	3.04E-06
95	Exposed Fruit	8.09E-07	4.05E-06
99	Exposed Fruit	1.28E-06	6.42E-06
50	Exposed Vegetables	9.31E-08	4.64E-07
75	Exposed Vegetables	2.13E-07	1.06E-06
90	Exposed Vegetables	3.82E-07	1.91E-06
95	Exposed Vegetables	5.33E-07	2.66E-06
99	Exposed Vegetables	8.62E-07	4.31E-06
50	Protected Fruit	3.85E-07	1.93E-06
75	Protected Fruit	8.55E-07	4.28E-06
90	Protected Fruit	1.58E-06	7.86E-06
95	Protected Fruit	2.18E-06	1.09E-05
99	Protected Fruit	3.16E-06	1.58E-05
50	Protected Vegetables	1.90E-07	9.54E-07
75	Protected Vegetables	3.36E-07	1.68E-06
90	Protected Vegetables	5.76E-07	2.88E-06
95	Protected Vegetables	7.76E-07	3.88E-06
99	Protected Vegetables	1.55E-06	7.73E-06
50	Fish	7.70E-08	3.85E-07
75	Fish	4.05E-07	2.03E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Butyl Benzyl Phthalate

CAS: 85-68-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.36E-06	6.81E-06
95	Fish	2.65E-06	1.33E-05
99	Fish	9.05E-06	4.54E-05
50	Beef	3.05E-08	1.53E-07
75	Beef	5.92E-08	2.96E-07
90	Beef	1.10E-07	5.53E-07
95	Beef	1.56E-07	7.83E-07
99	Beef	2.85E-07	1.42E-06
50	Milk	3.85E-07	1.92E-06
75	Milk	8.49E-07	4.24E-06
90	Milk	1.43E-06	7.17E-06
95	Milk	1.93E-06	9.67E-06
99	Milk	3.29E-06	1.65E-05
50	Surface Water	2.44E-07	1.22E-06
75	Surface Water	7.30E-07	3.65E-06
90	Surface Water	2.00E-06	1.00E-05
95	Surface Water	3.52E-06	1.77E-05
99	Surface Water	7.83E-06	3.92E-05
50	Total Ingestion	5.46E-06	2.73E-05
75	Total Ingestion	1.03E-05	5.13E-05
90	Total Ingestion	1.97E-05	9.87E-05
95	Total Ingestion	3.01E-05	1.50E-04
99	Total Ingestion	7.07E-05	3.52E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Carbon Disulfide

CAS: 75-15-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	5.45E-23	5.45E-22
75	Soil	8.29E-17	8.29E-16
90	Soil	6.76E-15	6.76E-14
95	Soil	3.16E-14	3.16E-13
99	Soil	2.46E-13	2.46E-12
50	Root	7.29E-08	7.29E-07
75	Root	4.38E-07	4.38E-06
90	Root	1.55E-06	1.55E-05
95	Root	3.16E-06	3.16E-05
99	Root	1.26E-05	1.26E-04
50	Exposed Fruit	1.75E-07	1.75E-06
75	Exposed Fruit	5.26E-07	5.26E-06
90	Exposed Fruit	1.32E-06	1.32E-05
95	Exposed Fruit	2.31E-06	2.31E-05
99	Exposed Fruit	5.23E-06	5.23E-05
50	Exposed Vegetables	1.02E-07	1.02E-06
75	Exposed Vegetables	2.96E-07	2.96E-06
90	Exposed Vegetables	7.20E-07	7.20E-06
95	Exposed Vegetables	1.27E-06	1.27E-05
99	Exposed Vegetables	2.73E-06	2.73E-05
50	Protected Fruit	6.73E-08	6.73E-07
75	Protected Fruit	4.51E-07	4.51E-06
90	Protected Fruit	1.36E-06	1.36E-05
95	Protected Fruit	2.21E-06	2.21E-05
99	Protected Fruit	5.29E-06	5.29E-05
50	Protected Vegetables	4.51E-08	4.51E-07
75	Protected Vegetables	2.44E-07	2.44E-06
90	Protected Vegetables	7.14E-07	7.14E-06
95	Protected Vegetables	1.23E-06	1.23E-05
99	Protected Vegetables	3.41E-06	3.41E-05
50	Fish	3.38E-11	3.38E-10
75	Fish	1.53E-10	1.53E-09

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Carbon Disulfide

CAS: 75-15-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	4.88E-10	4.88E-09
95	Fish	1.05E-09	1.05E-08
99	Fish	3.54E-09	3.54E-08
50	Beef	4.44E-11	4.44E-10
75	Beef	1.05E-10	1.05E-09
90	Beef	2.13E-10	2.13E-09
95	Beef	3.19E-10	3.19E-09
99	Beef	6.57E-10	6.57E-09
50	Milk	1.43E-09	1.43E-08
75	Milk	3.47E-09	3.47E-08
90	Milk	7.61E-09	7.61E-08
95	Milk	1.20E-08	1.20E-07
99	Milk	2.05E-08	2.05E-07
50	Ground Water	1.74E-13	1.74E-12
75	Ground Water	2.58E-11	2.58E-10
90	Ground Water	2.58E-10	2.58E-09
95	Ground Water	7.95E-10	7.95E-09
99	Ground Water	3.98E-09	3.98E-08
50	Surface Water	2.31E-06	2.31E-05
75	Surface Water	5.29E-06	5.29E-05
90	Surface Water	9.92E-06	9.92E-05
95	Surface Water	1.46E-05	1.46E-04
99	Surface Water	2.68E-05	2.68E-04
50	Total Ingestion	4.41E-06	4.41E-05
75	Total Ingestion	8.36E-06	8.36E-05
90	Total Ingestion	1.43E-05	1.43E-04
95	Total Ingestion	1.99E-05	1.99E-04
99	Total Ingestion	3.26E-05	3.26E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Carbon Disulfide

CAS: 75-15-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.06E-22	2.06E-21
75	Soil	6.20E-16	6.20E-15
90	Soil	5.01E-14	5.01E-13
95	Soil	2.91E-13	2.91E-12
99	Soil	2.10E-12	2.10E-11
50	Root	1.10E-07	1.10E-06
75	Root	6.39E-07	6.39E-06
90	Root	2.46E-06	2.46E-05
95	Root	5.35E-06	5.35E-05
99	Root	1.91E-05	1.91E-04
50	Exposed Fruit	3.10E-07	3.10E-06
75	Exposed Fruit	8.26E-07	8.26E-06
90	Exposed Fruit	1.63E-06	1.63E-05
95	Exposed Fruit	2.43E-06	2.43E-05
99	Exposed Fruit	4.41E-06	4.41E-05
50	Exposed Vegetables	1.57E-07	1.57E-06
75	Exposed Vegetables	4.29E-07	4.29E-06
90	Exposed Vegetables	9.89E-07	9.89E-06
95	Exposed Vegetables	1.56E-06	1.56E-05
99	Exposed Vegetables	2.78E-06	2.78E-05
50	Protected Fruit	2.27E-07	2.27E-06
75	Protected Fruit	1.21E-06	1.21E-05
90	Protected Fruit	3.02E-06	3.02E-05
95	Protected Fruit	4.85E-06	4.85E-05
99	Protected Fruit	1.08E-05	1.08E-04
50	Protected Vegetables	1.40E-07	1.40E-06
75	Protected Vegetables	5.70E-07	5.70E-06
90	Protected Vegetables	1.25E-06	1.25E-05
95	Protected Vegetables	1.88E-06	1.88E-05
99	Protected Vegetables	3.76E-06	3.76E-05
50	Fish	2.05E-10	2.05E-09
75	Fish	8.42E-10	8.42E-09

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Carbon Disulfide

CAS: 75-15-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	2.55E-09	2.55E-08
95	Fish	5.01E-09	5.01E-08
99	Fish	1.88E-08	1.88E-07
50	Beef	9.77E-11	9.77E-10
75	Beef	2.03E-10	2.03E-09
90	Beef	4.10E-10	4.10E-09
95	Beef	6.20E-10	6.20E-09
99	Beef	1.20E-09	1.20E-08
50	Milk	6.04E-09	6.04E-08
75	Milk	1.51E-08	1.51E-07
90	Milk	3.10E-08	3.10E-07
95	Milk	4.60E-08	4.60E-07
99	Milk	8.83E-08	8.83E-07
50	Ground Water	6.76E-13	6.76E-12
75	Ground Water	7.64E-11	7.64E-10
90	Ground Water	7.51E-10	7.51E-09
95	Ground Water	2.36E-09	2.36E-08
99	Ground Water	8.36E-09	8.36E-08
50	Surface Water	6.42E-06	6.42E-05
75	Surface Water	1.33E-05	1.33E-04
90	Surface Water	2.45E-05	2.45E-04
95	Surface Water	3.44E-05	3.44E-04
99	Surface Water	6.70E-05	6.70E-04
50	Total Ingestion	9.89E-06	9.89E-05
75	Total Ingestion	1.86E-05	1.86E-04
90	Total Ingestion	2.93E-05	2.93E-04
95	Total Ingestion	4.13E-05	4.13E-04
99	Total Ingestion	7.76E-05	7.76E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chloroaniline, 4-

CAS: 106-47-8 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.05E-09	2.64E-07
75	Soil	2.63E-09	6.57E-07
90	Soil	4.66E-09	1.17E-06
95	Soil	6.15E-09	1.54E-06
99	Soil	1.04E-08	2.60E-06
50	Root	5.74E-06	1.44E-03
75	Root	1.55E-05	3.87E-03
90	Root	3.85E-05	9.62E-03
95	Root	6.83E-05	1.71E-02
99	Root	2.00E-04	5.00E-02
50	Exposed Fruit	5.62E-06	1.40E-03
75	Exposed Fruit	1.51E-05	3.78E-03
90	Exposed Fruit	3.28E-05	8.20E-03
95	Exposed Fruit	5.24E-05	1.31E-02
99	Exposed Fruit	1.22E-04	3.06E-02
50	Exposed Vegetables	3.28E-06	8.19E-04
75	Exposed Vegetables	8.73E-06	2.18E-03
90	Exposed Vegetables	1.99E-05	4.98E-03
95	Exposed Vegetables	2.93E-05	7.33E-03
99	Exposed Vegetables	6.18E-05	1.54E-02
50	Protected Fruit	6.94E-06	1.74E-03
75	Protected Fruit	2.18E-05	5.45E-03
90	Protected Fruit	4.85E-05	1.21E-02
95	Protected Fruit	7.33E-05	1.83E-02
99	Protected Fruit	1.37E-04	3.43E-02
50	Protected Vegetables	4.21E-06	1.05E-03
75	Protected Vegetables	1.14E-05	2.86E-03
90	Protected Vegetables	2.57E-05	6.43E-03
95	Protected Vegetables	4.05E-05	1.01E-02
99	Protected Vegetables	8.92E-05	2.23E-02
50	Fish	9.35E-08	2.34E-05
75	Fish	3.42E-07	8.55E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chloroaniline, 4-

CAS: 106-47-8 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.03E-06	2.58E-04
95	Fish	1.89E-06	4.73E-04
99	Fish	6.39E-06	1.60E-03
50	Beef	4.91E-10	1.23E-07
75	Beef	1.12E-09	2.79E-07
90	Beef	2.19E-09	5.46E-07
95	Beef	3.24E-09	8.09E-07
99	Beef	6.46E-09	1.61E-06
50	Milk	3.50E-08	8.75E-06
75	Milk	8.24E-08	2.06E-05
90	Milk	1.61E-07	4.02E-05
95	Milk	2.25E-07	5.63E-05
99	Milk	3.52E-07	8.79E-05
50	Ground Water	4.00E-08	9.99E-06
75	Ground Water	4.44E-07	1.11E-04
90	Ground Water	3.34E-06	8.35E-04
95	Ground Water	9.71E-06	2.43E-03
99	Ground Water	3.50E-05	8.75E-03
50	Surface Water	7.60E-06	1.90E-03
75	Surface Water	1.55E-05	3.86E-03
90	Surface Water	2.81E-05	7.04E-03
95	Surface Water	3.86E-05	9.65E-03
99	Surface Water	7.64E-05	1.91E-02
50	Total Ingestion	6.04E-05	1.51E-02
75	Total Ingestion	1.08E-04	2.71E-02
90	Total Ingestion	1.71E-04	4.28E-02
95	Total Ingestion	2.31E-04	5.78E-02
99	Total Ingestion	3.69E-04	9.22E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chloroaniline, 4-

CAS: 106-47-8 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.18E-08	2.95E-06
75	Soil	2.52E-08	6.30E-06
90	Soil	4.27E-08	1.07E-05
95	Soil	5.52E-08	1.38E-05
99	Soil	1.01E-07	2.54E-05
50	Root	8.85E-06	2.21E-03
75	Root	2.59E-05	6.46E-03
90	Root	6.56E-05	1.64E-02
95	Root	1.24E-04	3.09E-02
99	Root	3.38E-04	8.44E-02
50	Exposed Fruit	1.06E-05	2.64E-03
75	Exposed Fruit	2.12E-05	5.30E-03
90	Exposed Fruit	3.84E-05	9.59E-03
95	Exposed Fruit	5.35E-05	1.34E-02
99	Exposed Fruit	9.04E-05	2.26E-02
50	Exposed Vegetables	5.20E-06	1.30E-03
75	Exposed Vegetables	1.23E-05	3.07E-03
90	Exposed Vegetables	2.36E-05	5.91E-03
95	Exposed Vegetables	3.32E-05	8.30E-03
99	Exposed Vegetables	5.64E-05	1.41E-02
50	Protected Fruit	2.20E-05	5.50E-03
75	Protected Fruit	5.21E-05	1.30E-02
90	Protected Fruit	9.79E-05	2.45E-02
95	Protected Fruit	1.39E-04	3.46E-02
99	Protected Fruit	2.59E-04	6.48E-02
50	Protected Vegetables	1.08E-05	2.70E-03
75	Protected Vegetables	2.12E-05	5.29E-03
90	Protected Vegetables	3.78E-05	9.45E-03
95	Protected Vegetables	5.15E-05	1.29E-02
99	Protected Vegetables	1.01E-04	2.53E-02
50	Fish	5.12E-07	1.28E-04
75	Fish	1.78E-06	4.46E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chloroaniline, 4-

CAS: 106-47-8 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	5.11E-06	1.28E-03
95	Fish	9.33E-06	2.33E-03
99	Fish	2.99E-05	7.47E-03
50	Beef	1.05E-09	2.63E-07
75	Beef	2.07E-09	5.19E-07
90	Beef	4.12E-09	1.03E-06
95	Beef	6.01E-09	1.50E-06
99	Beef	1.18E-08	2.95E-06
50	Milk	1.44E-07	3.61E-05
75	Milk	3.40E-07	8.50E-05
90	Milk	6.45E-07	1.61E-04
95	Milk	9.05E-07	2.26E-04
99	Milk	1.57E-06	3.92E-04
50	Ground Water	1.11E-07	2.76E-05
75	Ground Water	1.37E-06	3.42E-04
90	Ground Water	1.01E-05	2.53E-03
95	Ground Water	2.59E-05	6.48E-03
99	Ground Water	7.52E-05	1.88E-02
50	Surface Water	2.06E-05	5.15E-03
75	Surface Water	3.97E-05	9.92E-03
90	Surface Water	7.03E-05	1.76E-02
95	Surface Water	9.71E-05	2.43E-02
99	Surface Water	1.76E-04	4.40E-02
50	Total Ingestion	1.19E-04	2.96E-02
75	Total Ingestion	1.92E-04	4.79E-02
90	Total Ingestion	2.82E-04	7.04E-02
95	Total Ingestion	3.58E-04	8.96E-02
99	Total Ingestion	6.15E-04	1.54E-01

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorobenzene

CAS: 108-90-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.84E-11	9.20E-10
75	Soil	5.20E-11	2.60E-09
90	Soil	1.10E-10	5.51E-09
95	Soil	1.60E-10	7.98E-09
99	Soil	2.95E-10	1.47E-08
50	Root	1.43E-07	7.17E-06
75	Root	3.85E-07	1.93E-05
90	Root	9.11E-07	4.54E-05
95	Root	1.58E-06	7.89E-05
99	Root	4.69E-06	2.34E-04
50	Exposed Fruit	1.76E-07	8.80E-06
75	Exposed Fruit	4.32E-07	2.16E-05
90	Exposed Fruit	9.45E-07	4.73E-05
95	Exposed Fruit	1.52E-06	7.61E-05
99	Exposed Fruit	3.16E-06	1.58E-04
50	Exposed Vegetables	1.02E-07	5.10E-06
75	Exposed Vegetables	2.50E-07	1.25E-05
90	Exposed Vegetables	5.73E-07	2.86E-05
95	Exposed Vegetables	8.23E-07	4.13E-05
99	Exposed Vegetables	1.71E-06	8.54E-05
50	Protected Fruit	1.40E-07	7.01E-06
75	Protected Fruit	4.54E-07	2.27E-05
90	Protected Fruit	1.02E-06	5.07E-05
95	Protected Fruit	1.57E-06	7.86E-05
99	Protected Fruit	2.68E-06	1.34E-04
50	Protected Vegetables	8.45E-08	4.23E-06
75	Protected Vegetables	2.27E-07	1.13E-05
90	Protected Vegetables	5.29E-07	2.65E-05
95	Protected Vegetables	8.54E-07	4.26E-05
99	Protected Vegetables	1.76E-06	8.83E-05
50	Fish	9.48E-10	4.73E-08
75	Fish	4.23E-09	2.12E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorobenzene

CAS: 108-90-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.49E-08	7.45E-07
95	Fish	2.99E-08	1.49E-06
99	Fish	1.03E-07	5.13E-06
50	Beef	2.61E-10	1.31E-08
75	Beef	5.79E-10	2.90E-08
90	Beef	1.11E-09	5.54E-08
95	Beef	1.53E-09	7.67E-08
99	Beef	3.05E-09	1.53E-07
50	Milk	1.47E-09	7.36E-08
75	Milk	3.35E-09	1.67E-07
90	Milk	6.07E-09	3.04E-07
95	Milk	8.20E-09	4.10E-07
99	Milk	1.23E-08	6.17E-07
50	Ground Water	1.82E-08	9.14E-07
75	Ground Water	9.58E-08	4.79E-06
90	Ground Water	2.31E-07	1.16E-05
95	Ground Water	3.63E-07	1.82E-05
99	Ground Water	7.17E-07	3.60E-05
50	Surface Water	1.60E-06	8.01E-05
75	Surface Water	3.60E-06	1.79E-04
90	Surface Water	7.17E-06	3.57E-04
95	Surface Water	1.04E-05	5.20E-04
99	Surface Water	2.02E-05	1.01E-03
50	Total Ingestion	3.32E-06	1.66E-04
75	Total Ingestion	5.82E-06	2.91E-04
90	Total Ingestion	9.58E-06	4.79E-04
95	Total Ingestion	1.31E-05	6.54E-04
99	Total Ingestion	2.34E-05	1.17E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorobenzene

CAS: 108-90-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.04E-10	1.02E-08
75	Soil	5.26E-10	2.62E-08
90	Soil	1.02E-09	5.10E-08
95	Soil	1.48E-09	7.39E-08
99	Soil	2.59E-09	1.30E-07
50	Root	2.11E-07	1.06E-05
75	Root	6.57E-07	3.29E-05
90	Root	1.62E-06	8.14E-05
95	Root	2.76E-06	1.38E-04
99	Root	7.64E-06	3.82E-04
50	Exposed Fruit	3.22E-07	1.61E-05
75	Exposed Fruit	6.23E-07	3.11E-05
90	Exposed Fruit	1.05E-06	5.29E-05
95	Exposed Fruit	1.45E-06	7.26E-05
99	Exposed Fruit	2.37E-06	1.18E-04
50	Exposed Vegetables	1.59E-07	7.95E-06
75	Exposed Vegetables	3.57E-07	1.79E-05
90	Exposed Vegetables	6.64E-07	3.32E-05
95	Exposed Vegetables	9.23E-07	4.63E-05
99	Exposed Vegetables	1.54E-06	7.70E-05
50	Protected Fruit	4.51E-07	2.25E-05
75	Protected Fruit	1.09E-06	5.41E-05
90	Protected Fruit	2.08E-06	1.04E-04
95	Protected Fruit	2.98E-06	1.49E-04
99	Protected Fruit	4.57E-06	2.28E-04
50	Protected Vegetables	2.33E-07	1.16E-05
75	Protected Vegetables	4.32E-07	2.16E-05
90	Protected Vegetables	7.67E-07	3.85E-05
95	Protected Vegetables	1.07E-06	5.35E-05
99	Protected Vegetables	2.18E-06	1.09E-04
50	Fish	5.32E-09	2.66E-07
75	Fish	2.19E-08	1.09E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorobenzene

CAS: 108-90-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	7.29E-08	3.63E-06
95	Fish	1.38E-07	6.92E-06
99	Fish	5.20E-07	2.60E-05
50	Beef	5.51E-10	2.75E-08
75	Beef	1.09E-09	5.41E-08
90	Beef	2.04E-09	1.02E-07
95	Beef	2.84E-09	1.42E-07
99	Beef	5.51E-09	2.76E-07
50	Milk	6.20E-09	3.10E-07
75	Milk	1.39E-08	6.95E-07
90	Milk	2.41E-08	1.20E-06
95	Milk	3.22E-08	1.61E-06
99	Milk	5.54E-08	2.78E-06
50	Ground Water	5.85E-08	2.92E-06
75	Ground Water	2.71E-07	1.36E-05
90	Ground Water	5.98E-07	2.99E-05
95	Ground Water	9.01E-07	4.51E-05
99	Ground Water	1.80E-06	8.98E-05
50	Surface Water	4.41E-06	2.21E-04
75	Surface Water	9.23E-06	4.63E-04
90	Surface Water	1.72E-05	8.61E-04
95	Surface Water	2.51E-05	1.25E-03
99	Surface Water	5.04E-05	2.51E-03
50	Total Ingestion	7.17E-06	3.60E-04
75	Total Ingestion	1.25E-05	6.26E-04
90	Total Ingestion	2.04E-05	1.02E-03
95	Total Ingestion	2.85E-05	1.42E-03
99	Total Ingestion	5.54E-05	2.76E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorobenzilate

CAS: 510-15-6 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	4.12E-13	2.06E-11
75	Soil	7.49E-13	3.74E-11
90	Soil	1.04E-12	5.20E-11
95	Soil	1.24E-12	6.20E-11
99	Soil	1.56E-12	7.77E-11
50	Root	2.65E-09	1.32E-07
75	Root	7.09E-09	3.55E-07
90	Root	1.70E-08	8.52E-07
95	Root	2.83E-08	1.41E-06
99	Root	7.54E-08	3.77E-06
50	Exposed Fruit	5.60E-10	2.80E-08
75	Exposed Fruit	1.33E-09	6.65E-08
90	Exposed Fruit	2.76E-09	1.38E-07
95	Exposed Fruit	4.37E-09	2.19E-07
99	Exposed Fruit	8.79E-09	4.40E-07
50	Exposed Vegetables	3.05E-10	1.52E-08
75	Exposed Vegetables	7.65E-10	3.82E-08
90	Exposed Vegetables	1.75E-09	8.77E-08
95	Exposed Vegetables	2.36E-09	1.18E-07
99	Exposed Vegetables	5.06E-09	2.52E-07
50	Protected Fruit	6.75E-10	3.37E-08
75	Protected Fruit	2.01E-09	1.01E-07
90	Protected Fruit	4.11E-09	2.06E-07
95	Protected Fruit	6.22E-09	3.11E-07
99	Protected Fruit	9.86E-09	4.94E-07
50	Protected Vegetables	3.96E-10	1.98E-08
75	Protected Vegetables	9.77E-10	4.88E-08
90	Protected Vegetables	2.18E-09	1.09E-07
95	Protected Vegetables	3.42E-09	1.71E-07
99	Protected Vegetables	6.63E-09	3.32E-07
50	Fish	2.81E-10	1.40E-08
75	Fish	1.19E-09	5.94E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorobenzilate

CAS: 510-15-6 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	3.89E-09	1.94E-07
95	Fish	6.84E-09	3.41E-07
99	Fish	2.29E-08	1.14E-06
50	Beef	2.01E-11	1.01E-09
75	Beef	4.45E-11	2.22E-09
90	Beef	8.56E-11	4.27E-09
95	Beef	1.17E-10	5.83E-09
99	Beef	2.32E-10	1.16E-08
50	Milk	1.43E-10	7.16E-09
75	Milk	3.23E-10	1.61E-08
90	Milk	5.80E-10	2.90E-08
95	Milk	7.81E-10	3.91E-08
99	Milk	1.10E-09	5.52E-08
50	Surface Water	3.93E-10	1.96E-08
75	Surface Water	8.93E-10	4.46E-08
90	Surface Water	1.59E-09	7.94E-08
95	Surface Water	2.26E-09	1.13E-07
99	Surface Water	3.96E-09	1.97E-07
50	Total Ingestion	9.51E-09	4.75E-07
75	Total Ingestion	1.73E-08	8.65E-07
90	Total Ingestion	2.92E-08	1.46E-06
95	Total Ingestion	4.09E-08	2.04E-06
99	Total Ingestion	9.00E-08	4.50E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorobenzilate

CAS: 510-15-6 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	4.41E-12	2.20E-10
75	Soil	6.84E-12	3.42E-10
90	Soil	9.14E-12	4.56E-10
95	Soil	1.05E-11	5.26E-10
99	Soil	1.32E-11	6.60E-10
50	Root	4.00E-09	2.00E-07
75	Root	1.17E-08	5.87E-07
90	Root	2.92E-08	1.46E-06
95	Root	5.10E-08	2.55E-06
99	Root	1.36E-07	6.81E-06
50	Exposed Fruit	9.77E-10	4.90E-08
75	Exposed Fruit	1.86E-09	9.29E-08
90	Exposed Fruit	3.08E-09	1.54E-07
95	Exposed Fruit	4.14E-09	2.07E-07
99	Exposed Fruit	6.58E-09	3.29E-07
50	Exposed Vegetables	4.81E-10	2.41E-08
75	Exposed Vegetables	1.06E-09	5.34E-08
90	Exposed Vegetables	1.97E-09	9.86E-08
95	Exposed Vegetables	2.66E-09	1.33E-07
99	Exposed Vegetables	4.32E-09	2.17E-07
50	Protected Fruit	2.07E-09	1.03E-07
75	Protected Fruit	4.59E-09	2.29E-07
90	Protected Fruit	8.44E-09	4.23E-07
95	Protected Fruit	1.17E-08	5.84E-07
99	Protected Fruit	1.69E-08	8.47E-07
50	Protected Vegetables	1.03E-09	5.11E-08
75	Protected Vegetables	1.81E-09	9.02E-08
90	Protected Vegetables	3.08E-09	1.55E-07
95	Protected Vegetables	4.16E-09	2.08E-07
99	Protected Vegetables	8.30E-09	4.15E-07
50	Fish	1.58E-09	7.89E-08
75	Fish	6.30E-09	3.14E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorobenzilate

CAS: 510-15-6 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.91E-08	9.58E-07
95	Fish	3.48E-08	1.74E-06
99	Fish	1.14E-07	5.71E-06
50	Beef	4.34E-11	2.17E-09
75	Beef	8.35E-11	4.17E-09
90	Beef	1.56E-10	7.77E-09
95	Beef	2.16E-10	1.07E-08
99	Beef	4.06E-10	2.03E-08
50	Milk	6.02E-10	3.02E-08
75	Milk	1.33E-09	6.66E-08
90	Milk	2.27E-09	1.13E-07
95	Milk	3.06E-09	1.53E-07
99	Milk	5.32E-09	2.66E-07
50	Surface Water	1.10E-09	5.51E-08
75	Surface Water	2.28E-09	1.14E-07
90	Surface Water	3.95E-09	1.97E-07
95	Surface Water	5.44E-09	2.72E-07
99	Surface Water	9.96E-09	4.96E-07
50	Total Ingestion	1.98E-08	9.86E-07
75	Total Ingestion	3.48E-08	1.74E-06
90	Total Ingestion	6.32E-08	3.16E-06
95	Total Ingestion	9.31E-08	4.65E-06
99	Total Ingestion	2.04E-07	1.03E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorpyrifos

CAS: 2921-88-2 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	7.64E-13	2.55E-08
75	Soil	1.42E-12	4.73E-08
90	Soil	2.02E-12	6.73E-08
95	Soil	2.37E-12	7.89E-08
99	Soil	3.01E-12	1.00E-07
50	Root	3.52E-09	1.17E-04
75	Root	9.41E-09	3.14E-04
90	Root	2.26E-08	7.53E-04
95	Root	3.75E-08	1.25E-03
99	Root	1.00E-07	3.33E-03
50	Exposed Fruit	6.55E-10	2.18E-05
75	Exposed Fruit	1.57E-09	5.23E-05
90	Exposed Fruit	3.22E-09	1.07E-04
95	Exposed Fruit	5.08E-09	1.69E-04
99	Exposed Fruit	1.02E-08	3.40E-04
50	Exposed Vegetables	3.53E-10	1.18E-05
75	Exposed Vegetables	9.16E-10	3.05E-05
90	Exposed Vegetables	2.03E-09	6.77E-05
95	Exposed Vegetables	2.77E-09	9.23E-05
99	Exposed Vegetables	5.77E-09	1.92E-04
50	Protected Fruit	7.41E-10	2.47E-05
75	Protected Fruit	2.21E-09	7.37E-05
90	Protected Fruit	4.52E-09	1.51E-04
95	Protected Fruit	6.84E-09	2.28E-04
99	Protected Fruit	1.09E-08	3.62E-04
50	Protected Vegetables	4.35E-10	1.45E-05
75	Protected Vegetables	1.08E-09	3.58E-05
90	Protected Vegetables	2.40E-09	7.99E-05
95	Protected Vegetables	3.76E-09	1.25E-04
99	Protected Vegetables	7.29E-09	2.43E-04
50	Fish	1.04E-09	3.46E-05
75	Fish	4.31E-09	1.44E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorpyrifos

CAS: 2921-88-2 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.37E-08	4.58E-04
95	Fish	2.50E-08	8.34E-04
99	Fish	8.23E-08	2.74E-03
50	Beef	6.03E-11	2.01E-06
75	Beef	1.34E-10	4.46E-06
90	Beef	2.52E-10	8.39E-06
95	Beef	3.55E-10	1.18E-05
99	Beef	6.91E-10	2.30E-05
50	Milk	3.83E-10	1.28E-05
75	Milk	8.61E-10	2.87E-05
90	Milk	1.55E-09	5.16E-05
95	Milk	2.09E-09	6.95E-05
99	Milk	3.02E-09	1.01E-04
50	Surface Water	1.26E-09	4.19E-05
75	Surface Water	3.20E-09	1.07E-04
90	Surface Water	7.23E-09	2.41E-04
95	Surface Water	1.12E-08	3.75E-04
99	Surface Water	2.80E-08	9.33E-04
50	Total Ingestion	1.58E-08	5.25E-04
75	Total Ingestion	2.94E-08	9.81E-04
90	Total Ingestion	5.04E-08	1.68E-03
95	Total Ingestion	7.52E-08	2.51E-03
99	Total Ingestion	1.49E-07	4.97E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorpyrifos

CAS: 2921-88-2 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	8.25E-12	2.75E-07
75	Soil	1.31E-11	4.38E-07
90	Soil	1.75E-11	5.83E-07
95	Soil	2.02E-11	6.72E-07
99	Soil	2.56E-11	8.53E-07
50	Root	5.31E-09	1.77E-04
75	Root	1.56E-08	5.19E-04
90	Root	3.88E-08	1.29E-03
95	Root	6.76E-08	2.25E-03
99	Root	1.80E-07	6.02E-03
50	Exposed Fruit	1.17E-09	3.91E-05
75	Exposed Fruit	2.18E-09	7.26E-05
90	Exposed Fruit	3.67E-09	1.22E-04
95	Exposed Fruit	4.86E-09	1.62E-04
99	Exposed Fruit	7.65E-09	2.55E-04
50	Exposed Vegetables	5.66E-10	1.89E-05
75	Exposed Vegetables	1.28E-09	4.27E-05
90	Exposed Vegetables	2.30E-09	7.67E-05
95	Exposed Vegetables	3.21E-09	1.07E-04
99	Exposed Vegetables	5.22E-09	1.74E-04
50	Protected Fruit	2.27E-09	7.57E-05
75	Protected Fruit	5.04E-09	1.68E-04
90	Protected Fruit	9.28E-09	3.09E-04
95	Protected Fruit	1.28E-08	4.28E-04
99	Protected Fruit	1.86E-08	6.21E-04
50	Protected Vegetables	1.12E-09	3.74E-05
75	Protected Vegetables	1.99E-09	6.62E-05
90	Protected Vegetables	3.39E-09	1.13E-04
95	Protected Vegetables	4.58E-09	1.53E-04
99	Protected Vegetables	9.12E-09	3.04E-04
50	Fish	5.76E-09	1.92E-04
75	Fish	2.29E-08	7.63E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorpyrifos

CAS: 2921-88-2 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	6.74E-08	2.25E-03
95	Fish	1.35E-07	4.51E-03
99	Fish	4.03E-07	1.34E-02
50	Beef	1.29E-10	4.29E-06
75	Beef	2.48E-10	8.27E-06
90	Beef	4.64E-10	1.55E-05
95	Beef	6.65E-10	2.22E-05
99	Beef	1.21E-09	4.04E-05
50	Milk	1.63E-09	5.42E-05
75	Milk	3.58E-09	1.19E-04
90	Milk	6.05E-09	2.02E-04
95	Milk	8.13E-09	2.71E-04
99	Milk	1.39E-08	4.64E-04
50	Surface Water	3.55E-09	1.18E-04
75	Surface Water	8.03E-09	2.68E-04
90	Surface Water	1.78E-08	5.94E-04
95	Surface Water	2.81E-08	9.36E-04
99	Surface Water	6.29E-08	2.10E-03
50	Total Ingestion	3.81E-08	1.27E-03
75	Total Ingestion	7.08E-08	2.36E-03
90	Total Ingestion	1.35E-07	4.48E-03
95	Total Ingestion	2.09E-07	6.95E-03
99	Total Ingestion	4.89E-07	1.63E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Cresol, o-

CAS: 95-48-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	3.86E-13	7.70E-12
75	Soil	1.75E-11	3.49E-10
90	Soil	8.47E-11	1.69E-09
95	Soil	1.67E-10	3.34E-09
99	Soil	5.48E-10	1.10E-08
50	Root	1.10E-06	2.21E-05
75	Root	5.26E-06	1.05E-04
90	Root	1.84E-05	3.67E-04
95	Root	3.66E-05	7.32E-04
99	Root	1.34E-04	2.69E-03
50	Exposed Fruit	1.16E-06	2.32E-05
75	Exposed Fruit	4.71E-06	9.46E-05
90	Exposed Fruit	1.37E-05	2.73E-04
95	Exposed Fruit	2.35E-05	4.71E-04
99	Exposed Fruit	5.61E-05	1.12E-03
50	Exposed Vegetables	6.68E-07	1.34E-05
75	Exposed Vegetables	2.80E-06	5.61E-05
90	Exposed Vegetables	7.40E-06	1.48E-04
95	Exposed Vegetables	1.41E-05	2.82E-04
99	Exposed Vegetables	3.03E-05	6.08E-04
50	Protected Fruit	1.25E-06	2.49E-05
75	Protected Fruit	6.63E-06	1.33E-04
90	Protected Fruit	1.91E-05	3.83E-04
95	Protected Fruit	3.23E-05	6.46E-04
99	Protected Fruit	7.53E-05	1.50E-03
50	Protected Vegetables	8.17E-07	1.64E-05
75	Protected Vegetables	3.79E-06	7.58E-05
90	Protected Vegetables	1.01E-05	2.01E-04
95	Protected Vegetables	1.74E-05	3.48E-04
99	Protected Vegetables	4.67E-05	9.33E-04
50	Fish	5.52E-09	1.10E-07
75	Fish	3.47E-08	6.93E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Cresol, o-

CAS: 95-48-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.25E-07	2.49E-06
95	Fish	2.53E-07	5.05E-06
99	Fish	8.13E-07	1.63E-05
50	Beef	1.46E-10	2.91E-09
75	Beef	5.39E-10	1.08E-08
90	Beef	1.39E-09	2.78E-08
95	Beef	2.19E-09	4.37E-08
99	Beef	4.71E-09	9.46E-08
50	Milk	6.85E-09	1.37E-07
75	Milk	2.71E-08	5.44E-07
90	Milk	7.02E-08	1.40E-06
95	Milk	1.15E-07	2.31E-06
99	Milk	2.10E-07	4.20E-06
99	Ground Water	4.54E-19	9.07E-18
50	Surface Water	9.16E-07	1.83E-05
75	Surface Water	2.89E-06	5.78E-05
90	Surface Water	8.86E-06	1.77E-04
95	Surface Water	1.64E-05	3.29E-04
99	Surface Water	4.45E-05	8.95E-04
50	Total Ingestion	1.22E-05	2.45E-04
75	Total Ingestion	3.87E-05	7.75E-04
90	Total Ingestion	8.17E-05	1.63E-03
95	Total Ingestion	1.21E-04	2.41E-03
99	Total Ingestion	2.35E-04	4.71E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Cresol, o-

CAS: 95-48-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	3.60E-12	7.19E-11
75	Soil	1.84E-10	3.69E-09
90	Soil	8.56E-10	1.71E-08
95	Soil	1.68E-09	3.36E-08
99	Soil	5.91E-09	1.18E-07
50	Root	1.65E-06	3.30E-05
75	Root	7.79E-06	1.56E-04
90	Root	2.90E-05	5.82E-04
95	Root	6.03E-05	1.21E-03
99	Root	2.07E-04	4.14E-03
50	Exposed Fruit	2.18E-06	4.37E-05
75	Exposed Fruit	7.83E-06	1.57E-04
90	Exposed Fruit	1.75E-05	3.51E-04
95	Exposed Fruit	2.62E-05	5.26E-04
99	Exposed Fruit	4.96E-05	9.97E-04
50	Exposed Vegetables	1.02E-06	2.05E-05
75	Exposed Vegetables	4.13E-06	8.26E-05
90	Exposed Vegetables	1.09E-05	2.18E-04
95	Exposed Vegetables	1.71E-05	3.43E-04
99	Exposed Vegetables	3.08E-05	6.16E-04
50	Protected Fruit	3.83E-06	7.66E-05
75	Protected Fruit	1.73E-05	3.47E-04
90	Protected Fruit	4.14E-05	8.26E-04
95	Protected Fruit	6.68E-05	1.33E-03
99	Protected Fruit	1.48E-04	2.96E-03
50	Protected Vegetables	2.42E-06	4.84E-05
75	Protected Vegetables	8.22E-06	1.65E-04
90	Protected Vegetables	1.75E-05	3.51E-04
95	Protected Vegetables	2.58E-05	5.14E-04
99	Protected Vegetables	5.09E-05	1.02E-03
50	Fish	3.51E-08	7.02E-07
75	Fish	1.89E-07	3.78E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Cresol, o-

CAS: 95-48-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	6.76E-07	1.36E-05
95	Fish	1.19E-06	2.38E-05
99	Fish	4.07E-06	8.13E-05
50	Beef	3.36E-10	6.72E-09
75	Beef	1.08E-09	2.17E-08
90	Beef	2.54E-09	5.09E-08
95	Beef	4.11E-09	8.22E-08
99	Beef	8.69E-09	1.74E-07
50	Milk	2.88E-08	5.78E-07
75	Milk	1.19E-07	2.37E-06
90	Milk	2.89E-07	5.78E-06
95	Milk	4.58E-07	9.12E-06
99	Milk	8.60E-07	1.72E-05
99	Ground Water	5.44E-18	1.09E-16
50	Surface Water	2.61E-06	5.22E-05
75	Surface Water	7.45E-06	1.49E-04
90	Surface Water	2.23E-05	4.45E-04
95	Surface Water	4.49E-05	8.99E-04
99	Surface Water	1.07E-04	2.13E-03
50	Total Ingestion	2.77E-05	5.56E-04
75	Total Ingestion	7.10E-05	1.43E-03
90	Total Ingestion	1.37E-04	2.75E-03
95	Total Ingestion	1.95E-04	3.89E-03
99	Total Ingestion	3.57E-04	7.15E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Diazinon

CAS: 333-41-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.70E-13	1.35E-09
75	Soil	5.23E-13	2.63E-09
90	Soil	8.01E-13	4.01E-09
95	Soil	9.76E-13	4.87E-09
99	Soil	1.34E-12	6.69E-09
50	Root	6.78E-09	3.39E-05
75	Root	1.79E-08	8.95E-05
90	Root	4.26E-08	2.13E-04
95	Root	7.09E-08	3.54E-04
99	Root	1.89E-07	9.48E-04
50	Exposed Fruit	3.75E-09	1.87E-05
75	Exposed Fruit	8.95E-09	4.49E-05
90	Exposed Fruit	1.88E-08	9.34E-05
95	Exposed Fruit	2.94E-08	1.47E-04
99	Exposed Fruit	6.06E-08	3.03E-04
50	Exposed Vegetables	2.04E-09	1.02E-05
75	Exposed Vegetables	5.22E-09	2.61E-05
90	Exposed Vegetables	1.19E-08	5.94E-05
95	Exposed Vegetables	1.61E-08	8.01E-05
99	Exposed Vegetables	3.42E-08	1.71E-04
50	Protected Fruit	4.35E-09	2.17E-05
75	Protected Fruit	1.33E-08	6.63E-05
90	Protected Fruit	2.71E-08	1.36E-04
95	Protected Fruit	4.11E-08	2.06E-04
99	Protected Fruit	6.49E-08	3.24E-04
50	Protected Vegetables	2.58E-09	1.29E-05
75	Protected Vegetables	6.44E-09	3.21E-05
90	Protected Vegetables	1.44E-08	7.17E-05
95	Protected Vegetables	2.28E-08	1.14E-04
99	Protected Vegetables	4.40E-08	2.20E-04
50	Fish	1.31E-09	6.53E-06
75	Fish	5.90E-09	2.94E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Diazinon

CAS: 333-41-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.79E-08	8.91E-05
95	Fish	3.34E-08	1.68E-04
99	Fish	1.21E-07	6.06E-04
50	Beef	9.48E-12	4.74E-08
75	Beef	2.11E-11	1.06E-07
90	Beef	3.96E-11	1.98E-07
95	Beef	5.67E-11	2.83E-07
99	Beef	1.11E-10	5.53E-07
50	Milk	7.11E-11	3.55E-07
75	Milk	1.61E-10	8.04E-07
90	Milk	2.94E-10	1.47E-06
95	Milk	3.94E-10	1.96E-06
99	Milk	5.62E-10	2.82E-06
50	Surface Water	4.25E-09	2.13E-05
75	Surface Water	1.05E-08	5.26E-05
90	Surface Water	2.29E-08	1.15E-04
95	Surface Water	3.38E-08	1.68E-04
99	Surface Water	8.54E-08	4.27E-04
50	Total Ingestion	4.98E-08	2.49E-04
75	Total Ingestion	8.46E-08	4.23E-04
90	Total Ingestion	1.35E-07	6.77E-04
95	Total Ingestion	1.76E-07	8.78E-04
99	Total Ingestion	3.17E-07	1.58E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Diazinon

CAS: 333-41-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.96E-12	1.48E-08
75	Soil	4.93E-12	2.48E-08
90	Soil	6.96E-12	3.48E-08
95	Soil	8.34E-12	4.17E-08
99	Soil	1.22E-11	6.12E-08
50	Root	9.98E-09	4.99E-05
75	Root	2.97E-08	1.48E-04
90	Root	7.43E-08	3.72E-04
95	Root	1.30E-07	6.52E-04
99	Root	3.54E-07	1.77E-03
50	Exposed Fruit	6.75E-09	3.38E-05
75	Exposed Fruit	1.25E-08	6.26E-05
90	Exposed Fruit	2.13E-08	1.06E-04
95	Exposed Fruit	2.87E-08	1.43E-04
99	Exposed Fruit	4.56E-08	2.28E-04
50	Exposed Vegetables	3.26E-09	1.64E-05
75	Exposed Vegetables	7.29E-09	3.64E-05
90	Exposed Vegetables	1.32E-08	6.63E-05
95	Exposed Vegetables	1.83E-08	9.16E-05
99	Exposed Vegetables	2.98E-08	1.49E-04
50	Protected Fruit	1.36E-08	6.78E-05
75	Protected Fruit	3.04E-08	1.52E-04
90	Protected Fruit	5.55E-08	2.78E-04
95	Protected Fruit	7.78E-08	3.90E-04
99	Protected Fruit	1.13E-07	5.67E-04
50	Protected Vegetables	6.74E-09	3.38E-05
75	Protected Vegetables	1.19E-08	5.94E-05
90	Protected Vegetables	2.01E-08	1.01E-04
95	Protected Vegetables	2.79E-08	1.39E-04
99	Protected Vegetables	5.31E-08	2.66E-04
50	Fish	7.42E-09	3.70E-05
75	Fish	2.97E-08	1.49E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Diazinon

CAS: 333-41-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	9.57E-08	4.78E-04
95	Fish	1.65E-07	8.26E-04
99	Fish	5.53E-07	2.77E-03
50	Beef	2.04E-11	1.02E-07
75	Beef	4.02E-11	2.01E-07
90	Beef	7.34E-11	3.68E-07
95	Beef	1.03E-10	5.16E-07
99	Beef	1.94E-10	9.65E-07
50	Milk	3.00E-10	1.50E-06
75	Milk	6.73E-10	3.37E-06
90	Milk	1.15E-09	5.75E-06
95	Milk	1.54E-09	7.72E-06
99	Milk	2.64E-09	1.32E-05
50	Surface Water	1.18E-08	5.89E-05
75	Surface Water	2.67E-08	1.33E-04
90	Surface Water	5.56E-08	2.79E-04
95	Surface Water	8.70E-08	4.35E-04
99	Surface Water	1.95E-07	9.78E-04
50	Total Ingestion	1.04E-07	5.17E-04
75	Total Ingestion	1.72E-07	8.65E-04
90	Total Ingestion	2.75E-07	1.37E-03
95	Total Ingestion	3.86E-07	1.94E-03
99	Total Ingestion	8.01E-07	4.00E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloroethene, 1,2-trans-

CAS: 156-60-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.86E-13	9.26E-12
75	Soil	7.94E-13	3.97E-11
90	Soil	2.08E-12	1.04E-10
95	Soil	3.44E-12	1.72E-10
99	Soil	6.73E-12	3.35E-10
50	Root	5.03E-08	2.52E-06
75	Root	2.80E-07	1.40E-05
90	Root	1.07E-06	5.32E-05
95	Root	2.21E-06	1.11E-04
99	Root	8.53E-06	4.26E-04
50	Exposed Fruit	1.58E-07	7.91E-06
75	Exposed Fruit	4.70E-07	2.35E-05
90	Exposed Fruit	1.12E-06	5.62E-05
95	Exposed Fruit	1.88E-06	9.38E-05
99	Exposed Fruit	5.00E-06	2.49E-04
50	Exposed Vegetables	9.38E-08	4.70E-06
75	Exposed Vegetables	2.72E-07	1.36E-05
90	Exposed Vegetables	6.29E-07	3.15E-05
95	Exposed Vegetables	1.10E-06	5.50E-05
99	Exposed Vegetables	2.39E-06	1.19E-04
50	Protected Fruit	5.82E-08	2.90E-06
75	Protected Fruit	3.47E-07	1.73E-05
90	Protected Fruit	1.08E-06	5.38E-05
95	Protected Fruit	1.87E-06	9.38E-05
99	Protected Fruit	4.50E-06	2.25E-04
50	Protected Vegetables	3.91E-08	1.95E-06
75	Protected Vegetables	2.07E-07	1.03E-05
90	Protected Vegetables	6.20E-07	3.09E-05
95	Protected Vegetables	1.08E-06	5.41E-05
99	Protected Vegetables	2.92E-06	1.46E-04
50	Fish	3.62E-11	1.80E-09
75	Fish	1.76E-10	8.79E-09

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloroethene, 1,2-trans-

CAS: 156-60-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	6.32E-10	3.18E-08
95	Fish	1.39E-09	6.97E-08
99	Fish	5.32E-09	2.65E-07
50	Beef	4.94E-11	2.47E-09
75	Beef	1.14E-10	5.67E-09
90	Beef	2.24E-10	1.12E-08
95	Beef	3.29E-10	1.65E-08
99	Beef	6.88E-10	3.44E-08
50	Milk	1.34E-09	6.70E-08
75	Milk	3.15E-09	1.57E-07
90	Milk	6.64E-09	3.32E-07
95	Milk	1.03E-08	5.17E-07
99	Milk	1.78E-08	8.91E-07
50	Ground Water	3.70E-08	1.86E-06
75	Ground Water	9.94E-08	4.97E-06
90	Ground Water	1.91E-07	9.53E-06
95	Ground Water	2.68E-07	1.34E-05
99	Ground Water	5.06E-07	2.53E-05
50	Surface Water	2.21E-06	1.11E-04
75	Surface Water	5.06E-06	2.53E-04
90	Surface Water	9.50E-06	4.73E-04
95	Surface Water	1.41E-05	7.03E-04
99	Surface Water	2.64E-05	1.32E-03
50	Total Ingestion	4.00E-06	2.01E-04
75	Total Ingestion	7.59E-06	3.79E-04
90	Total Ingestion	1.32E-05	6.61E-04
95	Total Ingestion	1.78E-05	8.91E-04
99	Total Ingestion	2.94E-05	1.47E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloroethene, 1,2-trans-

CAS: 156-60-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.13E-12	1.06E-10
75	Soil	8.47E-12	4.23E-10
90	Soil	2.06E-11	1.03E-09
95	Soil	3.09E-11	1.55E-09
99	Soil	6.12E-11	3.06E-09
50	Root	7.26E-08	3.62E-06
75	Root	4.17E-07	2.08E-05
90	Root	1.70E-06	8.50E-05
95	Root	3.53E-06	1.76E-04
99	Root	1.30E-05	6.47E-04
50	Exposed Fruit	2.82E-07	1.41E-05
75	Exposed Fruit	6.82E-07	3.41E-05
90	Exposed Fruit	1.39E-06	6.94E-05
95	Exposed Fruit	2.06E-06	1.03E-04
99	Exposed Fruit	3.91E-06	1.96E-04
50	Exposed Vegetables	1.43E-07	7.17E-06
75	Exposed Vegetables	3.59E-07	1.80E-05
90	Exposed Vegetables	8.29E-07	4.15E-05
95	Exposed Vegetables	1.28E-06	6.41E-05
99	Exposed Vegetables	2.35E-06	1.18E-04
50	Protected Fruit	1.86E-07	9.29E-06
75	Protected Fruit	9.53E-07	4.76E-05
90	Protected Fruit	2.50E-06	1.25E-04
95	Protected Fruit	4.03E-06	2.01E-04
99	Protected Fruit	9.29E-06	4.65E-04
50	Protected Vegetables	1.13E-07	5.67E-06
75	Protected Vegetables	4.53E-07	2.26E-05
90	Protected Vegetables	1.04E-06	5.20E-05
95	Protected Vegetables	1.59E-06	7.97E-05
99	Protected Vegetables	3.09E-06	1.54E-04
50	Fish	2.18E-10	1.09E-08
75	Fish	9.35E-10	4.67E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Dichloroethene, 1,2-trans-

CAS: 156-60-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	3.35E-09	1.68E-07
95	Fish	6.56E-09	3.29E-07
99	Fish	2.58E-08	1.29E-06
50	Beef	1.04E-10	5.20E-09
75	Beef	2.12E-10	1.06E-08
90	Beef	4.29E-10	2.15E-08
95	Beef	6.41E-10	3.20E-08
99	Beef	1.18E-09	5.91E-08
50	Milk	5.56E-09	2.77E-07
75	Milk	1.35E-08	6.76E-07
90	Milk	2.73E-08	1.37E-06
95	Milk	4.06E-08	2.03E-06
99	Milk	7.79E-08	3.91E-06
50	Ground Water	1.16E-07	5.79E-06
75	Ground Water	2.65E-07	1.32E-05
90	Ground Water	4.73E-07	2.37E-05
95	Ground Water	6.44E-07	3.23E-05
99	Ground Water	1.36E-06	6.82E-05
50	Surface Water	6.14E-06	3.09E-04
75	Surface Water	1.27E-05	6.35E-04
90	Surface Water	2.34E-05	1.17E-03
95	Surface Water	3.32E-05	1.66E-03
99	Surface Water	6.56E-05	3.29E-03
50	Total Ingestion	9.06E-06	4.53E-04
75	Total Ingestion	1.66E-05	8.29E-04
90	Total Ingestion	2.71E-05	1.36E-03
95	Total Ingestion	3.67E-05	1.83E-03
99	Total Ingestion	7.26E-05	3.62E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Endrin

CAS: 72-20-8 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.07E-10	3.59E-07
75	Soil	1.76E-10	5.85E-07
90	Soil	2.47E-10	8.26E-07
95	Soil	2.98E-10	9.92E-07
99	Soil	3.83E-10	1.27E-06
50	Root	2.29E-08	7.64E-05
75	Root	5.44E-08	1.81E-04
90	Root	1.15E-07	3.84E-04
95	Root	1.81E-07	6.02E-04
99	Root	4.36E-07	1.46E-03
50	Exposed Fruit	2.00E-09	6.68E-06
75	Exposed Fruit	4.52E-09	1.51E-05
90	Exposed Fruit	9.13E-09	3.05E-05
95	Exposed Fruit	1.40E-08	4.69E-05
99	Exposed Fruit	2.71E-08	9.01E-05
50	Exposed Vegetables	1.15E-09	3.82E-06
75	Exposed Vegetables	2.59E-09	8.63E-06
90	Exposed Vegetables	5.52E-09	1.83E-05
95	Exposed Vegetables	7.84E-09	2.61E-05
99	Exposed Vegetables	1.52E-08	5.06E-05
50	Protected Fruit	2.72E-09	9.05E-06
75	Protected Fruit	6.89E-09	2.29E-05
90	Protected Fruit	1.34E-08	4.48E-05
95	Protected Fruit	1.93E-08	6.43E-05
99	Protected Fruit	3.27E-08	1.09E-04
50	Protected Vegetables	1.51E-09	5.02E-06
75	Protected Vegetables	3.33E-09	1.11E-05
90	Protected Vegetables	7.10E-09	2.36E-05
95	Protected Vegetables	1.07E-08	3.58E-05
99	Protected Vegetables	2.17E-08	7.22E-05
50	Fish	3.34E-08	1.11E-04
75	Fish	1.26E-07	4.19E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Endrin

CAS: 72-20-8 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	3.98E-07	1.33E-03
95	Fish	7.55E-07	2.51E-03
99	Fish	2.20E-06	7.30E-03
50	Beef	4.52E-10	1.51E-06
75	Beef	8.92E-10	2.98E-06
90	Beef	1.65E-09	5.52E-06
95	Beef	2.33E-09	7.76E-06
99	Beef	4.11E-09	1.37E-05
50	Milk	2.96E-09	9.88E-06
75	Milk	6.06E-09	2.02E-05
90	Milk	1.03E-08	3.44E-05
95	Milk	1.32E-08	4.40E-05
99	Milk	1.98E-08	6.60E-05
90	Ground Water	1.92E-22	6.39E-19
95	Ground Water	2.36E-19	7.88E-16
99	Ground Water	2.04E-16	6.81E-13
50	Surface Water	7.26E-09	2.42E-05
75	Surface Water	1.42E-08	4.73E-05
90	Surface Water	2.42E-08	8.05E-05
95	Surface Water	3.34E-08	1.11E-04
99	Surface Water	6.27E-08	2.10E-04
50	Total Ingestion	1.15E-07	3.83E-04
75	Total Ingestion	2.47E-07	8.22E-04
90	Total Ingestion	5.27E-07	1.75E-03
95	Total Ingestion	8.76E-07	2.92E-03
99	Total Ingestion	2.25E-06	7.47E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Endrin

CAS: 72-20-8 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	9.96E-10	3.32E-06
75	Soil	1.52E-09	5.06E-06
90	Soil	2.12E-09	7.05E-06
95	Soil	2.52E-09	8.38E-06
99	Soil	3.17E-09	1.06E-05
50	Root	3.16E-08	1.05E-04
75	Root	8.30E-08	2.77E-04
90	Root	1.88E-07	6.27E-04
95	Root	3.18E-07	1.06E-03
99	Root	8.51E-07	2.83E-03
50	Exposed Fruit	3.28E-09	1.09E-05
75	Exposed Fruit	5.77E-09	1.92E-05
90	Exposed Fruit	9.38E-09	3.12E-05
95	Exposed Fruit	1.26E-08	4.19E-05
99	Exposed Fruit	2.14E-08	7.14E-05
50	Exposed Vegetables	1.63E-09	5.44E-06
75	Exposed Vegetables	3.31E-09	1.10E-05
90	Exposed Vegetables	5.89E-09	1.97E-05
95	Exposed Vegetables	7.72E-09	2.58E-05
99	Exposed Vegetables	1.30E-08	4.36E-05
50	Protected Fruit	6.72E-09	2.25E-05
75	Protected Fruit	1.44E-08	4.77E-05
90	Protected Fruit	2.56E-08	8.55E-05
95	Protected Fruit	3.32E-08	1.10E-04
99	Protected Fruit	5.06E-08	1.69E-04
50	Protected Vegetables	3.25E-09	1.08E-05
75	Protected Vegetables	5.60E-09	1.86E-05
90	Protected Vegetables	9.38E-09	3.12E-05
95	Protected Vegetables	1.30E-08	4.36E-05
99	Protected Vegetables	2.44E-08	8.13E-05
50	Fish	1.58E-07	5.27E-04
75	Fish	6.10E-07	2.03E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Endrin

CAS: 72-20-8 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.76E-06	5.85E-03
95	Fish	3.44E-06	1.15E-02
99	Fish	1.05E-05	3.52E-02
50	Beef	8.67E-10	2.89E-06
75	Beef	1.61E-09	5.35E-06
90	Beef	2.90E-09	9.67E-06
95	Beef	4.15E-09	1.39E-05
99	Beef	7.80E-09	2.61E-05
50	Milk	1.10E-08	3.66E-05
75	Milk	2.21E-08	7.35E-05
90	Milk	3.83E-08	1.28E-04
95	Milk	5.10E-08	1.71E-04
99	Milk	9.09E-08	3.03E-04
90	Ground Water	3.81E-22	1.27E-18
95	Ground Water	3.34E-19	1.12E-15
99	Ground Water	5.69E-16	1.90E-12
50	Surface Water	1.83E-08	6.10E-05
75	Surface Water	3.42E-08	1.14E-04
90	Surface Water	5.77E-08	1.92E-04
95	Surface Water	8.01E-08	2.67E-04
99	Surface Water	1.40E-07	4.65E-04
50	Total Ingestion	3.23E-07	1.08E-03
75	Total Ingestion	8.05E-07	2.68E-03
90	Total Ingestion	1.96E-06	6.52E-03
95	Total Ingestion	3.61E-06	1.20E-02
99	Total Ingestion	1.07E-05	3.57E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Ethyl p-nitrophenyl Phenylphosphorothioate

CAS: 2104-64-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	3.71E-15	3.71E-10
75	Soil	6.77E-15	6.77E-10
90	Soil	9.62E-15	9.62E-10
95	Soil	1.14E-14	1.14E-09
99	Soil	1.46E-14	1.46E-09
50	Root	4.19E-09	4.19E-04
75	Root	1.12E-08	1.12E-03
90	Root	2.69E-08	2.69E-03
95	Root	4.48E-08	4.48E-03
99	Root	1.19E-07	1.19E-02
50	Exposed Fruit	1.46E-09	1.46E-04
75	Exposed Fruit	3.46E-09	3.46E-04
90	Exposed Fruit	7.18E-09	7.18E-04
95	Exposed Fruit	1.13E-08	1.13E-03
99	Exposed Fruit	2.28E-08	2.28E-03
50	Exposed Vegetables	7.91E-10	7.91E-05
75	Exposed Vegetables	2.00E-09	2.00E-04
90	Exposed Vegetables	4.58E-09	4.58E-04
95	Exposed Vegetables	6.15E-09	6.15E-04
99	Exposed Vegetables	1.31E-08	1.31E-03
50	Protected Fruit	1.76E-09	1.76E-04
75	Protected Fruit	5.26E-09	5.26E-04
90	Protected Fruit	1.07E-08	1.07E-03
95	Protected Fruit	1.62E-08	1.62E-03
99	Protected Fruit	2.58E-08	2.58E-03
50	Protected Vegetables	1.03E-09	1.03E-04
75	Protected Vegetables	2.55E-09	2.55E-04
90	Protected Vegetables	5.69E-09	5.69E-04
95	Protected Vegetables	8.93E-09	8.93E-04
99	Protected Vegetables	1.74E-08	1.74E-03
50	Fish	3.20E-10	3.20E-05
75	Fish	1.60E-09	1.60E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Ethyl p-nitrophenyl Phenylphosphorothioate

CAS: 2104-64-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	5.62E-09	5.62E-04
95	Fish	1.09E-08	1.09E-03
99	Fish	3.72E-08	3.72E-03
50	Beef	1.31E-11	1.31E-06
75	Beef	2.93E-11	2.93E-06
90	Beef	5.64E-11	5.64E-06
95	Beef	7.65E-11	7.65E-06
99	Beef	1.53E-10	1.53E-05
50	Milk	1.01E-10	1.01E-05
75	Milk	2.26E-10	2.26E-05
90	Milk	4.09E-10	4.09E-05
95	Milk	5.49E-10	5.49E-05
99	Milk	7.73E-10	7.73E-05
50	Surface Water	4.19E-10	4.19E-05
75	Surface Water	1.15E-09	1.15E-04
90	Surface Water	2.41E-09	2.41E-04
95	Surface Water	3.68E-09	3.68E-04
99	Surface Water	7.77E-09	7.77E-04
50	Total Ingestion	1.85E-08	1.85E-03
75	Total Ingestion	3.39E-08	3.39E-03
90	Total Ingestion	5.52E-08	5.52E-03
95	Total Ingestion	7.28E-08	7.28E-03
99	Total Ingestion	1.54E-07	1.54E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Ethyl p-nitrophenyl Phenylphosphorothioate

CAS: 2104-64-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	3.93E-14	3.93E-09
75	Soil	6.20E-14	6.20E-09
90	Soil	8.22E-14	8.22E-09
95	Soil	9.68E-14	9.68E-09
99	Soil	1.23E-13	1.23E-08
50	Root	6.32E-09	6.32E-04
75	Root	1.86E-08	1.86E-03
90	Root	4.63E-08	4.63E-03
95	Root	8.06E-08	8.06E-03
99	Root	2.16E-07	2.16E-02
50	Exposed Fruit	2.55E-09	2.55E-04
75	Exposed Fruit	4.84E-09	4.84E-04
90	Exposed Fruit	8.01E-09	8.01E-04
95	Exposed Fruit	1.08E-08	1.08E-03
99	Exposed Fruit	1.72E-08	1.72E-03
50	Exposed Vegetables	1.25E-09	1.25E-04
75	Exposed Vegetables	2.79E-09	2.79E-04
90	Exposed Vegetables	5.13E-09	5.13E-04
95	Exposed Vegetables	6.94E-09	6.94E-04
99	Exposed Vegetables	1.13E-08	1.13E-03
50	Protected Fruit	5.39E-09	5.39E-04
75	Protected Fruit	1.20E-08	1.20E-03
90	Protected Fruit	2.21E-08	2.21E-03
95	Protected Fruit	3.05E-08	3.05E-03
99	Protected Fruit	4.41E-08	4.41E-03
50	Protected Vegetables	2.67E-09	2.67E-04
75	Protected Vegetables	4.71E-09	4.71E-04
90	Protected Vegetables	8.05E-09	8.05E-04
95	Protected Vegetables	1.09E-08	1.09E-03
99	Protected Vegetables	2.16E-08	2.16E-03
50	Fish	1.88E-09	1.88E-04
75	Fish	9.05E-09	9.05E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Ethyl p-nitrophenyl Phenylphosphorothioate

CAS: 2104-64-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	2.95E-08	2.95E-03
95	Fish	5.41E-08	5.41E-03
99	Fish	1.71E-07	1.71E-02
50	Beef	2.85E-11	2.85E-06
75	Beef	5.49E-11	5.49E-06
90	Beef	1.02E-10	1.02E-05
95	Beef	1.41E-10	1.41E-05
99	Beef	2.68E-10	2.68E-05
50	Milk	4.24E-10	4.24E-05
75	Milk	9.32E-10	9.32E-05
90	Milk	1.60E-09	1.60E-04
95	Milk	2.16E-09	2.16E-04
99	Milk	3.72E-09	3.72E-04
50	Surface Water	1.21E-09	1.21E-04
75	Surface Water	2.88E-09	2.88E-04
90	Surface Water	6.03E-09	6.03E-04
95	Surface Water	9.42E-09	9.42E-04
99	Surface Water	1.87E-08	1.87E-03
50	Total Ingestion	3.70E-08	3.70E-03
75	Total Ingestion	6.36E-08	6.36E-03
90	Total Ingestion	1.06E-07	1.06E-02
95	Total Ingestion	1.56E-07	1.56E-02
99	Total Ingestion	3.39E-07	3.39E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Fluoranthene

CAS: 206-44-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.71E-08	4.28E-07
75	Soil	3.03E-08	7.58E-07
90	Soil	4.23E-08	1.06E-06
95	Soil	4.92E-08	1.23E-06
99	Soil	6.13E-08	1.53E-06
50	Root	4.40E-06	1.10E-04
75	Root	1.14E-05	2.85E-04
90	Root	2.62E-05	6.55E-04
95	Root	4.24E-05	1.06E-03
99	Root	1.06E-04	2.64E-03
50	Exposed Fruit	3.78E-07	9.44E-06
75	Exposed Fruit	8.56E-07	2.14E-05
90	Exposed Fruit	1.78E-06	4.44E-05
95	Exposed Fruit	2.78E-06	6.94E-05
99	Exposed Fruit	5.36E-06	1.34E-04
50	Exposed Vegetables	2.08E-07	5.20E-06
75	Exposed Vegetables	4.99E-07	1.25E-05
90	Exposed Vegetables	1.09E-06	2.73E-05
95	Exposed Vegetables	1.53E-06	3.83E-05
99	Exposed Vegetables	3.28E-06	8.19E-05
50	Protected Fruit	4.64E-07	1.16E-05
75	Protected Fruit	1.32E-06	3.30E-05
90	Protected Fruit	2.66E-06	6.65E-05
95	Protected Fruit	3.79E-06	9.47E-05
99	Protected Fruit	6.51E-06	1.63E-04
50	Protected Vegetables	2.66E-07	6.65E-06
75	Protected Vegetables	6.36E-07	1.59E-05
90	Protected Vegetables	1.42E-06	3.55E-05
95	Protected Vegetables	2.16E-06	5.39E-05
99	Protected Vegetables	4.17E-06	1.04E-04
50	Fish	2.87E-06	7.18E-05
75	Fish	1.12E-05	2.80E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Fluoranthene

CAS: 206-44-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	3.43E-05	8.58E-04
95	Fish	6.51E-05	1.63E-03
99	Fish	2.07E-04	5.17E-03
50	Beef	9.92E-08	2.48E-06
75	Beef	2.14E-07	5.35E-06
90	Beef	4.07E-07	1.02E-05
95	Beef	5.48E-07	1.37E-05
99	Beef	1.04E-06	2.60E-05
50	Milk	6.44E-07	1.61E-05
75	Milk	1.41E-06	3.52E-05
90	Milk	2.45E-06	6.13E-05
95	Milk	3.17E-06	7.94E-05
99	Milk	4.83E-06	1.21E-04
50	Surface Water	2.02E-06	5.05E-05
75	Surface Water	4.22E-06	1.05E-04
90	Surface Water	7.89E-06	1.97E-04
95	Surface Water	1.15E-05	2.87E-04
99	Surface Water	2.60E-05	6.50E-04
50	Total Ingestion	1.99E-05	4.99E-04
75	Total Ingestion	3.76E-05	9.41E-04
90	Total Ingestion	6.96E-05	1.74E-03
95	Total Ingestion	1.05E-04	2.62E-03
99	Total Ingestion	2.30E-04	5.75E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Fluoranthene

CAS: 206-44-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.81E-07	4.53E-06
75	Soil	2.78E-07	6.95E-06
90	Soil	3.69E-07	9.23E-06
95	Soil	4.14E-07	1.04E-05
99	Soil	5.17E-07	1.29E-05
50	Root	6.72E-06	1.68E-04
75	Root	1.90E-05	4.75E-04
90	Root	4.47E-05	1.12E-03
95	Root	7.45E-05	1.86E-03
99	Root	2.04E-04	5.10E-03
50	Exposed Fruit	6.63E-07	1.66E-05
75	Exposed Fruit	1.20E-06	3.01E-05
90	Exposed Fruit	1.94E-06	4.85E-05
95	Exposed Fruit	2.60E-06	6.49E-05
99	Exposed Fruit	4.13E-06	1.03E-04
50	Exposed Vegetables	3.29E-07	8.22E-06
75	Exposed Vegetables	6.90E-07	1.72E-05
90	Exposed Vegetables	1.24E-06	3.09E-05
95	Exposed Vegetables	1.65E-06	4.12E-05
99	Exposed Vegetables	2.55E-06	6.39E-05
50	Protected Fruit	1.38E-06	3.44E-05
75	Protected Fruit	2.96E-06	7.39E-05
90	Protected Fruit	5.44E-06	1.36E-04
95	Protected Fruit	7.29E-06	1.82E-04
99	Protected Fruit	1.03E-05	2.57E-04
50	Protected Vegetables	6.67E-07	1.67E-05
75	Protected Vegetables	1.16E-06	2.91E-05
90	Protected Vegetables	1.93E-06	4.83E-05
95	Protected Vegetables	2.66E-06	6.64E-05
99	Protected Vegetables	5.15E-06	1.29E-04
50	Fish	1.53E-05	3.82E-04
75	Fish	5.69E-05	1.42E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Fluoranthene

CAS: 206-44-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.67E-04	4.16E-03
95	Fish	3.22E-04	8.04E-03
99	Fish	9.18E-04	2.29E-02
50	Beef	2.10E-07	5.24E-06
75	Beef	3.91E-07	9.78E-06
90	Beef	7.31E-07	1.83E-05
95	Beef	9.79E-07	2.45E-05
99	Beef	1.86E-06	4.66E-05
50	Milk	2.63E-06	6.57E-05
75	Milk	5.74E-06	1.44E-04
90	Milk	9.40E-06	2.35E-04
95	Milk	1.26E-05	3.15E-04
99	Milk	2.12E-05	5.30E-04
50	Surface Water	5.42E-06	1.36E-04
75	Surface Water	1.05E-05	2.62E-04
90	Surface Water	1.98E-05	4.95E-04
95	Surface Water	2.82E-05	7.06E-04
99	Surface Water	5.96E-05	1.49E-03
50	Total Ingestion	5.32E-05	1.33E-03
75	Total Ingestion	1.07E-04	2.68E-03
90	Total Ingestion	2.32E-04	5.80E-03
95	Total Ingestion	3.86E-04	9.66E-03
99	Total Ingestion	9.55E-04	2.39E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Isobutyl Alcohol

CAS: 78-83-1 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	4.51E-14	1.51E-13
75	Soil	6.64E-13	2.21E-12
90	Soil	2.75E-12	9.17E-12
95	Soil	4.98E-12	1.66E-11
99	Soil	1.44E-11	4.79E-11
50	Root	2.99E-07	9.95E-07
75	Root	1.54E-06	5.13E-06
90	Root	8.11E-06	2.71E-05
95	Root	2.11E-05	7.04E-05
99	Root	8.95E-05	2.98E-04
50	Exposed Fruit	2.05E-07	6.82E-07
75	Exposed Fruit	7.51E-07	2.50E-06
90	Exposed Fruit	2.68E-06	8.95E-06
95	Exposed Fruit	5.51E-06	1.83E-05
99	Exposed Fruit	1.76E-05	5.85E-05
50	Exposed Vegetables	1.21E-07	4.04E-07
75	Exposed Vegetables	4.29E-07	1.43E-06
90	Exposed Vegetables	1.46E-06	4.88E-06
95	Exposed Vegetables	3.03E-06	1.01E-05
99	Exposed Vegetables	1.05E-05	3.51E-05
50	Protected Fruit	1.92E-07	6.39E-07
75	Protected Fruit	9.01E-07	3.01E-06
90	Protected Fruit	3.54E-06	1.18E-05
95	Protected Fruit	7.36E-06	2.45E-05
99	Protected Fruit	2.17E-05	7.23E-05
50	Protected Vegetables	1.24E-07	4.13E-07
75	Protected Vegetables	5.67E-07	1.89E-06
90	Protected Vegetables	1.98E-06	6.57E-06
95	Protected Vegetables	4.10E-06	1.36E-05
99	Protected Vegetables	1.40E-05	4.66E-05
50	Fish	7.89E-11	2.62E-10
75	Fish	5.73E-10	1.90E-09

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Isobutyl Alcohol

CAS: 78-83-1 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	2.38E-09	7.92E-09
95	Fish	5.54E-09	1.84E-08
99	Fish	2.13E-08	7.11E-08
50	Beef	7.01E-12	2.33E-11
75	Beef	2.12E-11	7.04E-11
90	Beef	6.35E-11	2.12E-10
95	Beef	1.22E-10	4.07E-10
99	Beef	3.07E-10	1.02E-09
50	Milk	1.29E-09	4.29E-09
75	Milk	4.19E-09	1.40E-08
90	Milk	1.47E-08	4.88E-08
95	Milk	2.71E-08	9.05E-08
99	Milk	6.89E-08	2.29E-07
50	Ground Water	3.32E-13	1.11E-12
75	Ground Water	6.20E-11	2.07E-10
90	Ground Water	5.23E-09	1.75E-08
95	Ground Water	1.95E-08	6.48E-08
99	Ground Water	7.76E-08	2.59E-07
50	Surface Water	7.32E-07	2.44E-06
75	Surface Water	1.77E-06	5.92E-06
90	Surface Water	3.66E-06	1.22E-05
95	Surface Water	5.70E-06	1.90E-05
99	Surface Water	1.15E-05	3.85E-05
50	Total Ingestion	3.11E-06	1.04E-05
75	Total Ingestion	7.86E-06	2.62E-05
90	Total Ingestion	2.66E-05	8.86E-05
95	Total Ingestion	4.82E-05	1.61E-04
99	Total Ingestion	1.26E-04	4.19E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Isobutyl Alcohol

CAS: 78-83-1 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	4.82E-13	1.61E-12
75	Soil	6.92E-12	2.31E-11
90	Soil	2.60E-11	8.67E-11
95	Soil	4.79E-11	1.60E-10
99	Soil	1.51E-10	5.04E-10
50	Root	4.63E-07	1.54E-06
75	Root	2.42E-06	8.08E-06
90	Root	1.34E-05	4.48E-05
95	Root	2.85E-05	9.48E-05
99	Root	1.18E-04	3.94E-04
50	Exposed Fruit	3.41E-07	1.14E-06
75	Exposed Fruit	1.16E-06	3.88E-06
90	Exposed Fruit	4.29E-06	1.43E-05
95	Exposed Fruit	7.36E-06	2.46E-05
99	Exposed Fruit	1.72E-05	5.73E-05
50	Exposed Vegetables	1.72E-07	5.76E-07
75	Exposed Vegetables	6.35E-07	2.11E-06
90	Exposed Vegetables	2.14E-06	7.14E-06
95	Exposed Vegetables	4.19E-06	1.40E-05
99	Exposed Vegetables	1.10E-05	3.69E-05
50	Protected Fruit	5.92E-07	1.97E-06
75	Protected Fruit	2.29E-06	7.64E-06
90	Protected Fruit	8.54E-06	2.85E-05
95	Protected Fruit	1.73E-05	5.79E-05
99	Protected Fruit	4.76E-05	1.59E-04
50	Protected Vegetables	2.99E-07	9.95E-07
75	Protected Vegetables	1.13E-06	3.76E-06
90	Protected Vegetables	4.04E-06	1.35E-05
95	Protected Vegetables	6.70E-06	2.24E-05
99	Protected Vegetables	1.64E-05	5.48E-05
50	Fish	4.91E-10	1.64E-09
75	Fish	3.19E-09	1.06E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Isobutyl Alcohol

CAS: 78-83-1 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.27E-08	4.23E-08
95	Fish	2.58E-08	8.61E-08
99	Fish	1.05E-07	3.51E-07
50	Beef	1.41E-11	4.69E-11
75	Beef	4.38E-11	1.46E-10
90	Beef	1.32E-10	4.41E-10
95	Beef	2.50E-10	8.33E-10
99	Beef	5.63E-10	1.88E-09
50	Milk	5.32E-09	1.77E-08
75	Milk	1.75E-08	5.85E-08
90	Milk	6.39E-08	2.13E-07
95	Milk	1.21E-07	4.04E-07
99	Milk	2.58E-07	8.58E-07
50	Ground Water	9.30E-13	3.10E-12
75	Ground Water	2.24E-10	7.48E-10
90	Ground Water	1.82E-08	6.07E-08
95	Ground Water	6.20E-08	2.07E-07
99	Ground Water	1.82E-07	6.07E-07
50	Surface Water	2.03E-06	6.79E-06
75	Surface Water	4.54E-06	1.51E-05
90	Surface Water	9.14E-06	3.04E-05
95	Surface Water	1.44E-05	4.79E-05
99	Surface Water	2.88E-05	9.61E-05
50	Total Ingestion	6.82E-06	2.27E-05
75	Total Ingestion	1.68E-05	5.60E-05
90	Total Ingestion	4.19E-05	1.40E-04
95	Total Ingestion	7.01E-05	2.34E-04
99	Total Ingestion	1.77E-04	5.88E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Manganese

CAS: 7439-96-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.12E-05	2.39E-04
75	Soil	1.93E-05	4.10E-04
90	Soil	2.84E-05	6.04E-04
95	Soil	3.45E-05	7.33E-04
99	Soil	4.73E-05	1.01E-03
50	Root	6.33E-04	4.52E-03
75	Root	1.45E-03	1.03E-02
90	Root	2.82E-03	2.01E-02
95	Root	4.28E-03	3.06E-02
99	Root	8.17E-03	5.84E-02
50	Exposed Fruit	2.05E-04	1.47E-03
75	Exposed Fruit	4.63E-04	3.30E-03
90	Exposed Fruit	9.62E-04	6.87E-03
95	Exposed Fruit	1.47E-03	1.05E-02
99	Exposed Fruit	2.85E-03	2.04E-02
50	Exposed Vegetables	5.83E-04	4.16E-03
75	Exposed Vegetables	1.29E-03	9.23E-03
90	Exposed Vegetables	2.76E-03	1.97E-02
95	Exposed Vegetables	4.07E-03	2.90E-02
99	Exposed Vegetables	7.86E-03	5.61E-02
50	Protected Fruit	2.86E-04	2.05E-03
75	Protected Fruit	6.91E-04	4.94E-03
90	Protected Fruit	1.38E-03	9.88E-03
95	Protected Fruit	2.02E-03	1.44E-02
99	Protected Fruit	3.58E-03	2.55E-02
50	Protected Vegetables	1.57E-04	1.12E-03
75	Protected Vegetables	3.55E-04	2.54E-03
90	Protected Vegetables	7.29E-04	5.21E-03
95	Protected Vegetables	1.14E-03	8.15E-03
99	Protected Vegetables	2.19E-03	1.57E-02
50	Fish	1.74E-04	1.25E-03
75	Fish	6.40E-04	4.57E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Manganese

CAS: 7439-96-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.77E-03	1.26E-02
95	Fish	3.47E-03	2.48E-02
99	Fish	9.62E-03	6.87E-02
50	Beef	2.10E-05	1.50E-04
75	Beef	4.28E-05	3.06E-04
90	Beef	7.57E-05	5.41E-04
95	Beef	1.09E-04	7.77E-04
99	Beef	1.95E-04	1.39E-03
50	Milk	4.61E-04	3.29E-03
75	Milk	9.15E-04	6.53E-03
90	Milk	1.57E-03	1.12E-02
95	Milk	2.10E-03	1.50E-02
99	Milk	3.39E-03	2.42E-02
50	Ground Water	3.26E-11	6.93E-10
75	Ground Water	7.70E-07	1.64E-05
90	Ground Water	5.00E-05	1.06E-03
95	Ground Water	1.51E-04	3.22E-03
99	Ground Water	6.55E-04	1.39E-02
50	Surface Water	2.87E-03	6.10E-02
75	Surface Water	5.84E-03	1.24E-01
90	Surface Water	1.08E-02	2.31E-01
95	Surface Water	1.49E-02	3.17E-01
99	Surface Water	2.70E-02	5.74E-01
50	Total Ingestion	2.72E-03	9.69E-02
75	Total Ingestion	7.71E-03	1.73E-01
90	Total Ingestion	1.04E-02	2.83E-01
95	Total Ingestion	1.69E-02	3.82E-01
99	Total Ingestion	3.08E-02	6.67E-01

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Manganese

CAS: 7439-96-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	7.63E-05	1.62E-03
75	Soil	1.33E-04	2.84E-03
90	Soil	2.11E-04	4.48E-03
95	Soil	2.62E-04	5.58E-03
99	Soil	3.58E-04	7.63E-03
50	Root	7.05E-04	5.04E-03
75	Root	1.76E-03	1.25E-02
90	Root	3.82E-03	2.73E-02
95	Root	6.64E-03	4.74E-02
99	Root	1.52E-02	1.09E-01
50	Exposed Fruit	2.59E-04	1.85E-03
75	Exposed Fruit	5.04E-04	3.60E-03
90	Exposed Fruit	8.70E-04	6.21E-03
95	Exposed Fruit	1.16E-03	8.27E-03
99	Exposed Fruit	2.19E-03	1.56E-02
50	Exposed Vegetables	6.43E-04	4.59E-03
75	Exposed Vegetables	1.39E-03	9.90E-03
90	Exposed Vegetables	2.55E-03	1.82E-02
95	Exposed Vegetables	3.75E-03	2.68E-02
99	Exposed Vegetables	6.60E-03	4.72E-02
50	Protected Fruit	5.45E-04	3.89E-03
75	Protected Fruit	1.20E-03	8.55E-03
90	Protected Fruit	2.13E-03	1.52E-02
95	Protected Fruit	2.99E-03	2.13E-02
99	Protected Fruit	5.00E-03	3.57E-02
50	Protected Vegetables	2.68E-04	1.91E-03
75	Protected Vegetables	4.87E-04	3.48E-03
90	Protected Vegetables	8.29E-04	5.92E-03
95	Protected Vegetables	1.21E-03	8.67E-03
99	Protected Vegetables	2.23E-03	1.59E-02
50	Fish	6.90E-04	4.93E-03
75	Fish	2.46E-03	1.76E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Manganese

CAS: 7439-96-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	7.66E-03	5.47E-02
95	Fish	1.35E-02	9.63E-02
99	Fish	3.98E-02	2.84E-01
50	Beef	3.28E-05	2.34E-04
75	Beef	6.42E-05	4.58E-04
90	Beef	1.18E-04	8.46E-04
95	Beef	1.70E-04	1.21E-03
99	Beef	3.11E-04	2.22E-03
50	Milk	1.30E-03	9.27E-03
75	Milk	2.67E-03	1.91E-02
90	Milk	5.03E-03	3.59E-02
95	Milk	6.76E-03	4.83E-02
99	Milk	1.20E-02	8.58E-02
50	Ground Water	2.61E-11	5.56E-10
75	Ground Water	7.98E-07	1.70E-05
90	Ground Water	6.14E-05	1.31E-03
95	Ground Water	2.09E-04	4.46E-03
99	Ground Water	9.25E-04	1.97E-02
50	Surface Water	5.98E-03	1.27E-01
75	Surface Water	1.24E-02	2.64E-01
90	Surface Water	2.21E-02	4.71E-01
95	Surface Water	3.22E-02	6.86E-01
99	Surface Water	5.40E-02	1.15E+00
50	Total Ingestion	3.05E-03	1.94E-01
75	Total Ingestion	1.01E-02	3.56E-01
90	Total Ingestion	6.87E-03	5.95E-01
95	Total Ingestion	3.07E-02	8.14E-01
99	Total Ingestion	2.14E-02	1.32E+00

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.23E-13	3.71E-13
75	Soil	4.52E-12	7.54E-12
90	Soil	2.48E-11	4.14E-11
95	Soil	5.46E-11	9.10E-11
99	Soil	1.61E-10	2.68E-10
50	Root	1.19E-05	1.99E-05
75	Root	7.98E-05	1.33E-04
90	Root	4.76E-04	7.93E-04
95	Root	1.30E-03	2.17E-03
99	Root	5.36E-03	8.94E-03
50	Exposed Fruit	6.26E-06	1.04E-05
75	Exposed Fruit	2.77E-05	4.61E-05
90	Exposed Fruit	1.08E-04	1.80E-04
95	Exposed Fruit	2.29E-04	3.82E-04
99	Exposed Fruit	7.62E-04	1.27E-03
50	Exposed Vegetables	3.54E-06	5.90E-06
75	Exposed Vegetables	1.67E-05	2.78E-05
90	Exposed Vegetables	6.12E-05	1.02E-04
95	Exposed Vegetables	1.29E-04	2.15E-04
99	Exposed Vegetables	4.43E-04	7.38E-04
50	Protected Fruit	5.48E-06	9.13E-06
75	Protected Fruit	3.15E-05	5.25E-05
90	Protected Fruit	1.38E-04	2.30E-04
95	Protected Fruit	3.02E-04	5.03E-04
99	Protected Fruit	9.46E-04	1.58E-03
50	Protected Vegetables	3.42E-06	5.69E-06
75	Protected Vegetables	1.95E-05	3.25E-05
90	Protected Vegetables	8.43E-05	1.40E-04
95	Protected Vegetables	1.72E-04	2.86E-04
99	Protected Vegetables	5.58E-04	9.30E-04
50	Fish	7.38E-10	1.23E-09
75	Fish	6.10E-09	1.02E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	2.71E-08	4.51E-08
95	Fish	6.78E-08	1.13E-07
99	Fish	2.87E-07	4.78E-07
50	Beef	2.35E-10	3.91E-10
75	Beef	7.69E-10	1.28E-09
90	Beef	2.75E-09	4.58E-09
95	Beef	5.11E-09	8.52E-09
99	Beef	1.26E-08	2.10E-08
50	Milk	4.14E-08	6.89E-08
75	Milk	1.49E-07	2.48E-07
90	Milk	5.86E-07	9.77E-07
95	Milk	1.18E-06	1.96E-06
99	Milk	2.78E-06	4.63E-06
50	Ground Water	6.64E-08	1.11E-07
75	Ground Water	4.75E-07	7.92E-07
90	Ground Water	2.64E-06	4.40E-06
95	Ground Water	4.45E-06	7.41E-06
99	Ground Water	9.53E-06	1.59E-05
50	Surface Water	3.15E-05	5.25E-05
75	Surface Water	7.09E-05	1.18E-04
90	Surface Water	1.47E-04	2.45E-04
95	Surface Water	2.17E-04	3.62E-04
99	Surface Water	4.02E-04	6.70E-04
50	Total Ingestion	1.20E-04	2.00E-04
75	Total Ingestion	3.27E-04	5.45E-04
90	Total Ingestion	1.25E-03	2.08E-03
95	Total Ingestion	2.36E-03	3.94E-03
99	Total Ingestion	7.27E-03	1.21E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.18E-12	3.64E-12
75	Soil	4.41E-11	7.35E-11
90	Soil	2.54E-10	4.23E-10
95	Soil	5.79E-10	9.64E-10
99	Soil	1.70E-09	2.83E-09
50	Root	1.89E-05	3.16E-05
75	Root	1.27E-04	2.11E-04
90	Root	8.23E-04	1.37E-03
95	Root	1.87E-03	3.12E-03
99	Root	7.33E-03	1.22E-02
50	Exposed Fruit	1.00E-05	1.67E-05
75	Exposed Fruit	4.21E-05	7.02E-05
90	Exposed Fruit	1.68E-04	2.80E-04
95	Exposed Fruit	2.85E-04	4.75E-04
99	Exposed Fruit	6.84E-04	1.14E-03
50	Exposed Vegetables	5.21E-06	8.68E-06
75	Exposed Vegetables	2.29E-05	3.81E-05
90	Exposed Vegetables	8.36E-05	1.39E-04
95	Exposed Vegetables	1.74E-04	2.90E-04
99	Exposed Vegetables	4.19E-04	6.99E-04
50	Protected Fruit	1.68E-05	2.81E-05
75	Protected Fruit	8.23E-05	1.37E-04
90	Protected Fruit	3.65E-04	6.08E-04
95	Protected Fruit	7.12E-04	1.19E-03
99	Protected Fruit	2.08E-03	3.47E-03
50	Protected Vegetables	8.51E-06	1.42E-05
75	Protected Vegetables	4.28E-05	7.13E-05
90	Protected Vegetables	1.67E-04	2.78E-04
95	Protected Vegetables	2.82E-04	4.69E-04
99	Protected Vegetables	6.78E-04	1.13E-03
50	Fish	4.89E-09	8.15E-09
75	Fish	3.32E-08	5.53E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.39E-07	2.32E-07
95	Fish	3.14E-07	5.24E-07
99	Fish	1.37E-06	2.28E-06
50	Beef	4.79E-10	7.98E-10
75	Beef	1.57E-09	2.62E-09
90	Beef	5.41E-09	9.02E-09
95	Beef	9.50E-09	1.58E-08
99	Beef	2.28E-08	3.80E-08
50	Milk	1.71E-07	2.86E-07
75	Milk	6.28E-07	1.05E-06
90	Milk	2.59E-06	4.31E-06
95	Milk	4.82E-06	8.04E-06
99	Milk	1.07E-05	1.79E-05
50	Ground Water	1.96E-07	3.27E-07
75	Ground Water	1.47E-06	2.45E-06
90	Ground Water	7.07E-06	1.18E-05
95	Ground Water	1.31E-05	2.19E-05
99	Ground Water	2.54E-05	4.23E-05
50	Surface Water	8.79E-05	1.47E-04
75	Surface Water	1.86E-04	3.09E-04
90	Surface Water	3.55E-04	5.91E-04
95	Surface Water	5.09E-04	8.48E-04
99	Surface Water	9.88E-04	1.65E-03
50	Total Ingestion	2.62E-04	4.36E-04
75	Total Ingestion	7.04E-04	1.17E-03
90	Total Ingestion	1.98E-03	3.29E-03
95	Total Ingestion	3.40E-03	5.67E-03
99	Total Ingestion	9.64E-03	1.61E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Naled

CAS: 300-76-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
75	Soil	1.52E-22	7.58E-20
90	Soil	1.06E-16	5.29E-14
95	Soil	4.85E-15	2.42E-12
99	Soil	9.30E-14	4.65E-11
50	Root	1.19E-08	5.93E-06
75	Root	1.03E-07	5.13E-05
90	Root	6.37E-07	3.19E-04
95	Root	1.46E-06	7.32E-04
99	Root	5.87E-06	2.94E-03
50	Exposed Fruit	9.18E-09	4.59E-06
75	Exposed Fruit	7.28E-08	3.64E-05
90	Exposed Fruit	2.98E-07	1.49E-04
95	Exposed Fruit	5.85E-07	2.92E-04
99	Exposed Fruit	1.65E-06	8.26E-04
50	Exposed Vegetables	5.40E-09	2.70E-06
75	Exposed Vegetables	4.29E-08	2.14E-05
90	Exposed Vegetables	1.62E-07	8.09E-05
95	Exposed Vegetables	3.44E-07	1.72E-04
99	Exposed Vegetables	9.35E-07	4.68E-04
50	Protected Fruit	9.64E-09	4.82E-06
75	Protected Fruit	9.04E-08	4.52E-05
90	Protected Fruit	3.71E-07	1.86E-04
95	Protected Fruit	7.55E-07	3.77E-04
99	Protected Fruit	2.11E-06	1.06E-03
50	Protected Vegetables	7.01E-09	3.51E-06
75	Protected Vegetables	5.72E-08	2.86E-05
90	Protected Vegetables	2.28E-07	1.14E-04
95	Protected Vegetables	4.25E-07	2.13E-04
99	Protected Vegetables	1.32E-06	6.60E-04
50	Fish	2.74E-14	1.37E-11
75	Fish	6.51E-13	3.26E-10
90	Fish	4.24E-12	2.12E-09

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Naled

CAS: 300-76-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
95	Fish	1.17E-11	5.84E-09
99	Fish	5.47E-11	2.73E-08
50	Beef	2.92E-13	1.46E-10
75	Beef	1.93E-12	9.66E-10
90	Beef	7.26E-12	3.63E-09
95	Beef	1.35E-11	6.73E-09
99	Beef	3.25E-11	1.63E-08
50	Milk	5.60E-11	2.80E-08
75	Milk	4.00E-10	2.00E-07
90	Milk	1.60E-09	8.00E-07
95	Milk	2.95E-09	1.47E-06
99	Milk	6.35E-09	3.17E-06
50	Surface Water	2.59E-09	1.30E-06
75	Surface Water	9.32E-09	4.66E-06
90	Surface Water	4.30E-08	2.15E-05
95	Surface Water	8.14E-08	4.07E-05
99	Surface Water	2.29E-07	1.14E-04
50	Total Ingestion	9.23E-08	4.62E-05
75	Total Ingestion	5.69E-07	2.85E-04
90	Total Ingestion	2.26E-06	1.13E-03
95	Total Ingestion	3.83E-06	1.92E-03
99	Total Ingestion	8.84E-06	4.42E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Naled

CAS: 300-76-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
75	Soil	4.84E-22	2.42E-19
90	Soil	3.81E-16	1.91E-13
95	Soil	2.05E-14	1.03E-11
99	Soil	9.20E-13	4.60E-10
50	Root	1.44E-08	7.20E-06
75	Root	1.48E-07	7.42E-05
90	Root	9.23E-07	4.61E-04
95	Root	2.20E-06	1.10E-03
99	Root	8.35E-06	4.17E-03
50	Exposed Fruit	1.62E-08	8.10E-06
75	Exposed Fruit	1.23E-07	6.17E-05
90	Exposed Fruit	4.31E-07	2.15E-04
95	Exposed Fruit	7.33E-07	3.67E-04
99	Exposed Fruit	1.59E-06	7.97E-04
50	Exposed Vegetables	7.94E-09	3.97E-06
75	Exposed Vegetables	5.94E-08	2.97E-05
90	Exposed Vegetables	2.37E-07	1.18E-04
95	Exposed Vegetables	4.43E-07	2.22E-04
99	Exposed Vegetables	1.01E-06	5.07E-04
50	Protected Fruit	2.81E-08	1.41E-05
75	Protected Fruit	2.34E-07	1.17E-04
90	Protected Fruit	9.16E-07	4.58E-04
95	Protected Fruit	1.76E-06	8.81E-04
99	Protected Fruit	4.69E-06	2.34E-03
50	Protected Vegetables	1.82E-08	9.09E-06
75	Protected Vegetables	1.22E-07	6.08E-05
90	Protected Vegetables	4.29E-07	2.14E-04
95	Protected Vegetables	6.80E-07	3.40E-04
99	Protected Vegetables	1.53E-06	7.64E-04
50	Fish	1.69E-13	8.45E-11
75	Fish	3.74E-12	1.87E-09
90	Fish	2.28E-11	1.14E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Naled

CAS: 300-76-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
95	Fish	6.02E-11	3.01E-08
99	Fish	3.21E-10	1.60E-07
50	Beef	5.59E-13	2.79E-10
75	Beef	4.15E-12	2.07E-09
90	Beef	1.45E-11	7.25E-09
95	Beef	2.58E-11	1.29E-08
99	Beef	5.54E-11	2.77E-08
50	Milk	2.14E-10	1.07E-07
75	Milk	1.55E-09	7.75E-07
90	Milk	6.61E-09	3.31E-06
95	Milk	1.14E-08	5.72E-06
99	Milk	2.57E-08	1.29E-05
50	Surface Water	7.10E-09	3.55E-06
75	Surface Water	2.69E-08	1.35E-05
90	Surface Water	1.04E-07	5.20E-05
95	Surface Water	2.10E-07	1.05E-04
99	Surface Water	5.41E-07	2.71E-04
50	Total Ingestion	1.86E-07	9.30E-05
75	Total Ingestion	1.05E-06	5.23E-04
90	Total Ingestion	3.68E-06	1.84E-03
95	Total Ingestion	5.77E-06	2.88E-03
99	Total Ingestion	1.24E-05	6.21E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Nitrite

CAS: 14797-65-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.31E-08	2.31E-07
75	Soil	2.56E-07	2.56E-06
90	Soil	2.01E-06	2.01E-05
95	Soil	3.39E-06	3.39E-05
99	Soil	6.75E-06	6.75E-05
50	Fish	1.22E-05	1.22E-04
75	Fish	6.27E-05	6.27E-04
90	Fish	2.71E-04	2.71E-03
95	Fish	5.69E-04	5.69E-03
99	Fish	2.19E-03	2.19E-02
50	Ground Water	6.07E-03	6.07E-02
75	Ground Water	1.33E-02	1.33E-01
90	Ground Water	2.63E-02	2.63E-01
95	Ground Water	4.04E-02	4.04E-01
99	Ground Water	8.39E-02	8.39E-01
50	Surface Water	1.37E-03	1.37E-02
75	Surface Water	6.32E-03	6.32E-02
90	Surface Water	2.65E-02	2.65E-01
95	Surface Water	4.62E-02	4.62E-01
99	Surface Water	9.37E-02	9.37E-01
50	Total Ingestion	7.00E-03	7.00E-02
75	Total Ingestion	1.67E-02	1.67E-01
90	Total Ingestion	4.04E-02	4.04E-01
95	Total Ingestion	6.04E-02	6.04E-01
99	Total Ingestion	1.08E-01	1.08E+00

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Nitrite

CAS: 14797-65-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.44E-07	2.44E-06
75	Soil	2.14E-06	2.14E-05
90	Soil	1.54E-05	1.54E-04
95	Soil	2.83E-05	2.83E-04
99	Soil	5.62E-05	5.62E-04
50	Fish	6.51E-05	6.51E-04
75	Fish	3.12E-04	3.12E-03
90	Fish	1.26E-03	1.26E-02
95	Fish	2.59E-03	2.59E-02
99	Fish	9.39E-03	9.39E-02
50	Ground Water	1.52E-02	1.52E-01
75	Ground Water	3.05E-02	3.05E-01
90	Ground Water	5.73E-02	5.73E-01
95	Ground Water	8.03E-02	8.03E-01
99	Ground Water	1.54E-01	1.54E+00
50	Surface Water	3.83E-03	3.83E-02
75	Surface Water	1.72E-02	1.72E-01
90	Surface Water	6.43E-02	6.43E-01
95	Surface Water	1.11E-01	1.11E+00
99	Surface Water	2.05E-01	2.05E+00
50	Total Ingestion	1.78E-02	1.78E-01
75	Total Ingestion	4.18E-02	4.18E-01
90	Total Ingestion	8.87E-02	8.87E-01
95	Total Ingestion	1.32E-01	1.32E+00
99	Total Ingestion	2.20E-01	2.20E+00

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Phenol

CAS: 108-95-2 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	9.77E-12	3.26E-11
75	Soil	7.94E-11	2.64E-10
90	Soil	2.29E-10	7.65E-10
95	Soil	3.73E-10	1.24E-09
99	Soil	7.42E-10	2.48E-09
50	Root	2.32E-06	7.76E-06
75	Root	1.04E-05	3.46E-05
90	Root	4.30E-05	1.43E-04
95	Root	9.32E-05	3.12E-04
99	Root	3.78E-04	1.26E-03
50	Exposed Fruit	2.24E-06	7.47E-06
75	Exposed Fruit	8.17E-06	2.72E-05
90	Exposed Fruit	2.62E-05	8.74E-05
95	Exposed Fruit	4.96E-05	1.66E-04
99	Exposed Fruit	1.31E-04	4.36E-04
50	Exposed Vegetables	1.29E-06	4.31E-06
75	Exposed Vegetables	4.87E-06	1.62E-05
90	Exposed Vegetables	1.39E-05	4.63E-05
95	Exposed Vegetables	2.77E-05	9.20E-05
99	Exposed Vegetables	7.82E-05	2.62E-04
50	Protected Fruit	2.59E-06	8.62E-06
75	Protected Fruit	1.15E-05	3.83E-05
90	Protected Fruit	3.67E-05	1.22E-04
95	Protected Fruit	6.67E-05	2.22E-04
99	Protected Fruit	1.59E-04	5.30E-04
50	Protected Vegetables	1.55E-06	5.18E-06
75	Protected Vegetables	6.55E-06	2.19E-05
90	Protected Vegetables	2.00E-05	6.67E-05
95	Protected Vegetables	3.61E-05	1.20E-04
99	Protected Vegetables	1.05E-04	3.50E-04
50	Fish	3.38E-08	1.13E-07
75	Fish	1.85E-07	6.15E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Phenol

CAS: 108-95-2 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	6.73E-07	2.24E-06
95	Fish	1.31E-06	4.37E-06
99	Fish	4.44E-06	1.48E-05
50	Beef	7.65E-11	2.54E-10
75	Beef	2.77E-10	9.26E-10
90	Beef	8.11E-10	2.70E-09
95	Beef	1.36E-09	4.55E-09
99	Beef	3.25E-09	1.09E-08
50	Milk	1.25E-08	4.17E-08
75	Milk	4.45E-08	1.48E-07
90	Milk	1.43E-07	4.76E-07
95	Milk	2.46E-07	8.22E-07
99	Milk	5.05E-07	1.68E-06
75	Ground Water	4.25E-18	1.41E-17
90	Ground Water	1.28E-15	4.27E-15
95	Ground Water	2.43E-13	8.11E-13
99	Ground Water	5.12E-12	1.71E-11
50	Surface Water	1.93E-06	6.44E-06
75	Surface Water	5.31E-06	1.77E-05
90	Surface Water	1.26E-05	4.23E-05
95	Surface Water	2.02E-05	6.73E-05
99	Surface Water	4.76E-05	1.59E-04
50	Total Ingestion	2.29E-05	7.65E-05
75	Total Ingestion	6.15E-05	2.06E-04
90	Total Ingestion	1.77E-04	5.87E-04
95	Total Ingestion	2.86E-04	9.54E-04
99	Total Ingestion	5.98E-04	2.00E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Phenol

CAS: 108-95-2 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	9.95E-11	3.31E-10
75	Soil	8.28E-10	2.75E-09
90	Soil	2.14E-09	7.13E-09
95	Soil	3.49E-09	1.16E-08
99	Soil	9.60E-09	3.20E-08
50	Root	3.73E-06	1.24E-05
75	Root	1.67E-05	5.56E-05
90	Root	6.79E-05	2.25E-04
95	Root	1.41E-04	4.70E-04
99	Root	5.24E-04	1.75E-03
50	Exposed Fruit	3.69E-06	1.23E-05
75	Exposed Fruit	1.28E-05	4.28E-05
90	Exposed Fruit	3.47E-05	1.16E-04
95	Exposed Fruit	5.81E-05	1.94E-04
99	Exposed Fruit	1.26E-04	4.20E-04
50	Exposed Vegetables	1.85E-06	6.15E-06
75	Exposed Vegetables	7.07E-06	2.36E-05
90	Exposed Vegetables	2.05E-05	6.84E-05
95	Exposed Vegetables	3.50E-05	1.17E-04
99	Exposed Vegetables	8.05E-05	2.67E-04
50	Protected Fruit	7.70E-06	2.58E-05
75	Protected Fruit	2.82E-05	9.37E-05
90	Protected Fruit	8.11E-05	2.70E-04
95	Protected Fruit	1.46E-04	4.87E-04
99	Protected Fruit	3.71E-04	1.24E-03
50	Protected Vegetables	4.01E-06	1.33E-05
75	Protected Vegetables	1.40E-05	4.67E-05
90	Protected Vegetables	3.66E-05	1.22E-04
95	Protected Vegetables	5.65E-05	1.88E-04
99	Protected Vegetables	1.20E-04	4.00E-04
50	Fish	2.10E-07	7.02E-07
75	Fish	1.02E-06	3.41E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Phenol

CAS: 108-95-2 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	3.65E-06	1.22E-05
95	Fish	6.32E-06	2.10E-05
99	Fish	2.18E-05	7.24E-05
50	Beef	1.60E-10	5.35E-10
75	Beef	5.98E-10	1.98E-09
90	Beef	1.54E-09	5.11E-09
95	Beef	2.78E-09	9.26E-09
99	Beef	5.86E-09	1.96E-08
50	Milk	5.01E-08	1.67E-07
75	Milk	1.83E-07	6.09E-07
90	Milk	5.72E-07	1.90E-06
95	Milk	9.77E-07	3.27E-06
99	Milk	2.10E-06	7.01E-06
75	Ground Water	1.63E-17	5.42E-17
90	Ground Water	3.46E-15	1.16E-14
95	Ground Water	9.83E-13	3.27E-12
99	Ground Water	1.34E-11	4.46E-11
50	Surface Water	5.42E-06	1.81E-05
75	Surface Water	1.40E-05	4.67E-05
90	Surface Water	3.26E-05	1.09E-04
95	Surface Water	5.13E-05	1.71E-04
99	Surface Water	1.15E-04	3.84E-04
50	Total Ingestion	4.81E-05	1.60E-04
75	Total Ingestion	1.23E-04	4.10E-04
90	Total Ingestion	2.90E-04	9.66E-04
95	Total Ingestion	4.44E-04	1.48E-03
99	Total Ingestion	8.97E-04	3.00E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Pyrene

CAS: 129-00-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	8.22E-08	2.73E-06
75	Soil	1.33E-07	4.42E-06
90	Soil	1.84E-07	6.14E-06
95	Soil	2.20E-07	7.33E-06
99	Soil	2.80E-07	9.34E-06
50	Root	8.68E-06	2.90E-04
75	Root	2.08E-05	6.93E-04
90	Root	4.46E-05	1.49E-03
95	Root	6.93E-05	2.31E-03
99	Root	1.73E-04	5.74E-03
50	Exposed Fruit	1.38E-06	4.59E-05
75	Exposed Fruit	3.11E-06	1.04E-04
90	Exposed Fruit	6.27E-06	2.09E-04
95	Exposed Fruit	9.74E-06	3.25E-04
99	Exposed Fruit	1.86E-05	6.20E-04
50	Exposed Vegetables	7.72E-07	2.57E-05
75	Exposed Vegetables	1.77E-06	5.87E-05
90	Exposed Vegetables	3.76E-06	1.25E-04
95	Exposed Vegetables	5.45E-06	1.81E-04
99	Exposed Vegetables	1.04E-05	3.46E-04
50	Protected Fruit	1.84E-06	6.14E-05
75	Protected Fruit	4.72E-06	1.58E-04
90	Protected Fruit	9.11E-06	3.04E-04
95	Protected Fruit	1.30E-05	4.36E-04
99	Protected Fruit	2.25E-05	7.49E-04
50	Protected Vegetables	1.03E-06	3.43E-05
75	Protected Vegetables	2.25E-06	7.49E-05
90	Protected Vegetables	4.85E-06	1.62E-04
95	Protected Vegetables	7.36E-06	2.46E-04
99	Protected Vegetables	1.46E-05	4.85E-04
50	Fish	2.72E-06	9.04E-05
75	Fish	1.06E-05	3.53E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Pyrene

CAS: 129-00-0 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	3.27E-05	1.09E-03
95	Fish	6.17E-05	2.05E-03
99	Fish	1.83E-04	6.11E-03
50	Beef	3.56E-07	1.19E-05
75	Beef	7.13E-07	2.37E-05
90	Beef	1.31E-06	4.36E-05
95	Beef	1.85E-06	6.17E-05
99	Beef	3.28E-06	1.09E-04
50	Milk	2.28E-06	7.59E-05
75	Milk	4.69E-06	1.56E-04
90	Milk	8.02E-06	2.68E-04
95	Milk	1.04E-05	3.46E-04
99	Milk	1.56E-05	5.21E-04
95	Ground Water	3.40E-19	1.13E-17
99	Ground Water	3.66E-15	1.22E-13
50	Surface Water	4.16E-06	1.39E-04
75	Surface Water	8.05E-06	2.69E-04
90	Surface Water	1.40E-05	4.65E-04
95	Surface Water	1.93E-05	6.43E-04
99	Surface Water	3.56E-05	1.18E-03
50	Total Ingestion	3.93E-05	1.31E-03
75	Total Ingestion	6.30E-05	2.10E-03
90	Total Ingestion	1.06E-04	3.53E-03
95	Total Ingestion	1.49E-04	4.98E-03
99	Total Ingestion	2.60E-04	8.68E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Pyrene

CAS: 129-00-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	7.69E-07	2.56E-05
75	Soil	1.16E-06	3.86E-05
90	Soil	1.58E-06	5.25E-05
95	Soil	1.85E-06	6.17E-05
99	Soil	2.31E-06	7.69E-05
50	Root	1.21E-05	4.03E-04
75	Root	3.19E-05	1.07E-03
90	Root	7.26E-05	2.42E-03
95	Root	1.25E-04	4.16E-03
99	Root	3.33E-04	1.11E-02
50	Exposed Fruit	2.26E-06	7.56E-05
75	Exposed Fruit	3.96E-06	1.32E-04
90	Exposed Fruit	6.50E-06	2.17E-04
95	Exposed Fruit	8.68E-06	2.89E-04
99	Exposed Fruit	1.46E-05	4.85E-04
50	Exposed Vegetables	1.12E-06	3.73E-05
75	Exposed Vegetables	2.29E-06	7.62E-05
90	Exposed Vegetables	4.03E-06	1.34E-04
95	Exposed Vegetables	5.35E-06	1.79E-04
99	Exposed Vegetables	8.78E-06	2.92E-04
50	Protected Fruit	4.65E-06	1.55E-04
75	Protected Fruit	9.97E-06	3.33E-04
90	Protected Fruit	1.77E-05	5.91E-04
95	Protected Fruit	2.29E-05	7.62E-04
99	Protected Fruit	3.47E-05	1.16E-03
50	Protected Vegetables	2.23E-06	7.43E-05
75	Protected Vegetables	3.89E-06	1.30E-04
90	Protected Vegetables	6.47E-06	2.15E-04
95	Protected Vegetables	8.88E-06	2.96E-04
99	Protected Vegetables	1.70E-05	5.68E-04
50	Fish	1.36E-05	4.52E-04
75	Fish	5.15E-05	1.72E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Pyrene

CAS: 129-00-0 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.53E-04	5.08E-03
95	Fish	2.88E-04	9.60E-03
99	Fish	8.61E-04	2.87E-02
50	Beef	6.86E-07	2.29E-05
75	Beef	1.28E-06	4.26E-05
90	Beef	2.33E-06	7.76E-05
95	Beef	3.33E-06	1.11E-04
99	Beef	6.20E-06	2.07E-04
50	Milk	8.61E-06	2.87E-04
75	Milk	1.75E-05	5.81E-04
90	Milk	2.99E-05	9.97E-04
95	Milk	4.03E-05	1.34E-03
99	Milk	7.03E-05	2.35E-03
95	Ground Water	5.71E-19	1.91E-17
99	Ground Water	9.54E-15	3.18E-13
50	Surface Water	1.08E-05	3.60E-04
75	Surface Water	2.01E-05	6.70E-04
90	Surface Water	3.33E-05	1.11E-03
95	Surface Water	4.75E-05	1.58E-03
99	Surface Water	8.15E-05	2.72E-03
50	Total Ingestion	8.98E-05	2.99E-03
75	Total Ingestion	1.51E-04	5.02E-03
90	Total Ingestion	2.83E-04	9.44E-03
95	Total Ingestion	4.39E-04	1.46E-02
99	Total Ingestion	9.44E-04	3.14E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Silver

CAS: 7440-22-4 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.55E-06	3.10E-04
75	Soil	2.33E-06	4.67E-04
90	Soil	3.20E-06	6.40E-04
95	Soil	3.81E-06	7.62E-04
99	Soil	5.18E-06	1.04E-03
50	Root	1.09E-04	2.17E-02
75	Root	2.39E-04	4.77E-02
90	Root	4.69E-04	9.38E-02
95	Root	6.74E-04	1.35E-01
99	Root	1.29E-03	2.59E-01
50	Exposed Fruit	4.27E-05	8.54E-03
75	Exposed Fruit	9.66E-05	1.93E-02
90	Exposed Fruit	1.97E-04	3.94E-02
95	Exposed Fruit	3.01E-04	6.02E-02
99	Exposed Fruit	5.90E-04	1.18E-01
50	Exposed Vegetables	9.72E-05	1.94E-02
75	Exposed Vegetables	2.13E-04	4.25E-02
90	Exposed Vegetables	4.57E-04	9.14E-02
95	Exposed Vegetables	6.89E-04	1.38E-01
99	Exposed Vegetables	1.28E-03	2.56E-01
50	Protected Fruit	6.02E-05	1.20E-02
75	Protected Fruit	1.45E-04	2.90E-02
90	Protected Fruit	2.84E-04	5.68E-02
95	Protected Fruit	4.15E-04	8.30E-02
99	Protected Fruit	7.45E-04	1.49E-01
50	Protected Vegetables	3.28E-05	6.56E-03
75	Protected Vegetables	7.53E-05	1.51E-02
90	Protected Vegetables	1.49E-04	2.97E-02
95	Protected Vegetables	2.28E-04	4.56E-02
99	Protected Vegetables	4.76E-04	9.52E-02
50	Beef	2.46E-05	4.92E-03
75	Beef	5.01E-05	1.00E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Silver

CAS: 7440-22-4 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Beef	8.84E-05	1.77E-02
95	Beef	1.23E-04	2.45E-02
99	Beef	2.14E-04	4.29E-02
50	Milk	4.23E-03	8.47E-01
75	Milk	8.48E-03	1.70E+00
90	Milk	1.45E-02	2.89E+00
95	Milk	1.92E-02	3.84E+00
99	Milk	3.23E-02	6.45E+00
50	Surface Water	2.00E-05	4.01E-03
75	Surface Water	4.30E-05	8.60E-03
90	Surface Water	7.51E-05	1.50E-02
95	Surface Water	1.04E-04	2.08E-02
99	Surface Water	2.02E-04	4.04E-02
50	Total Ingestion	4.92E-03	9.84E-01
75	Total Ingestion	9.28E-03	1.86E+00
90	Total Ingestion	1.54E-02	3.09E+00
95	Total Ingestion	2.02E-02	4.04E+00
99	Total Ingestion	3.35E-02	6.71E+00

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Silver

CAS: 7440-22-4 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.05E-05	2.10E-03
75	Soil	1.69E-05	3.37E-03
90	Soil	2.43E-05	4.87E-03
95	Soil	2.94E-05	5.88E-03
99	Soil	4.03E-05	8.06E-03
50	Root	1.11E-04	2.21E-02
75	Root	2.74E-04	5.47E-02
90	Root	6.04E-04	1.21E-01
95	Root	9.91E-04	1.98E-01
99	Root	2.44E-03	4.88E-01
50	Exposed Fruit	5.00E-05	1.00E-02
75	Exposed Fruit	9.97E-05	1.99E-02
90	Exposed Fruit	1.72E-04	3.44E-02
95	Exposed Fruit	2.32E-04	4.63E-02
99	Exposed Fruit	4.22E-04	8.44E-02
50	Exposed Vegetables	9.82E-05	1.96E-02
75	Exposed Vegetables	2.13E-04	4.26E-02
90	Exposed Vegetables	4.06E-04	8.12E-02
95	Exposed Vegetables	5.80E-04	1.16E-01
99	Exposed Vegetables	1.03E-03	2.07E-01
50	Protected Fruit	1.04E-04	2.08E-02
75	Protected Fruit	2.31E-04	4.62E-02
90	Protected Fruit	4.23E-04	8.46E-02
95	Protected Fruit	5.77E-04	1.15E-01
99	Protected Fruit	9.52E-04	1.90E-01
50	Protected Vegetables	5.07E-05	1.01E-02
75	Protected Vegetables	9.56E-05	1.91E-02
90	Protected Vegetables	1.64E-04	3.28E-02
95	Protected Vegetables	2.42E-04	4.84E-02
99	Protected Vegetables	4.69E-04	9.38E-02
50	Beef	3.66E-05	7.32E-03
75	Beef	7.16E-05	1.43E-02

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Silver

CAS: 7440-22-4 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Beef	1.31E-04	2.63E-02
95	Beef	1.86E-04	3.71E-02
99	Beef	3.58E-04	7.16E-02
50	Milk	1.10E-02	2.19E+00
75	Milk	2.29E-02	4.59E+00
90	Milk	4.33E-02	8.65E+00
95	Milk	6.01E-02	1.20E+01
99	Milk	1.04E-01	2.08E+01
50	Surface Water	3.82E-05	7.64E-03
75	Surface Water	8.27E-05	1.65E-02
90	Surface Water	1.60E-04	3.20E-02
95	Surface Water	2.17E-04	4.33E-02
99	Surface Water	3.75E-04	7.50E-02
50	Total Ingestion	1.19E-02	2.37E+00
75	Total Ingestion	2.41E-02	4.83E+00
90	Total Ingestion	4.44E-02	8.88E+00
95	Total Ingestion	6.17E-02	1.23E+01
99	Total Ingestion	1.06E-01	2.12E+01

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Total Nitrate Nitrogen

CAS: 14797-55-8 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.12E-07	1.33E-07
75	Soil	2.59E-06	1.62E-06
90	Soil	2.06E-05	1.29E-05
95	Soil	3.59E-05	2.24E-05
99	Soil	7.23E-05	4.52E-05
50	Fish	1.20E-04	7.53E-05
75	Fish	6.43E-04	4.01E-04
90	Fish	2.85E-03	1.78E-03
95	Fish	5.97E-03	3.74E-03
99	Fish	2.33E-02	1.46E-02
50	Ground Water	6.63E-02	4.13E-02
75	Ground Water	1.47E-01	9.14E-02
90	Ground Water	2.86E-01	1.79E-01
95	Ground Water	4.42E-01	2.76E-01
99	Ground Water	9.54E-01	5.92E-01
50	Surface Water	1.39E-02	8.68E-03
75	Surface Water	6.53E-02	4.09E-02
90	Surface Water	2.80E-01	1.75E-01
95	Surface Water	4.93E-01	3.08E-01
99	Surface Water	9.94E-01	6.22E-01
50	Total Ingestion	7.63E-02	4.76E-02
75	Total Ingestion	1.83E-01	1.14E-01
90	Total Ingestion	4.34E-01	2.71E-01
95	Total Ingestion	6.63E-01	4.16E-01
99	Total Ingestion	1.19E+00	7.43E-01

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Total Nitrate Nitrogen

CAS: 14797-55-8 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	2.21E-06	1.38E-06
75	Soil	2.05E-05	1.29E-05
90	Soil	1.58E-04	9.84E-05
95	Soil	2.93E-04	1.83E-04
99	Soil	5.97E-04	3.73E-04
50	Fish	6.58E-04	4.11E-04
75	Fish	3.21E-03	2.01E-03
90	Fish	1.32E-02	8.23E-03
95	Fish	2.71E-02	1.70E-02
99	Fish	9.94E-02	6.22E-02
50	Ground Water	1.64E-01	1.02E-01
75	Ground Water	3.30E-01	2.06E-01
90	Ground Water	6.12E-01	3.83E-01
95	Ground Water	8.63E-01	5.37E-01
99	Ground Water	1.69E+00	1.06E+00
50	Surface Water	3.85E-02	2.40E-02
75	Surface Water	1.77E-01	1.10E-01
90	Surface Water	6.83E-01	4.27E-01
95	Surface Water	1.17E+00	7.38E-01
99	Surface Water	2.18E+00	1.37E+00
50	Total Ingestion	1.94E-01	1.21E-01
75	Total Ingestion	4.53E-01	2.83E-01
90	Total Ingestion	9.54E-01	5.97E-01
95	Total Ingestion	1.42E+00	8.89E-01
99	Total Ingestion	2.34E+00	1.46E+00

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorofluoromethane

CAS: 75-69-4 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.16E-12	3.85E-12
75	Soil	3.35E-12	1.12E-11
90	Soil	6.84E-12	2.28E-11
95	Soil	9.89E-12	3.30E-11
99	Soil	2.10E-11	6.97E-11
50	Root	1.46E-07	4.86E-07
75	Root	4.62E-07	1.54E-06
90	Root	1.30E-06	4.34E-06
95	Root	2.32E-06	7.74E-06
99	Root	7.81E-06	2.60E-05
50	Exposed Fruit	2.32E-07	7.74E-07
75	Exposed Fruit	5.86E-07	1.96E-06
90	Exposed Fruit	1.28E-06	4.27E-06
95	Exposed Fruit	2.06E-06	6.87E-06
99	Exposed Fruit	4.75E-06	1.59E-05
50	Exposed Vegetables	1.30E-07	4.34E-07
75	Exposed Vegetables	3.44E-07	1.15E-06
90	Exposed Vegetables	7.91E-07	2.63E-06
95	Exposed Vegetables	1.20E-06	3.99E-06
99	Exposed Vegetables	2.30E-06	7.67E-06
50	Protected Fruit	1.25E-07	4.16E-07
75	Protected Fruit	4.82E-07	1.61E-06
90	Protected Fruit	1.16E-06	3.89E-06
95	Protected Fruit	1.81E-06	6.04E-06
99	Protected Fruit	3.35E-06	1.12E-05
50	Protected Vegetables	8.19E-08	2.73E-07
75	Protected Vegetables	2.53E-07	8.43E-07
90	Protected Vegetables	6.38E-07	2.12E-06
95	Protected Vegetables	1.04E-06	3.47E-06
99	Protected Vegetables	2.26E-06	7.53E-06
50	Fish	1.00E-10	3.34E-10
75	Fish	4.06E-10	1.36E-09

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorofluoromethane

CAS: 75-69-4 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.33E-09	4.44E-09
95	Fish	2.69E-09	8.95E-09
99	Fish	8.92E-09	2.97E-08
50	Beef	1.92E-10	6.38E-10
75	Beef	4.23E-10	1.41E-09
90	Beef	8.12E-10	2.71E-09
95	Beef	1.14E-09	3.78E-09
99	Beef	2.42E-09	8.09E-09
50	Milk	1.81E-09	6.04E-09
75	Milk	4.20E-09	1.40E-08
90	Milk	7.88E-09	2.62E-08
95	Milk	1.08E-08	3.61E-08
99	Milk	1.66E-08	5.52E-08
50	Ground Water	2.70E-08	8.99E-08
75	Ground Water	6.63E-08	2.21E-07
90	Ground Water	1.41E-07	4.68E-07
95	Ground Water	2.15E-07	7.15E-07
99	Ground Water	6.25E-07	2.09E-06
50	Surface Water	3.10E-06	1.03E-05
75	Surface Water	6.94E-06	2.31E-05
90	Surface Water	1.31E-05	4.37E-05
95	Surface Water	1.91E-05	6.35E-05
99	Surface Water	3.57E-05	1.19E-04
50	Total Ingestion	5.31E-06	1.76E-05
75	Total Ingestion	9.68E-06	3.23E-05
90	Total Ingestion	1.62E-05	5.38E-05
95	Total Ingestion	2.24E-05	7.46E-05
99	Total Ingestion	3.96E-05	1.32E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorofluoromethane

CAS: 75-69-4 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.37E-11	4.58E-11
75	Soil	3.37E-11	1.12E-10
90	Soil	6.28E-11	2.10E-10
95	Soil	9.20E-11	3.07E-10
99	Soil	1.81E-10	6.04E-10
50	Root	2.08E-07	6.94E-07
75	Root	7.77E-07	2.59E-06
90	Root	2.18E-06	7.29E-06
95	Root	4.27E-06	1.42E-05
99	Root	1.28E-05	4.27E-05
50	Exposed Fruit	4.20E-07	1.40E-06
75	Exposed Fruit	8.47E-07	2.83E-06
90	Exposed Fruit	1.50E-06	5.00E-06
95	Exposed Fruit	2.08E-06	6.94E-06
99	Exposed Fruit	3.54E-06	1.18E-05
50	Exposed Vegetables	2.05E-07	6.84E-07
75	Exposed Vegetables	4.75E-07	1.59E-06
90	Exposed Vegetables	9.40E-07	3.13E-06
95	Exposed Vegetables	1.30E-06	4.34E-06
99	Exposed Vegetables	2.17E-06	7.22E-06
50	Protected Fruit	4.27E-07	1.42E-06
75	Protected Fruit	1.23E-06	4.09E-06
90	Protected Fruit	2.52E-06	8.40E-06
95	Protected Fruit	3.82E-06	1.27E-05
99	Protected Fruit	6.21E-06	2.08E-05
50	Protected Vegetables	2.36E-07	7.88E-07
75	Protected Vegetables	5.03E-07	1.68E-06
90	Protected Vegetables	9.58E-07	3.19E-06
95	Protected Vegetables	1.38E-06	4.58E-06
99	Protected Vegetables	2.67E-06	8.92E-06
50	Fish	5.55E-10	1.85E-09
75	Fish	2.18E-09	7.25E-09

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorofluoromethane

CAS: 75-69-4 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	7.08E-09	2.36E-08
95	Fish	1.33E-08	4.41E-08
99	Fish	4.93E-08	1.65E-07
50	Beef	4.06E-10	1.35E-09
75	Beef	7.81E-10	2.61E-09
90	Beef	1.50E-09	5.00E-09
95	Beef	2.08E-09	6.94E-09
99	Beef	4.06E-09	1.35E-08
50	Milk	7.63E-09	2.54E-08
75	Milk	1.73E-08	5.76E-08
90	Milk	3.15E-08	1.05E-07
95	Milk	4.48E-08	1.49E-07
99	Milk	7.81E-08	2.60E-07
50	Ground Water	8.15E-08	2.72E-07
75	Ground Water	1.75E-07	5.83E-07
90	Ground Water	3.57E-07	1.20E-06
95	Ground Water	5.93E-07	1.98E-06
99	Ground Water	1.44E-06	4.82E-06
50	Surface Water	8.43E-06	2.81E-05
75	Surface Water	1.80E-05	6.00E-05
90	Surface Water	3.25E-05	1.08E-04
95	Surface Water	4.58E-05	1.52E-04
99	Surface Water	8.85E-05	2.95E-04
50	Total Ingestion	1.18E-05	3.92E-05
75	Total Ingestion	2.19E-05	7.29E-05
90	Total Ingestion	3.61E-05	1.20E-04
95	Total Ingestion	5.10E-05	1.70E-04
99	Total Ingestion	9.23E-05	3.07E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorophenoxy) Propionic Acid, 2-(2,4,5-

CAS: 93-72-1 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	3.47E-14	4.33E-12
75	Soil	1.90E-13	2.37E-11
90	Soil	4.74E-13	5.93E-11
95	Soil	7.29E-13	9.11E-11
99	Soil	1.68E-12	2.10E-10
50	Root	2.41E-08	3.01E-06
75	Root	8.66E-08	1.08E-05
90	Root	2.63E-07	3.28E-05
95	Root	4.97E-07	6.21E-05
99	Root	1.83E-06	2.29E-04
50	Exposed Fruit	1.56E-10	1.94E-08
75	Exposed Fruit	4.93E-10	6.17E-08
90	Exposed Fruit	1.24E-09	1.55E-07
95	Exposed Fruit	2.05E-09	2.56E-07
99	Exposed Fruit	4.89E-09	6.11E-07
50	Exposed Vegetables	8.78E-11	1.10E-08
75	Exposed Vegetables	2.80E-10	3.50E-08
90	Exposed Vegetables	7.01E-10	8.76E-08
95	Exposed Vegetables	1.24E-09	1.55E-07
99	Exposed Vegetables	2.71E-09	3.39E-07
50	Protected Fruit	1.90E-10	2.37E-08
75	Protected Fruit	7.12E-10	8.91E-08
90	Protected Fruit	1.73E-09	2.17E-07
95	Protected Fruit	2.83E-09	3.54E-07
99	Protected Fruit	6.48E-09	8.11E-07
50	Protected Vegetables	1.12E-10	1.40E-08
75	Protected Vegetables	3.85E-10	4.82E-08
90	Protected Vegetables	9.45E-10	1.18E-07
95	Protected Vegetables	1.66E-09	2.07E-07
99	Protected Vegetables	4.23E-09	5.29E-07
50	Fish	5.98E-12	7.47E-10
75	Fish	2.59E-11	3.24E-09

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorophenoxy) Propionic Acid, 2-(2,4,5-

CAS: 93-72-1 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	8.77E-11	1.10E-08
95	Fish	1.59E-10	1.98E-08
99	Fish	5.32E-10	6.64E-08
50	Beef	1.25E-12	1.57E-10
75	Beef	3.78E-12	4.72E-10
90	Beef	8.79E-12	1.10E-09
95	Beef	1.37E-11	1.71E-09
99	Beef	2.96E-11	3.71E-09
50	Milk	9.41E-12	1.18E-09
75	Milk	2.78E-11	3.47E-09
90	Milk	6.48E-11	8.10E-09
95	Milk	1.07E-10	1.34E-08
99	Milk	1.79E-10	2.24E-08
90	Ground Water	5.20E-21	6.50E-19
95	Ground Water	1.47E-17	1.84E-15
99	Ground Water	2.67E-15	3.33E-13
50	Surface Water	9.11E-10	1.14E-07
75	Surface Water	2.25E-09	2.82E-07
90	Surface Water	4.43E-09	5.54E-07
95	Surface Water	6.23E-09	7.79E-07
99	Surface Water	1.14E-08	1.43E-06
50	Total Ingestion	2.80E-08	3.50E-06
75	Total Ingestion	9.02E-08	1.13E-05
90	Total Ingestion	2.68E-07	3.35E-05
95	Total Ingestion	5.05E-07	6.31E-05
99	Total Ingestion	1.84E-06	2.30E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorophenoxy) Propionic Acid, 2-(2,4,5-

CAS: 93-72-1 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	4.50E-13	5.63E-11
75	Soil	1.98E-12	2.48E-10
90	Soil	4.44E-12	5.55E-10
95	Soil	6.86E-12	8.57E-10
99	Soil	1.50E-11	1.87E-09
50	Root	3.65E-08	4.57E-06
75	Root	1.36E-07	1.70E-05
90	Root	4.39E-07	5.49E-05
95	Root	8.66E-07	1.08E-04
99	Root	2.79E-06	3.49E-04
50	Exposed Fruit	2.84E-10	3.55E-08
75	Exposed Fruit	7.46E-10	9.32E-08
90	Exposed Fruit	1.54E-09	1.93E-07
95	Exposed Fruit	2.29E-09	2.87E-07
99	Exposed Fruit	4.22E-09	5.28E-07
50	Exposed Vegetables	1.41E-10	1.76E-08
75	Exposed Vegetables	4.10E-10	5.13E-08
90	Exposed Vegetables	9.59E-10	1.20E-07
95	Exposed Vegetables	1.49E-09	1.86E-07
99	Exposed Vegetables	2.68E-09	3.35E-07
50	Protected Fruit	5.72E-10	7.15E-08
75	Protected Fruit	1.73E-09	2.17E-07
90	Protected Fruit	3.77E-09	4.72E-07
95	Protected Fruit	5.92E-09	7.40E-07
99	Protected Fruit	1.28E-08	1.60E-06
50	Protected Vegetables	3.07E-10	3.84E-08
75	Protected Vegetables	7.73E-10	9.66E-08
90	Protected Vegetables	1.56E-09	1.95E-07
95	Protected Vegetables	2.28E-09	2.85E-07
99	Protected Vegetables	4.47E-09	5.58E-07
50	Fish	3.53E-11	4.41E-09
75	Fish	1.42E-10	1.77E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorophenoxy) Propionic Acid, 2-(2,4,5-

CAS: 93-72-1 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	4.58E-10	5.72E-08
95	Fish	7.84E-10	9.80E-08
99	Fish	2.72E-09	3.40E-07
50	Beef	2.79E-12	3.48E-10
75	Beef	7.33E-12	9.17E-10
90	Beef	1.62E-11	2.03E-09
95	Beef	2.63E-11	3.29E-09
99	Beef	5.51E-11	6.89E-09
50	Milk	4.12E-11	5.15E-09
75	Milk	1.20E-10	1.50E-08
90	Milk	2.65E-10	3.31E-08
95	Milk	4.03E-10	5.04E-08
99	Milk	7.65E-10	9.56E-08
90	Ground Water	1.73E-20	2.17E-18
95	Ground Water	5.77E-17	7.21E-15
99	Ground Water	5.23E-15	6.53E-13
50	Surface Water	2.71E-09	3.38E-07
75	Surface Water	6.17E-09	7.71E-07
90	Surface Water	1.14E-08	1.43E-06
95	Surface Water	1.60E-08	2.00E-06
99	Surface Water	2.85E-08	3.57E-06
50	Total Ingestion	4.58E-08	5.72E-06
75	Total Ingestion	1.46E-07	1.82E-05
90	Total Ingestion	4.45E-07	5.57E-05
95	Total Ingestion	8.81E-07	1.10E-04
99	Total Ingestion	2.81E-06	3.52E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorophenoxyacetic Acid, 2,4,5-

CAS: 93-76-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	4.39E-14	4.39E-12
75	Soil	2.06E-13	2.06E-11
90	Soil	4.87E-13	4.87E-11
95	Soil	7.47E-13	7.47E-11
99	Soil	1.68E-12	1.68E-10
50	Root	2.27E-08	2.27E-06
75	Root	7.61E-08	7.61E-06
90	Root	2.48E-07	2.48E-05
95	Root	4.75E-07	4.75E-05
99	Root	1.78E-06	1.78E-04
50	Exposed Fruit	3.13E-10	3.13E-08
75	Exposed Fruit	9.59E-10	9.59E-08
90	Exposed Fruit	2.43E-09	2.43E-07
95	Exposed Fruit	4.43E-09	4.43E-07
99	Exposed Fruit	1.15E-08	1.15E-06
50	Exposed Vegetables	1.92E-10	1.92E-08
75	Exposed Vegetables	5.80E-10	5.80E-08
90	Exposed Vegetables	1.43E-09	1.43E-07
95	Exposed Vegetables	2.58E-09	2.58E-07
99	Exposed Vegetables	6.12E-09	6.12E-07
50	Protected Fruit	3.79E-10	3.79E-08
75	Protected Fruit	1.41E-09	1.41E-07
90	Protected Fruit	3.55E-09	3.55E-07
95	Protected Fruit	5.70E-09	5.70E-07
99	Protected Fruit	1.30E-08	1.30E-06
50	Protected Vegetables	2.28E-10	2.28E-08
75	Protected Vegetables	7.54E-10	7.54E-08
90	Protected Vegetables	1.97E-09	1.97E-07
95	Protected Vegetables	3.36E-09	3.36E-07
99	Protected Vegetables	9.08E-09	9.08E-07
50	Fish	8.99E-12	8.99E-10
75	Fish	4.11E-11	4.11E-09

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorophenoxyacetic Acid, 2,4,5-

CAS: 93-76-5 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.38E-10	1.38E-08
95	Fish	2.57E-10	2.57E-08
99	Fish	8.19E-10	8.19E-08
50	Beef	7.99E-13	7.99E-11
75	Beef	2.24E-12	2.24E-10
90	Beef	5.43E-12	5.43E-10
95	Beef	8.75E-12	8.75E-10
99	Beef	1.96E-11	1.96E-09
50	Milk	6.21E-12	6.21E-10
75	Milk	1.74E-11	1.74E-09
90	Milk	3.93E-11	3.93E-09
95	Milk	6.46E-11	6.46E-09
99	Milk	1.28E-10	1.28E-08
75	Ground Water	1.29E-19	1.29E-17
90	Ground Water	1.72E-16	1.72E-14
95	Ground Water	5.02E-14	5.02E-12
99	Ground Water	1.33E-12	1.33E-10
50	Surface Water	1.63E-09	1.63E-07
75	Surface Water	3.97E-09	3.97E-07
90	Surface Water	7.70E-09	7.70E-07
95	Surface Water	1.09E-08	1.09E-06
99	Surface Water	1.93E-08	1.93E-06
50	Total Ingestion	3.02E-08	3.02E-06
75	Total Ingestion	8.48E-08	8.48E-06
90	Total Ingestion	2.59E-07	2.59E-05
95	Total Ingestion	4.94E-07	4.94E-05
99	Total Ingestion	1.80E-06	1.80E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorophenoxyacetic Acid, 2,4,5-

CAS: 93-76-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	5.15E-13	5.15E-11
75	Soil	2.23E-12	2.23E-10
90	Soil	4.97E-12	4.97E-10
95	Soil	7.42E-12	7.42E-10
99	Soil	1.59E-11	1.59E-09
50	Root	3.32E-08	3.32E-06
75	Root	1.23E-07	1.23E-05
90	Root	4.01E-07	4.01E-05
95	Root	7.93E-07	7.93E-05
99	Root	2.59E-06	2.59E-04
50	Exposed Fruit	5.52E-10	5.52E-08
75	Exposed Fruit	1.48E-09	1.48E-07
90	Exposed Fruit	3.15E-09	3.15E-07
95	Exposed Fruit	4.90E-09	4.90E-07
99	Exposed Fruit	9.77E-09	9.77E-07
50	Exposed Vegetables	2.75E-10	2.75E-08
75	Exposed Vegetables	8.17E-10	8.17E-08
90	Exposed Vegetables	1.89E-09	1.89E-07
95	Exposed Vegetables	3.04E-09	3.04E-07
99	Exposed Vegetables	6.13E-09	6.13E-07
50	Protected Fruit	1.13E-09	1.13E-07
75	Protected Fruit	3.37E-09	3.37E-07
90	Protected Fruit	7.66E-09	7.66E-07
95	Protected Fruit	1.24E-08	1.24E-06
99	Protected Fruit	2.97E-08	2.97E-06
50	Protected Vegetables	5.99E-10	5.99E-08
75	Protected Vegetables	1.49E-09	1.49E-07
90	Protected Vegetables	3.33E-09	3.33E-07
95	Protected Vegetables	4.76E-09	4.76E-07
99	Protected Vegetables	9.77E-09	9.77E-07
50	Fish	5.59E-11	5.59E-09
75	Fish	2.25E-10	2.25E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Trichlorophenoxyacetic Acid, 2,4,5-

CAS: 93-76-5 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	7.43E-10	7.43E-08
95	Fish	1.27E-09	1.27E-07
99	Fish	4.05E-09	4.05E-07
50	Beef	1.66E-12	1.66E-10
75	Beef	4.55E-12	4.55E-10
90	Beef	1.03E-11	1.03E-09
95	Beef	1.71E-11	1.71E-09
99	Beef	3.47E-11	3.47E-09
50	Milk	2.50E-11	2.50E-09
75	Milk	7.17E-11	7.17E-09
90	Milk	1.68E-10	1.68E-08
95	Milk	2.58E-10	2.58E-08
99	Milk	5.11E-10	5.11E-08
75	Ground Water	3.80E-19	3.80E-17
90	Ground Water	5.70E-16	5.70E-14
95	Ground Water	2.17E-13	2.17E-11
99	Ground Water	2.79E-12	2.79E-10
50	Surface Water	4.72E-09	4.72E-07
75	Surface Water	1.05E-08	1.05E-06
90	Surface Water	1.99E-08	1.99E-06
95	Surface Water	2.80E-08	2.80E-06
99	Surface Water	4.88E-08	4.88E-06
50	Total Ingestion	5.03E-08	5.03E-06
75	Total Ingestion	1.42E-07	1.42E-05
90	Total Ingestion	4.21E-07	4.21E-05
95	Total Ingestion	8.14E-07	8.14E-05
99	Total Ingestion	2.61E-06	2.61E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Xylenes

CAS: 1330-20-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.44E-12	7.20E-12
75	Soil	3.22E-12	1.60E-11
90	Soil	5.95E-12	2.98E-11
95	Soil	8.30E-12	4.14E-11
99	Soil	1.54E-11	7.68E-11
50	Root	4.56E-07	2.27E-06
75	Root	1.20E-06	6.00E-06
90	Root	2.88E-06	1.44E-05
95	Root	4.80E-06	2.40E-05
99	Root	1.26E-05	6.29E-05
50	Exposed Fruit	7.28E-07	3.63E-06
75	Exposed Fruit	1.74E-06	8.74E-06
90	Exposed Fruit	3.65E-06	1.82E-05
95	Exposed Fruit	5.73E-06	2.86E-05
99	Exposed Fruit	1.15E-05	5.76E-05
50	Exposed Vegetables	3.95E-07	1.98E-06
75	Exposed Vegetables	1.03E-06	5.14E-06
90	Exposed Vegetables	2.27E-06	1.13E-05
95	Exposed Vegetables	3.12E-06	1.56E-05
99	Exposed Vegetables	6.59E-06	3.30E-05
50	Protected Fruit	5.54E-07	2.77E-06
75	Protected Fruit	1.66E-06	8.30E-06
90	Protected Fruit	3.41E-06	1.71E-05
95	Protected Fruit	5.18E-06	2.59E-05
99	Protected Fruit	8.26E-06	4.13E-05
50	Protected Vegetables	3.26E-07	1.63E-06
75	Protected Vegetables	8.08E-07	4.05E-06
90	Protected Vegetables	1.79E-06	8.98E-06
95	Protected Vegetables	2.85E-06	1.42E-05
99	Protected Vegetables	5.47E-06	2.74E-05
50	Fish	9.38E-10	4.69E-09
75	Fish	4.26E-09	2.13E-08

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Xylenes

CAS: 1330-20-7 **PathwayCategory:** Ingestion **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	1.51E-08	7.55E-08
95	Fish	2.96E-08	1.48E-07
99	Fish	1.05E-07	5.26E-07
50	Beef	2.37E-09	1.18E-08
75	Beef	5.17E-09	2.59E-08
90	Beef	9.84E-09	4.91E-08
95	Beef	1.36E-08	6.80E-08
99	Beef	2.74E-08	1.37E-07
50	Milk	1.24E-08	6.21E-08
75	Milk	2.78E-08	1.40E-07
90	Milk	5.10E-08	2.54E-07
95	Milk	6.85E-08	3.42E-07
99	Milk	9.98E-08	4.99E-07
50	Ground Water	1.65E-10	8.27E-10
75	Ground Water	2.22E-09	1.11E-08
90	Ground Water	6.77E-09	3.39E-08
95	Ground Water	1.21E-08	6.08E-08
99	Ground Water	2.54E-08	1.27E-07
50	Surface Water	7.86E-06	3.94E-05
75	Surface Water	1.74E-05	8.74E-05
90	Surface Water	3.50E-05	1.74E-04
95	Surface Water	4.93E-05	2.46E-04
99	Surface Water	9.95E-05	4.98E-04
50	Total Ingestion	1.40E-05	7.01E-05
75	Total Ingestion	2.53E-05	1.27E-04
90	Total Ingestion	4.27E-05	2.14E-04
95	Total Ingestion	5.84E-05	2.93E-04
99	Total Ingestion	1.10E-04	5.50E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Xylenes

CAS: 1330-20-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Soil	1.54E-11	7.71E-11
75	Soil	3.15E-11	1.58E-10
90	Soil	5.36E-11	2.69E-10
95	Soil	7.26E-11	3.63E-10
99	Soil	1.46E-10	7.31E-10
50	Root	6.75E-07	3.38E-06
75	Root	2.00E-06	9.97E-06
90	Root	4.98E-06	2.48E-05
95	Root	8.69E-06	4.34E-05
99	Root	2.27E-05	1.14E-04
50	Exposed Fruit	1.32E-06	6.61E-06
75	Exposed Fruit	2.46E-06	1.23E-05
90	Exposed Fruit	4.10E-06	2.05E-05
95	Exposed Fruit	5.49E-06	2.75E-05
99	Exposed Fruit	8.69E-06	4.34E-05
50	Exposed Vegetables	6.32E-07	3.15E-06
75	Exposed Vegetables	1.43E-06	7.14E-06
90	Exposed Vegetables	2.58E-06	1.29E-05
95	Exposed Vegetables	3.58E-06	1.79E-05
99	Exposed Vegetables	6.30E-06	3.15E-05
50	Protected Fruit	1.71E-06	8.53E-06
75	Protected Fruit	3.81E-06	1.90E-05
90	Protected Fruit	6.96E-06	3.47E-05
95	Protected Fruit	9.71E-06	4.85E-05
99	Protected Fruit	1.41E-05	7.07E-05
50	Protected Vegetables	8.43E-07	4.22E-06
75	Protected Vegetables	1.50E-06	7.47E-06
90	Protected Vegetables	2.54E-06	1.27E-05
95	Protected Vegetables	3.47E-06	1.74E-05
99	Protected Vegetables	6.91E-06	3.46E-05
50	Fish	5.50E-09	2.75E-08
75	Fish	2.19E-08	1.10E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Xylenes

CAS: 1330-20-7 **PathwayCategory:** Ingestion **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
90	Fish	7.57E-08	3.79E-07
95	Fish	1.39E-07	6.96E-07
99	Fish	5.87E-07	2.94E-06
50	Beef	4.93E-09	2.46E-08
75	Beef	9.68E-09	4.85E-08
90	Beef	1.81E-08	9.01E-08
95	Beef	2.61E-08	1.31E-07
99	Beef	4.88E-08	2.43E-07
50	Milk	5.22E-08	2.61E-07
75	Milk	1.17E-07	5.82E-07
90	Milk	1.98E-07	9.89E-07
95	Milk	2.67E-07	1.34E-06
99	Milk	4.56E-07	2.27E-06
50	Ground Water	5.54E-10	2.77E-09
75	Ground Water	6.69E-09	3.34E-08
90	Ground Water	1.78E-08	8.90E-08
95	Ground Water	2.83E-08	1.41E-07
99	Ground Water	6.35E-08	3.17E-07
50	Surface Water	2.16E-05	1.08E-04
75	Surface Water	4.54E-05	2.27E-04
90	Surface Water	8.43E-05	4.22E-04
95	Surface Water	1.22E-04	6.08E-04
99	Surface Water	2.40E-04	1.20E-03
50	Total Ingestion	3.12E-05	1.56E-04
75	Total Ingestion	5.63E-05	2.82E-04
90	Total Ingestion	9.38E-05	4.69E-04
95	Total Ingestion	1.34E-04	6.69E-04
99	Total Ingestion	2.54E-04	1.27E-03

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Azinphos Methyl

CAS: 86-50-0 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	4.50E-05
75	Air	NA	5.75E-05
90	Air	NA	6.75E-05
95	Air	NA	7.47E-05
99	Air	NA	9.77E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Azinphos Methyl

CAS: 86-50-0 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	4.50E-05
75	Air	NA	5.75E-05
90	Air	NA	6.75E-05
95	Air	NA	7.47E-05
99	Air	NA	9.77E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Carbon Disulfide

CAS: 75-15-0 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	1.52E-06
75	Air	NA	1.86E-06
90	Air	NA	2.24E-06
95	Air	NA	2.47E-06
99	Air	NA	3.12E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Carbon Disulfide

CAS: 75-15-0 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	1.52E-06
75	Air	NA	1.86E-06
90	Air	NA	2.24E-06
95	Air	NA	2.47E-06
99	Air	NA	3.12E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorpyrifos

CAS: 2921-88-2 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	9.47E-06
75	Air	NA	1.80E-05
90	Air	NA	3.10E-05
95	Air	NA	4.34E-05
99	Air	NA	8.03E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Chlorpyrifos

CAS: 2921-88-2 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	9.47E-06
75	Air	NA	1.80E-05
90	Air	NA	3.10E-05
95	Air	NA	4.34E-05
99	Air	NA	8.03E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Diazinon

CAS: 333-41-5 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	2.64E-05
75	Air	NA	5.03E-05
90	Air	NA	8.15E-05
95	Air	NA	1.11E-04
99	Air	NA	1.93E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Diazinon

CAS: 333-41-5 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	2.64E-05
75	Air	NA	5.03E-05
90	Air	NA	8.15E-05
95	Air	NA	1.11E-04
99	Air	NA	1.93E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Manganese

CAS: 7439-96-5 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	1.28E-02
75	Air	NA	2.74E-02
90	Air	NA	4.62E-02
95	Air	NA	6.24E-02
99	Air	NA	1.17E-01

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Manganese

CAS: 7439-96-5 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	1.28E-02
75	Air	NA	2.74E-02
90	Air	NA	4.62E-02
95	Air	NA	6.24E-02
99	Air	NA	1.17E-01

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	2.65E-06
75	Air	NA	3.55E-06
90	Air	NA	4.73E-06
95	Air	NA	5.37E-06
99	Air	NA	7.20E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	2.65E-06
75	Air	NA	3.55E-06
90	Air	NA	4.73E-06
95	Air	NA	5.37E-06
99	Air	NA	7.20E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

MIBK

CAS: 108-10-1 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	8.76E-07
75	Air	NA	1.18E-06
90	Air	NA	1.56E-06
95	Air	NA	1.84E-06
99	Air	NA	2.45E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

MIBK

CAS: 108-10-1 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	8.76E-07
75	Air	NA	1.18E-06
90	Air	NA	1.56E-06
95	Air	NA	1.84E-06
99	Air	NA	2.45E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Naled

CAS: 300-76-5 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	4.67E-06
75	Air	NA	2.29E-05
90	Air	NA	5.12E-05
95	Air	NA	8.91E-05
99	Air	NA	1.54E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Naled

CAS: 300-76-5 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	4.67E-06
75	Air	NA	2.29E-05
90	Air	NA	5.12E-05
95	Air	NA	8.91E-05
99	Air	NA	1.54E-04

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Xylenes

CAS: 1330-20-7 **PathwayCategory:** Inhalation **Receptor:** Adult Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	3.34E-05
75	Air	NA	4.38E-05
90	Air	NA	5.52E-05
95	Air	NA	6.32E-05
99	Air	NA	8.54E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Xylenes

CAS: 1330-20-7 **PathwayCategory:** Inhalation **Receptor:** Child Farmer

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Air	NA	3.34E-05
75	Air	NA	4.38E-05
90	Air	NA	5.52E-05
95	Air	NA	6.32E-05
99	Air	NA	8.54E-05

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Azinphos Methyl

CAS: 86-50-0 **PathwayCategory:** Inhalation

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
75	Shower	NA	4.63E-12
90	Shower	NA	9.90E-11
95	Shower	NA	2.32E-10
99	Shower	NA	5.95E-10

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Carbon Disulfide

CAS: 75-15-0 **PathwayCategory:** Inhalation

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Shower	NA	2.84E-11
75	Shower	NA	1.81E-09
90	Shower	NA	1.59E-08
95	Shower	NA	5.13E-08
99	Shower	NA	1.92E-07

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3 **PathwayCategory:** Inhalation

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Shower	NA	6.38E-08
75	Shower	NA	4.14E-07
90	Shower	NA	1.55E-06
95	Shower	NA	2.55E-06
99	Shower	NA	4.90E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

MIBK

CAS: 108-10-1 **PathwayCategory:** Inhalation

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Shower	NA	9.32E-10
75	Shower	NA	5.90E-08
90	Shower	NA	5.97E-07
95	Shower	NA	1.08E-06
99	Shower	NA	2.20E-06

Table Q-C-1. Non-Cancer Risk Screening Hazard Quotients in the Agricultural Application

Xylenes

CAS: 1330-20-7 **PathwayCategory:** Inhalation

Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
50	Shower	NA	7.36E-08
75	Shower	NA	7.97E-07
90	Shower	NA	2.08E-06
95	Shower	NA	3.54E-06
99	Shower	NA	9.07E-06

Appendix R

Detailed Ecological Results

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Acetone

CAS: 67-64-1

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	1.47E-04
Aquatic Community	75	Direct Contact	4.18E-04
Aquatic Community	90	Direct Contact	8.30E-04
Aquatic Community	95	Direct Contact	1.17E-03
Aquatic Community	99	Direct Contact	2.31E-03
Aquatic Invertebrates	50	Direct Contact	2.00E-06
Aquatic Invertebrates	75	Direct Contact	5.70E-06
Aquatic Invertebrates	90	Direct Contact	1.13E-05
Aquatic Invertebrates	95	Direct Contact	1.60E-05
Aquatic Invertebrates	99	Direct Contact	3.15E-05
Aquatic Plants	50	Direct Contact	2.66E-06
Aquatic Plants	75	Direct Contact	7.56E-06
Aquatic Plants	90	Direct Contact	1.50E-05
Aquatic Plants	95	Direct Contact	2.11E-05
Aquatic Plants	99	Direct Contact	4.18E-05
Fish	50	Direct Contact	3.94E-07
Fish	75	Direct Contact	1.12E-06
Fish	90	Direct Contact	2.22E-06
Fish	95	Direct Contact	3.13E-06
Fish	99	Direct Contact	6.20E-06
Sediment Biota	50	Direct Contact	3.51E+01
Sediment Biota	75	Direct Contact	8.94E+01
Sediment Biota	90	Direct Contact	2.09E+02
Sediment Biota	95	Direct Contact	3.56E+02
Sediment Biota	99	Direct Contact	7.42E+02

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Acetophenone

CAS: 98-86-2

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Invertebrates	50	Direct Contact	3.52E-05
Aquatic Invertebrates	75	Direct Contact	6.37E-05
Aquatic Invertebrates	90	Direct Contact	9.14E-05
Aquatic Invertebrates	95	Direct Contact	1.09E-04
Aquatic Invertebrates	99	Direct Contact	1.42E-04
Aquatic Plants	50	Direct Contact	3.04E-05
Aquatic Plants	75	Direct Contact	5.50E-05
Aquatic Plants	90	Direct Contact	7.89E-05
Aquatic Plants	95	Direct Contact	9.42E-05
Aquatic Plants	99	Direct Contact	1.23E-04
Fish	50	Direct Contact	1.29E-05
Fish	75	Direct Contact	2.33E-05
Fish	90	Direct Contact	3.34E-05
Fish	95	Direct Contact	3.99E-05
Fish	99	Direct Contact	5.20E-05

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Anthracene

CAS: 120-12-7

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	2.71E-01
Aquatic Community	75	Direct Contact	4.18E-01
Aquatic Community	90	Direct Contact	5.43E-01
Aquatic Community	95	Direct Contact	6.32E-01
Aquatic Community	99	Direct Contact	8.32E-01
Sediment Biota	50	Direct Contact	1.56E+00
Sediment Biota	75	Direct Contact	1.99E+00
Sediment Biota	90	Direct Contact	2.53E+00
Sediment Biota	95	Direct Contact	2.90E+00
Sediment Biota	99	Direct Contact	3.92E+00

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Azinphos Methyl

CAS: 86-50-0

Receptor	Percentile	Pathway	Pathway HQ
Amphibians	50	Direct Contact	6.69E-08
Amphibians	75	Direct Contact	3.01E-07
Amphibians	90	Direct Contact	1.80E-06
Amphibians	95	Direct Contact	2.84E-06
Amphibians	99	Direct Contact	6.07E-06
Aquatic Invertebrates	50	Direct Contact	5.67E-04
Aquatic Invertebrates	75	Direct Contact	2.33E-03
Aquatic Invertebrates	90	Direct Contact	1.48E-02
Aquatic Invertebrates	95	Direct Contact	2.23E-02
Aquatic Invertebrates	99	Direct Contact	3.92E-02
Fish	50	Direct Contact	4.72E-03
Fish	75	Direct Contact	1.95E-02
Fish	90	Direct Contact	1.23E-01
Fish	95	Direct Contact	1.86E-01
Fish	99	Direct Contact	3.26E-01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Barium

CAS: 7440-39-3

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	5.63E+01
Aquatic Community	75	Direct Contact	1.09E+02
Aquatic Community	90	Direct Contact	1.88E+02
Aquatic Community	95	Direct Contact	2.36E+02
Aquatic Community	99	Direct Contact	3.49E+02
Soil Biota	50	Direct Contact	1.03E-01
Soil Biota	75	Direct Contact	1.34E-01
Soil Biota	90	Direct Contact	1.68E-01
Soil Biota	95	Direct Contact	1.89E-01
Soil Biota	99	Direct Contact	2.27E-01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Benzoic Acid

CAS: 65-85-0

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	6.89E-02
Aquatic Community	75	Direct Contact	1.22E-01
Aquatic Community	90	Direct Contact	1.79E-01
Aquatic Community	95	Direct Contact	2.22E-01
Aquatic Community	99	Direct Contact	2.95E-01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Beryllium

CAS: 7440-41-7

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	2.06E+00
Aquatic Community	75	Direct Contact	3.77E+00
Aquatic Community	90	Direct Contact	6.11E+00
Aquatic Community	95	Direct Contact	7.84E+00
Aquatic Community	99	Direct Contact	1.13E+01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Biphenyl, 1,1-

CAS: 92-52-4

Receptor	Percentile	Pathway	Pathway HQ
Sediment Biota	50	Direct Contact	2.18E-02
Sediment Biota	75	Direct Contact	3.97E-02
Sediment Biota	90	Direct Contact	6.48E-02
Sediment Biota	95	Direct Contact	8.57E-02
Sediment Biota	99	Direct Contact	1.22E-01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Butyl Benzyl Phthalate

CAS: 85-68-7

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	3.31E-04
Aquatic Community	75	Direct Contact	7.43E-04
Aquatic Community	90	Direct Contact	1.13E-03
Aquatic Community	95	Direct Contact	1.36E-03
Aquatic Community	99	Direct Contact	2.12E-03
Sediment Biota	50	Direct Contact	1.16E-03
Sediment Biota	75	Direct Contact	1.97E-03
Sediment Biota	90	Direct Contact	2.94E-03
Sediment Biota	95	Direct Contact	3.79E-03
Sediment Biota	99	Direct Contact	5.87E-03

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Carbon Disulfide

CAS: 75-15-0

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	1.84E-04
Aquatic Community	75	Direct Contact	3.74E-04
Aquatic Community	90	Direct Contact	6.55E-04
Aquatic Community	95	Direct Contact	8.61E-04
Aquatic Community	99	Direct Contact	1.47E-03
Sediment Biota	50	Direct Contact	4.43E-01
Sediment Biota	75	Direct Contact	7.13E-01
Sediment Biota	90	Direct Contact	1.32E+00
Sediment Biota	95	Direct Contact	1.94E+00
Sediment Biota	99	Direct Contact	4.53E+00

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Chloroaniline, 4-

CAS: 106-47-8

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Invertebrates	50	Direct Contact	4.34E-01
Aquatic Invertebrates	75	Direct Contact	6.68E-01
Aquatic Invertebrates	90	Direct Contact	9.72E-01
Aquatic Invertebrates	95	Direct Contact	1.30E+00
Aquatic Invertebrates	99	Direct Contact	2.17E+00
Aquatic Plants	50	Direct Contact	2.75E-04
Aquatic Plants	75	Direct Contact	4.56E-04
Aquatic Plants	90	Direct Contact	6.22E-04
Aquatic Plants	95	Direct Contact	7.19E-04
Aquatic Plants	99	Direct Contact	9.86E-04
Fish	50	Direct Contact	2.17E-02
Fish	75	Direct Contact	3.34E-02
Fish	90	Direct Contact	4.86E-02
Fish	95	Direct Contact	6.52E-02
Fish	99	Direct Contact	1.09E-01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Chlorobenzene

CAS: 108-90-7

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	7.80E-05
Aquatic Community	75	Direct Contact	1.80E-04
Aquatic Community	90	Direct Contact	2.93E-04
Aquatic Community	95	Direct Contact	3.89E-04
Aquatic Community	99	Direct Contact	7.02E-04
Sediment Biota	50	Direct Contact	2.09E-02
Sediment Biota	75	Direct Contact	3.85E-02
Sediment Biota	90	Direct Contact	7.27E-02
Sediment Biota	95	Direct Contact	1.06E-01
Sediment Biota	99	Direct Contact	2.26E-01
Soil Biota	50	Direct Contact	9.07E-05
Soil Biota	75	Direct Contact	1.07E-04
Soil Biota	90	Direct Contact	1.19E-04
Soil Biota	95	Direct Contact	1.25E-04
Soil Biota	99	Direct Contact	1.38E-04

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Chlorobenzilate

CAS: 510-15-6

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Invertebrates	50	Direct Contact	5.18E-07
Aquatic Invertebrates	75	Direct Contact	9.20E-07
Aquatic Invertebrates	90	Direct Contact	1.34E-06
Aquatic Invertebrates	95	Direct Contact	1.65E-06
Aquatic Invertebrates	99	Direct Contact	2.36E-06
Aquatic Plants	50	Direct Contact	5.76E-07
Aquatic Plants	75	Direct Contact	1.02E-06
Aquatic Plants	90	Direct Contact	1.48E-06
Aquatic Plants	95	Direct Contact	1.83E-06
Aquatic Plants	99	Direct Contact	2.63E-06
Fish	50	Direct Contact	1.73E-06
Fish	75	Direct Contact	3.07E-06
Fish	90	Direct Contact	4.45E-06
Fish	95	Direct Contact	5.49E-06
Fish	99	Direct Contact	7.88E-06

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Chlorpyrifos

CAS: 2921-88-2

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	2.95E-03
Aquatic Community	75	Direct Contact	5.32E-03
Aquatic Community	90	Direct Contact	7.83E-03
Aquatic Community	95	Direct Contact	9.84E-03
Aquatic Community	99	Direct Contact	1.41E-02
Aquatic Invertebrates	50	Direct Contact	2.35E-02
Aquatic Invertebrates	75	Direct Contact	3.80E-02
Aquatic Invertebrates	90	Direct Contact	5.49E-02
Aquatic Invertebrates	95	Direct Contact	6.47E-02
Aquatic Invertebrates	99	Direct Contact	8.37E-02
Fish	50	Direct Contact	2.03E-04
Fish	75	Direct Contact	3.28E-04
Fish	90	Direct Contact	4.73E-04
Fish	95	Direct Contact	5.58E-04
Fish	99	Direct Contact	7.21E-04

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Diazinon

CAS: 333-41-5

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	9.46E-03
Aquatic Community	75	Direct Contact	1.75E-02
Aquatic Community	90	Direct Contact	2.63E-02
Aquatic Community	95	Direct Contact	3.24E-02
Aquatic Community	99	Direct Contact	4.63E-02
Fish	50	Direct Contact	2.86E-05
Fish	75	Direct Contact	4.98E-05
Fish	90	Direct Contact	7.36E-05
Fish	95	Direct Contact	8.76E-05
Fish	99	Direct Contact	1.18E-04
Sediment Biota	50	Direct Contact	3.73E-01
Sediment Biota	75	Direct Contact	6.06E-01
Sediment Biota	90	Direct Contact	8.86E-01
Sediment Biota	95	Direct Contact	1.08E+00
Sediment Biota	99	Direct Contact	1.71E+00

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Dichloroethene, 1,2-trans-

CAS: 156-60-5

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	1.55E-06
Aquatic Community	75	Direct Contact	3.33E-06
Aquatic Community	90	Direct Contact	5.62E-06
Aquatic Community	95	Direct Contact	7.13E-06
Aquatic Community	99	Direct Contact	1.60E-05
Sediment Biota	50	Direct Contact	3.82E-03
Sediment Biota	75	Direct Contact	6.75E-03
Sediment Biota	90	Direct Contact	1.34E-02
Sediment Biota	95	Direct Contact	2.03E-02
Sediment Biota	99	Direct Contact	4.75E-02
Soil Biota	50	Direct Contact	2.09E-02
Soil Biota	75	Direct Contact	3.12E-02
Soil Biota	90	Direct Contact	3.81E-02
Soil Biota	95	Direct Contact	4.06E-02
Soil Biota	99	Direct Contact	4.28E-02

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Dichloromethane

CAS: 75-09-2

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	1.54E-04
Aquatic Community	75	Direct Contact	3.44E-04
Aquatic Community	90	Direct Contact	6.75E-04
Aquatic Community	95	Direct Contact	9.17E-04
Aquatic Community	99	Direct Contact	2.42E-03
Sediment Biota	50	Direct Contact	6.82E-02
Sediment Biota	75	Direct Contact	1.27E-01
Sediment Biota	90	Direct Contact	2.86E-01
Sediment Biota	95	Direct Contact	5.10E-01
Sediment Biota	99	Direct Contact	1.36E+00
Soil Biota	50	Direct Contact	9.06E-02
Soil Biota	75	Direct Contact	3.00E-01
Soil Biota	90	Direct Contact	3.91E-01
Soil Biota	95	Direct Contact	4.23E-01
Soil Biota	99	Direct Contact	4.48E-01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Endrin

CAS: 72-20-8

Receptor	Percentile	Pathway	Pathway HQ
Amphibians	50	Direct Contact	3.98E-03
Amphibians	75	Direct Contact	5.61E-03
Amphibians	90	Direct Contact	7.23E-03
Amphibians	95	Direct Contact	8.22E-03
Amphibians	99	Direct Contact	1.06E-02
Aquatic Community	50	Direct Contact	2.12E-02
Aquatic Community	75	Direct Contact	3.54E-02
Aquatic Community	90	Direct Contact	5.00E-02
Aquatic Community	95	Direct Contact	5.83E-02
Aquatic Community	99	Direct Contact	7.65E-02
Sediment Biota	50	Direct Contact	5.20E-01
Sediment Biota	75	Direct Contact	6.73E-01
Sediment Biota	90	Direct Contact	8.16E-01
Sediment Biota	95	Direct Contact	9.03E-01
Sediment Biota	99	Direct Contact	1.17E+00

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Ethyl p-nitrophenyl Phenylphosphorothioate

CAS: 2104-64-5

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Invertebrates	50	Direct Contact	1.84E-02
Aquatic Invertebrates	75	Direct Contact	3.30E-02
Aquatic Invertebrates	90	Direct Contact	4.92E-02
Aquatic Invertebrates	95	Direct Contact	5.75E-02
Aquatic Invertebrates	99	Direct Contact	7.98E-02
Fish	50	Direct Contact	2.60E-05
Fish	75	Direct Contact	5.27E-05
Fish	90	Direct Contact	8.00E-05
Fish	95	Direct Contact	9.53E-05
Fish	99	Direct Contact	1.21E-04

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Fluoranthene

CAS: 206-44-0

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	3.96E+00
Aquatic Community	75	Direct Contact	6.67E+00
Aquatic Community	90	Direct Contact	9.22E+00
Aquatic Community	95	Direct Contact	1.07E+01
Aquatic Community	99	Direct Contact	1.47E+01
Sediment Biota	50	Direct Contact	2.60E+00
Sediment Biota	75	Direct Contact	3.24E+00
Sediment Biota	90	Direct Contact	3.82E+00
Sediment Biota	95	Direct Contact	4.21E+00
Sediment Biota	99	Direct Contact	5.12E+00

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Hexachlorocyclohexane, alpha-

CAS: 319-84-6

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Invertebrates	50	Direct Contact	2.73E-06
Aquatic Invertebrates	75	Direct Contact	4.26E-06
Aquatic Invertebrates	90	Direct Contact	6.08E-06
Aquatic Invertebrates	95	Direct Contact	7.44E-06
Aquatic Invertebrates	99	Direct Contact	9.98E-06
Fish	50	Direct Contact	3.03E-07
Fish	75	Direct Contact	4.74E-07
Fish	90	Direct Contact	6.76E-07
Fish	95	Direct Contact	8.27E-07
Fish	99	Direct Contact	1.11E-06

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Hexachlorocyclohexane, beta-

CAS: 319-85-7

Receptor	Percentile	Pathway	Pathway HQ
Sediment Biota	50	Direct Contact	5.98E-03
Sediment Biota	75	Direct Contact	8.30E-03
Sediment Biota	90	Direct Contact	1.15E-02
Sediment Biota	95	Direct Contact	1.36E-02
Sediment Biota	99	Direct Contact	1.94E-02

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Manganese

CAS: 7439-96-5

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	5.13E+00
Aquatic Community	75	Direct Contact	8.13E+00
Aquatic Community	90	Direct Contact	1.16E+01
Aquatic Community	95	Direct Contact	1.39E+01
Aquatic Community	99	Direct Contact	1.87E+01
Soil Biota	50	Direct Contact	4.03E-01
Soil Biota	75	Direct Contact	5.44E-01
Soil Biota	90	Direct Contact	6.86E-01
Soil Biota	95	Direct Contact	7.77E-01
Soil Biota	99	Direct Contact	9.59E-01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	8.13E-06
Aquatic Community	75	Direct Contact	2.26E-05
Aquatic Community	90	Direct Contact	4.65E-05
Aquatic Community	95	Direct Contact	6.51E-05
Aquatic Community	99	Direct Contact	1.28E-04
Aquatic Invertebrates	50	Direct Contact	2.19E-06
Aquatic Invertebrates	75	Direct Contact	6.09E-06
Aquatic Invertebrates	90	Direct Contact	1.25E-05
Aquatic Invertebrates	95	Direct Contact	1.75E-05
Aquatic Invertebrates	99	Direct Contact	3.44E-05
Aquatic Plants	50	Direct Contact	2.53E-06
Aquatic Plants	75	Direct Contact	7.03E-06
Aquatic Plants	90	Direct Contact	1.45E-05
Aquatic Plants	95	Direct Contact	2.03E-05
Aquatic Plants	99	Direct Contact	3.98E-05
Fish	50	Direct Contact	5.18E-07
Fish	75	Direct Contact	1.44E-06
Fish	90	Direct Contact	2.96E-06
Fish	95	Direct Contact	4.15E-06
Fish	99	Direct Contact	8.13E-06
Sediment Biota	50	Direct Contact	5.82E-01
Sediment Biota	75	Direct Contact	1.44E+00
Sediment Biota	90	Direct Contact	3.49E+00
Sediment Biota	95	Direct Contact	5.76E+00
Sediment Biota	99	Direct Contact	1.25E+01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Naled

CAS: 300-76-5

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Plants	50	Direct Contact	6.89E-05
Aquatic Plants	75	Direct Contact	4.94E-04
Aquatic Plants	90	Direct Contact	1.50E-03
Aquatic Plants	95	Direct Contact	2.03E-03
Aquatic Plants	99	Direct Contact	2.84E-03
Fish	50	Direct Contact	3.87E-05
Fish	75	Direct Contact	2.59E-04
Fish	90	Direct Contact	7.81E-04
Fish	95	Direct Contact	1.06E-03
Fish	99	Direct Contact	1.53E-03

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Nitrosodiphenylamine, N-

CAS: 86-30-6

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	1.63E-05
Aquatic Community	75	Direct Contact	2.88E-05
Aquatic Community	90	Direct Contact	6.58E-05
Aquatic Community	95	Direct Contact	1.05E-04
Aquatic Community	99	Direct Contact	3.24E-04
Aquatic Invertebrates	50	Direct Contact	3.80E-05
Aquatic Invertebrates	75	Direct Contact	6.71E-05
Aquatic Invertebrates	90	Direct Contact	1.54E-04
Aquatic Invertebrates	95	Direct Contact	2.44E-04
Aquatic Invertebrates	99	Direct Contact	7.57E-04
Aquatic Plants	50	Direct Contact	4.89E-06
Aquatic Plants	75	Direct Contact	8.62E-06
Aquatic Plants	90	Direct Contact	1.98E-05
Aquatic Plants	95	Direct Contact	3.13E-05
Aquatic Plants	99	Direct Contact	9.74E-05
Fish	50	Direct Contact	3.42E-06
Fish	75	Direct Contact	6.03E-06
Fish	90	Direct Contact	1.39E-05
Fish	95	Direct Contact	2.20E-05
Fish	99	Direct Contact	6.78E-05
Soil Biota	50	Direct Contact	3.61E-03
Soil Biota	75	Direct Contact	4.21E-03
Soil Biota	90	Direct Contact	4.59E-03
Soil Biota	95	Direct Contact	4.72E-03
Soil Biota	99	Direct Contact	4.94E-03

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Phenol

CAS: 108-95-2

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Invertebrates	50	Direct Contact	1.73E-04
Aquatic Invertebrates	75	Direct Contact	3.22E-04
Aquatic Invertebrates	90	Direct Contact	4.69E-04
Aquatic Invertebrates	95	Direct Contact	5.64E-04
Aquatic Invertebrates	99	Direct Contact	7.36E-04
Aquatic Plants	50	Direct Contact	5.36E-05
Aquatic Plants	75	Direct Contact	9.95E-05
Aquatic Plants	90	Direct Contact	1.45E-04
Aquatic Plants	95	Direct Contact	1.74E-04
Aquatic Plants	99	Direct Contact	2.28E-04
Fish	50	Direct Contact	2.74E-03
Fish	75	Direct Contact	5.09E-03
Fish	90	Direct Contact	7.42E-03
Fish	95	Direct Contact	8.91E-03
Fish	99	Direct Contact	1.17E-02
Sediment Biota	50	Direct Contact	2.88E+01
Sediment Biota	75	Direct Contact	4.93E+01
Sediment Biota	90	Direct Contact	7.88E+01
Sediment Biota	95	Direct Contact	1.02E+02
Sediment Biota	99	Direct Contact	1.82E+02
Soil Biota	50	Direct Contact	8.05E-04
Soil Biota	75	Direct Contact	1.96E-03
Soil Biota	90	Direct Contact	2.46E-03
Soil Biota	95	Direct Contact	2.63E-03
Soil Biota	99	Direct Contact	2.78E-03

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Pyrene

CAS: 129-00-0

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	1.40E+01
Aquatic Community	75	Direct Contact	2.47E+01
Aquatic Community	90	Direct Contact	3.60E+01
Aquatic Community	95	Direct Contact	4.19E+01
Aquatic Community	99	Direct Contact	5.68E+01
Sediment Biota	50	Direct Contact	1.25E+01
Sediment Biota	75	Direct Contact	1.59E+01
Sediment Biota	90	Direct Contact	1.91E+01
Sediment Biota	95	Direct Contact	2.11E+01
Sediment Biota	99	Direct Contact	2.48E+01
Soil Biota	50	Direct Contact	3.03E+00
Soil Biota	75	Direct Contact	3.66E+00
Soil Biota	90	Direct Contact	4.22E+00
Soil Biota	95	Direct Contact	4.52E+00
Soil Biota	99	Direct Contact	4.92E+00

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Silver

CAS: 7440-22-4

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Community	50	Direct Contact	7.33E+01
Aquatic Community	75	Direct Contact	1.33E+02
Aquatic Community	90	Direct Contact	1.97E+02
Aquatic Community	95	Direct Contact	2.47E+02
Aquatic Community	99	Direct Contact	3.57E+02
Aquatic Invertebrates	50	Direct Contact	1.31E+01
Aquatic Invertebrates	75	Direct Contact	1.83E+01
Aquatic Invertebrates	90	Direct Contact	2.39E+01
Aquatic Invertebrates	95	Direct Contact	2.82E+01
Aquatic Invertebrates	99	Direct Contact	3.74E+01
Fish	50	Direct Contact	1.95E+00
Fish	75	Direct Contact	2.91E+00
Fish	90	Direct Contact	3.97E+00
Fish	95	Direct Contact	4.79E+00
Fish	99	Direct Contact	6.40E+00
Soil Biota	50	Direct Contact	1.99E-01
Soil Biota	75	Direct Contact	2.59E-01
Soil Biota	90	Direct Contact	3.20E-01
Soil Biota	95	Direct Contact	3.63E-01
Soil Biota	99	Direct Contact	4.32E-01

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Trichlorophenoxyacetic Acid, 2,4,5-

CAS: 93-76-5

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Invertebrates	50	Direct Contact	1.20E-06
Aquatic Invertebrates	75	Direct Contact	1.95E-06
Aquatic Invertebrates	90	Direct Contact	2.79E-06
Aquatic Invertebrates	95	Direct Contact	3.48E-06
Aquatic Invertebrates	99	Direct Contact	5.87E-06
Fish	50	Direct Contact	4.00E-05
Fish	75	Direct Contact	6.49E-05
Fish	90	Direct Contact	9.29E-05
Fish	95	Direct Contact	1.16E-04
Fish	99	Direct Contact	1.96E-04

Table R-1. Ecological Screening Hazard Quotients for Direct Contact

Trifluralin

CAS: 1582-09-8

Receptor	Percentile	Pathway	Pathway HQ
Aquatic Invertebrates	50	Direct Contact	2.53E-05
Aquatic Invertebrates	75	Direct Contact	4.86E-05
Aquatic Invertebrates	90	Direct Contact	7.24E-05
Aquatic Invertebrates	95	Direct Contact	8.99E-05
Aquatic Invertebrates	99	Direct Contact	1.28E-04
Aquatic Plants	50	Direct Contact	1.12E-05
Aquatic Plants	75	Direct Contact	1.86E-05
Aquatic Plants	90	Direct Contact	2.83E-05
Aquatic Plants	95	Direct Contact	3.57E-05
Aquatic Plants	99	Direct Contact	5.20E-05
Fish	50	Direct Contact	3.09E-04
Fish	75	Direct Contact	5.11E-04
Fish	90	Direct Contact	7.80E-04
Fish	95	Direct Contact	9.83E-04
Fish	99	Direct Contact	1.43E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Acetone

CAS: 67-64-1

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Black Bear	50	Ingestion	1.80E-02	3.53E-04
Black Bear	75	Ingestion	8.93E-02	1.75E-03
Black Bear	90	Ingestion	1.21E-01	2.37E-03
Black Bear	95	Ingestion	1.31E-01	2.56E-03
Black Bear	99	Ingestion	1.39E-01	2.72E-03
Coyote	50	Ingestion	1.17E-02	1.29E-04
Coyote	75	Ingestion	5.83E-02	6.45E-04
Coyote	90	Ingestion	7.89E-02	8.73E-04
Coyote	95	Ingestion	8.53E-02	9.44E-04
Coyote	99	Ingestion	9.08E-02	1.00E-03
Deer Mouse	50	Ingestion	8.75E-02	1.91E-04
Deer Mouse	75	Ingestion	4.43E-01	9.68E-04
Deer Mouse	90	Ingestion	6.00E-01	1.31E-03
Deer Mouse	95	Ingestion	6.49E-01	1.42E-03
Deer Mouse	99	Ingestion	6.90E-01	1.51E-03
Eastern Cottontail	50	Ingestion	6.50E-02	3.98E-04
Eastern Cottontail	75	Ingestion	3.10E-01	1.89E-03
Eastern Cottontail	90	Ingestion	4.19E-01	2.56E-03
Eastern Cottontail	95	Ingestion	4.53E-01	2.77E-03
Eastern Cottontail	99	Ingestion	4.81E-01	2.94E-03
Least Weasel	50	Ingestion	1.74E-02	4.54E-05
Least Weasel	75	Ingestion	8.53E-02	2.23E-04
Least Weasel	90	Ingestion	1.15E-01	3.02E-04
Least Weasel	95	Ingestion	1.25E-01	3.27E-04
Least Weasel	99	Ingestion	1.33E-01	3.48E-04
Little Brown Bat	50	Ingestion	2.26E-02	4.04E-05
Little Brown Bat	75	Ingestion	1.11E-01	1.99E-04

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Acetone

CAS: 67-64-1

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Little Brown Bat	90	Ingestion	1.50E-01	2.69E-04
Little Brown Bat	95	Ingestion	1.63E-01	2.91E-04
Little Brown Bat	99	Ingestion	1.73E-01	3.10E-04
Long Tailed Weasel	50	Ingestion	1.35E-02	5.16E-05
Long Tailed Weasel	75	Ingestion	6.61E-02	2.53E-04
Long Tailed Weasel	90	Ingestion	8.94E-02	3.43E-04
Long Tailed Weasel	95	Ingestion	9.69E-02	3.71E-04
Long Tailed Weasel	99	Ingestion	1.03E-01	3.95E-04
Meadow Vole	50	Ingestion	1.28E-01	2.84E-04
Meadow Vole	75	Ingestion	6.91E-01	1.53E-03
Meadow Vole	90	Ingestion	1.04E+00	2.29E-03
Meadow Vole	95	Ingestion	1.29E+00	2.86E-03
Meadow Vole	99	Ingestion	2.15E+00	4.76E-03
Mink	50	Ingestion	1.50E-02	8.73E-05
Mink	75	Ingestion	3.49E-02	2.02E-04
Mink	90	Ingestion	7.97E-02	4.62E-04
Mink	95	Ingestion	1.34E-01	7.78E-04
Mink	99	Ingestion	2.76E-01	1.60E-03
Muskrat	50	Ingestion	3.96E-02	2.22E-04
Muskrat	75	Ingestion	9.92E-02	5.57E-04
Muskrat	90	Ingestion	1.30E-01	7.28E-04
Muskrat	95	Ingestion	1.41E-01	7.90E-04
Muskrat	99	Ingestion	1.56E-01	8.78E-04
Prairie Vole	50	Ingestion	1.17E-01	3.07E-04
Prairie Vole	75	Ingestion	6.28E-01	1.65E-03
Prairie Vole	90	Ingestion	9.39E-01	2.47E-03
Prairie Vole	95	Ingestion	1.16E+00	3.05E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Acetone

CAS: 67-64-1

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Prairie Vole	99	Ingestion	1.92E+00	5.04E-03
Raccoon	50	Ingestion	7.20E-02	6.47E-04
Raccoon	75	Ingestion	1.85E-01	1.66E-03
Raccoon	90	Ingestion	2.40E-01	2.16E-03
Raccoon	95	Ingestion	2.60E-01	2.33E-03
Raccoon	99	Ingestion	2.97E-01	2.67E-03
Red Fox	50	Ingestion	2.28E-02	1.94E-04
Red Fox	75	Ingestion	1.14E-01	9.70E-04
Red Fox	90	Ingestion	1.55E-01	1.31E-03
Red Fox	95	Ingestion	1.68E-01	1.42E-03
Red Fox	99	Ingestion	1.78E-01	1.51E-03
Short Tail Weasel	50	Ingestion	1.33E-02	5.19E-05
Short Tail Weasel	75	Ingestion	6.53E-02	2.55E-04
Short Tail Weasel	90	Ingestion	8.84E-02	3.45E-04
Short Tail Weasel	95	Ingestion	9.57E-02	3.73E-04
Short Tail Weasel	99	Ingestion	1.02E-01	3.97E-04
Short Tailed Shrew	50	Ingestion	3.79E-02	7.70E-05
Short Tailed Shrew	75	Ingestion	1.89E-01	3.84E-04
Short Tailed Shrew	90	Ingestion	2.56E-01	5.20E-04
Short Tailed Shrew	95	Ingestion	2.76E-01	5.62E-04
Short Tailed Shrew	99	Ingestion	2.94E-01	5.99E-04
White Tailed Deer	50	Ingestion	2.31E-02	3.87E-04
White Tailed Deer	75	Ingestion	1.09E-01	1.84E-03
White Tailed Deer	90	Ingestion	1.48E-01	2.48E-03
White Tailed Deer	95	Ingestion	1.60E-01	2.68E-03
White Tailed Deer	99	Ingestion	1.70E-01	2.86E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Barium

CAS: 7440-39-3

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
American Kestrel	50	Ingestion	1.15E+00	3.83E-02
American Kestrel	75	Ingestion	1.49E+00	4.97E-02
American Kestrel	90	Ingestion	1.86E+00	6.20E-02
American Kestrel	95	Ingestion	2.08E+00	6.92E-02
American Kestrel	99	Ingestion	2.48E+00	8.26E-02
American Robin	50	Ingestion	9.40E-01	3.13E-02
American Robin	75	Ingestion	1.22E+00	4.07E-02
American Robin	90	Ingestion	1.52E+00	5.06E-02
American Robin	95	Ingestion	1.69E+00	5.64E-02
American Robin	99	Ingestion	2.02E+00	6.75E-02
American Woodcock	50	Ingestion	4.30E+00	1.43E-01
American Woodcock	75	Ingestion	5.60E+00	1.87E-01
American Woodcock	90	Ingestion	7.02E+00	2.34E-01
American Woodcock	95	Ingestion	7.87E+00	2.62E-01
American Woodcock	99	Ingestion	9.45E+00	3.15E-01
Belted Kingfisher	50	Ingestion	6.12E+00	2.04E-01
Belted Kingfisher	75	Ingestion	8.80E+00	2.93E-01
Belted Kingfisher	90	Ingestion	1.20E+01	3.99E-01
Belted Kingfisher	95	Ingestion	1.40E+01	4.67E-01
Belted Kingfisher	99	Ingestion	1.89E+01	6.31E-01
Canada Goose	50	Ingestion	1.23E+00	4.11E-02
Canada Goose	75	Ingestion	1.60E+00	5.33E-02
Canada Goose	90	Ingestion	2.01E+00	6.68E-02
Canada Goose	95	Ingestion	2.24E+00	7.47E-02
Canada Goose	99	Ingestion	2.68E+00	8.94E-02
Coopers Hawk	50	Ingestion	7.85E-01	2.62E-02
Coopers Hawk	75	Ingestion	1.02E+00	3.39E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Barium

CAS: 7440-39-3

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Coopers Hawk	90	Ingestion	1.27E+00	4.24E-02
Coopers Hawk	95	Ingestion	1.42E+00	4.73E-02
Coopers Hawk	99	Ingestion	1.69E+00	5.65E-02
Great Blue Heron	50	Ingestion	3.61E+00	1.20E-01
Great Blue Heron	75	Ingestion	5.24E+00	1.75E-01
Great Blue Heron	90	Ingestion	7.16E+00	2.39E-01
Great Blue Heron	95	Ingestion	8.42E+00	2.81E-01
Great Blue Heron	99	Ingestion	1.15E+01	3.82E-01
Green Heron	50	Ingestion	7.93E+00	2.64E-01
Green Heron	75	Ingestion	1.16E+01	3.87E-01
Green Heron	90	Ingestion	1.60E+01	5.33E-01
Green Heron	95	Ingestion	1.89E+01	6.29E-01
Green Heron	99	Ingestion	2.57E+01	8.56E-01
Mallard Duck	50	Ingestion	1.56E+00	5.19E-02
Mallard Duck	75	Ingestion	2.30E+00	7.65E-02
Mallard Duck	90	Ingestion	3.20E+00	1.07E-01
Mallard Duck	95	Ingestion	3.74E+00	1.25E-01
Mallard Duck	99	Ingestion	5.13E+00	1.71E-01
Northern Bobwhite	50	Ingestion	3.49E+00	1.16E-01
Northern Bobwhite	75	Ingestion	4.54E+00	1.51E-01
Northern Bobwhite	90	Ingestion	5.69E+00	1.90E-01
Northern Bobwhite	95	Ingestion	6.38E+00	2.13E-01
Northern Bobwhite	99	Ingestion	7.65E+00	2.55E-01
Red Tailed Hawk	50	Ingestion	5.40E-01	1.80E-02
Red Tailed Hawk	75	Ingestion	7.01E-01	2.34E-02
Red Tailed Hawk	90	Ingestion	8.75E-01	2.92E-02
Red Tailed Hawk	95	Ingestion	9.77E-01	3.26E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Barium

CAS: 7440-39-3

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Red Tailed Hawk	99	Ingestion	1.17E+00	3.89E-02
Tree Swallow	50	Ingestion	1.80E+00	5.99E-02
Tree Swallow	75	Ingestion	2.33E+00	7.76E-02
Tree Swallow	90	Ingestion	2.90E+00	9.67E-02
Tree Swallow	95	Ingestion	3.24E+00	1.08E-01
Tree Swallow	99	Ingestion	3.88E+00	1.29E-01
Western Meadowlark	50	Ingestion	5.90E-01	1.97E-02
Western Meadowlark	75	Ingestion	7.63E-01	2.54E-02
Western Meadowlark	90	Ingestion	9.47E-01	3.16E-02
Western Meadowlark	95	Ingestion	1.06E+00	3.52E-02
Western Meadowlark	99	Ingestion	1.27E+00	4.24E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Chlorpyrifos

CAS: 2921-88-2

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Black Bear	50	Ingestion	1.55E-05	4.50E-07
Black Bear	75	Ingestion	1.80E-05	5.23E-07
Black Bear	90	Ingestion	1.97E-05	5.71E-07
Black Bear	95	Ingestion	2.06E-05	5.98E-07
Black Bear	99	Ingestion	2.23E-05	6.46E-07
Coyote	50	Ingestion	4.54E-05	7.43E-07
Coyote	75	Ingestion	5.29E-05	8.68E-07
Coyote	90	Ingestion	5.76E-05	9.44E-07
Coyote	95	Ingestion	5.93E-05	9.73E-07
Coyote	99	Ingestion	6.21E-05	1.02E-06
Deer Mouse	50	Ingestion	5.64E-05	1.82E-07
Deer Mouse	75	Ingestion	6.57E-05	2.13E-07
Deer Mouse	90	Ingestion	7.15E-05	2.32E-07
Deer Mouse	95	Ingestion	7.36E-05	2.38E-07
Deer Mouse	99	Ingestion	7.71E-05	2.50E-07
Eastern Cottontail	50	Ingestion	5.77E-06	5.23E-08
Eastern Cottontail	75	Ingestion	6.77E-06	6.14E-08
Eastern Cottontail	90	Ingestion	7.37E-06	6.68E-08
Eastern Cottontail	95	Ingestion	7.63E-06	6.92E-08
Eastern Cottontail	99	Ingestion	8.08E-06	7.32E-08
Least Weasel	50	Ingestion	1.42E-04	5.50E-07
Least Weasel	75	Ingestion	1.66E-04	6.42E-07
Least Weasel	90	Ingestion	1.80E-04	6.99E-07
Least Weasel	95	Ingestion	1.86E-04	7.20E-07
Least Weasel	99	Ingestion	1.95E-04	7.54E-07
Little Brown Bat	50	Ingestion	1.85E-04	4.90E-07
Little Brown Bat	75	Ingestion	2.16E-04	5.72E-07

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Chlorpyrifos

CAS: 2921-88-2

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Little Brown Bat	90	Ingestion	2.35E-04	6.23E-07
Little Brown Bat	95	Ingestion	2.42E-04	6.41E-07
Little Brown Bat	99	Ingestion	2.53E-04	6.71E-07
Long Tailed Weasel	50	Ingestion	1.10E-04	6.25E-07
Long Tailed Weasel	75	Ingestion	1.29E-04	7.30E-07
Long Tailed Weasel	90	Ingestion	1.40E-04	7.94E-07
Long Tailed Weasel	95	Ingestion	1.44E-04	8.18E-07
Long Tailed Weasel	99	Ingestion	1.51E-04	8.56E-07
Meadow Vole	50	Ingestion	7.69E-06	2.52E-08
Meadow Vole	75	Ingestion	9.56E-06	3.13E-08
Meadow Vole	90	Ingestion	1.18E-05	3.86E-08
Meadow Vole	95	Ingestion	1.39E-05	4.56E-08
Meadow Vole	99	Ingestion	2.18E-05	7.14E-08
Mink	50	Ingestion	8.30E-05	7.13E-07
Mink	75	Ingestion	1.37E-04	1.18E-06
Mink	90	Ingestion	1.93E-04	1.66E-06
Mink	95	Ingestion	2.37E-04	2.04E-06
Mink	99	Ingestion	3.31E-04	2.84E-06
Muskrat	50	Ingestion	4.70E-05	3.92E-07
Muskrat	75	Ingestion	8.16E-05	6.79E-07
Muskrat	90	Ingestion	1.18E-04	9.83E-07
Muskrat	95	Ingestion	1.47E-04	1.22E-06
Muskrat	99	Ingestion	2.09E-04	1.74E-06
Prairie Vole	50	Ingestion	6.85E-06	2.67E-08
Prairie Vole	75	Ingestion	8.51E-06	3.32E-08
Prairie Vole	90	Ingestion	1.05E-05	4.08E-08
Prairie Vole	95	Ingestion	1.24E-05	4.81E-08

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Chlorpyrifos

CAS: 2921-88-2

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Prairie Vole	99	Ingestion	1.94E-05	7.54E-08
Raccoon	50	Ingestion	3.34E-05	4.44E-07
Raccoon	75	Ingestion	3.97E-05	5.28E-07
Raccoon	90	Ingestion	4.47E-05	5.94E-07
Raccoon	95	Ingestion	4.76E-05	6.33E-07
Raccoon	99	Ingestion	5.36E-05	7.13E-07
Red Fox	50	Ingestion	4.45E-05	5.59E-07
Red Fox	75	Ingestion	5.19E-05	6.52E-07
Red Fox	90	Ingestion	5.65E-05	7.10E-07
Red Fox	95	Ingestion	5.82E-05	7.31E-07
Red Fox	99	Ingestion	6.10E-05	7.66E-07
Short Tail Weasel	50	Ingestion	1.09E-04	6.28E-07
Short Tail Weasel	75	Ingestion	1.27E-04	7.33E-07
Short Tail Weasel	90	Ingestion	1.38E-04	7.98E-07
Short Tail Weasel	95	Ingestion	1.42E-04	8.22E-07
Short Tail Weasel	99	Ingestion	1.49E-04	8.60E-07
Short Tailed Shrew	50	Ingestion	1.37E-04	4.14E-07
Short Tailed Shrew	75	Ingestion	1.60E-04	4.83E-07
Short Tailed Shrew	90	Ingestion	1.74E-04	5.26E-07
Short Tailed Shrew	95	Ingestion	1.80E-04	5.41E-07
Short Tailed Shrew	99	Ingestion	1.88E-04	5.67E-07
White Tailed Deer	50	Ingestion	2.89E-06	7.18E-08
White Tailed Deer	75	Ingestion	3.37E-06	8.39E-08
White Tailed Deer	90	Ingestion	3.67E-06	9.13E-08
White Tailed Deer	95	Ingestion	3.79E-06	9.42E-08
White Tailed Deer	99	Ingestion	3.97E-06	9.86E-08

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Dioxane, 1,4-

CAS: 123-91-1

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Black Bear	50	Ingestion	1.86E-03	1.15E-02
Black Bear	75	Ingestion	3.40E-03	2.10E-02
Black Bear	90	Ingestion	4.45E-03	2.76E-02
Black Bear	95	Ingestion	4.85E-03	3.01E-02
Black Bear	99	Ingestion	5.57E-03	3.45E-02
Coyote	50	Ingestion	1.18E-03	4.15E-03
Coyote	75	Ingestion	2.23E-03	7.82E-03
Coyote	90	Ingestion	2.88E-03	1.01E-02
Coyote	95	Ingestion	3.27E-03	1.15E-02
Coyote	99	Ingestion	4.45E-03	1.56E-02
Deer Mouse	50	Ingestion	9.19E-03	6.35E-03
Deer Mouse	75	Ingestion	1.69E-02	1.17E-02
Deer Mouse	90	Ingestion	2.22E-02	1.53E-02
Deer Mouse	95	Ingestion	2.41E-02	1.66E-02
Deer Mouse	99	Ingestion	2.74E-02	1.89E-02
Eastern Cottontail	50	Ingestion	6.42E-03	1.24E-02
Eastern Cottontail	75	Ingestion	1.17E-02	2.27E-02
Eastern Cottontail	90	Ingestion	1.53E-02	2.96E-02
Eastern Cottontail	95	Ingestion	1.66E-02	3.22E-02
Eastern Cottontail	99	Ingestion	1.84E-02	3.56E-02
Least Weasel	50	Ingestion	1.65E-03	1.36E-03
Least Weasel	75	Ingestion	3.14E-03	2.59E-03
Least Weasel	90	Ingestion	4.27E-03	3.53E-03
Least Weasel	95	Ingestion	5.38E-03	4.45E-03
Least Weasel	99	Ingestion	8.23E-03	6.81E-03
Little Brown Bat	50	Ingestion	2.14E-03	1.21E-03
Little Brown Bat	75	Ingestion	4.08E-03	2.31E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Dioxane, 1,4-

CAS: 123-91-1

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Little Brown Bat	90	Ingestion	5.55E-03	3.14E-03
Little Brown Bat	95	Ingestion	7.00E-03	3.96E-03
Little Brown Bat	99	Ingestion	1.07E-02	6.07E-03
Long Tailed Weasel	50	Ingestion	1.28E-03	1.55E-03
Long Tailed Weasel	75	Ingestion	2.43E-03	2.95E-03
Long Tailed Weasel	90	Ingestion	3.31E-03	4.01E-03
Long Tailed Weasel	95	Ingestion	4.18E-03	5.07E-03
Long Tailed Weasel	99	Ingestion	6.39E-03	7.74E-03
Meadow Vole	50	Ingestion	3.31E-02	2.32E-02
Meadow Vole	75	Ingestion	7.34E-02	5.14E-02
Meadow Vole	90	Ingestion	1.23E-01	8.60E-02
Meadow Vole	95	Ingestion	1.73E-01	1.21E-01
Meadow Vole	99	Ingestion	3.14E-01	2.20E-01
Mink	50	Ingestion	3.97E-03	7.29E-03
Mink	75	Ingestion	7.04E-03	1.29E-02
Mink	90	Ingestion	1.72E-02	3.16E-02
Mink	95	Ingestion	2.66E-02	4.88E-02
Mink	99	Ingestion	5.69E-02	1.04E-01
Muskrat	50	Ingestion	3.83E-03	6.80E-03
Muskrat	75	Ingestion	5.78E-03	1.03E-02
Muskrat	90	Ingestion	9.09E-03	1.62E-02
Muskrat	95	Ingestion	1.29E-02	2.29E-02
Muskrat	99	Ingestion	2.37E-02	4.22E-02
Prairie Vole	50	Ingestion	2.96E-02	2.46E-02
Prairie Vole	75	Ingestion	6.56E-02	5.46E-02
Prairie Vole	90	Ingestion	1.10E-01	9.12E-02
Prairie Vole	95	Ingestion	1.54E-01	1.28E-01

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Dioxane, 1,4-

CAS: 123-91-1

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Prairie Vole	99	Ingestion	2.78E-01	2.32E-01
Raccoon	50	Ingestion	7.28E-03	2.07E-02
Raccoon	75	Ingestion	1.10E-02	3.13E-02
Raccoon	90	Ingestion	1.79E-02	5.09E-02
Raccoon	95	Ingestion	2.59E-02	7.37E-02
Raccoon	99	Ingestion	4.76E-02	1.35E-01
Red Fox	50	Ingestion	2.35E-03	6.32E-03
Red Fox	75	Ingestion	4.41E-03	1.18E-02
Red Fox	90	Ingestion	5.70E-03	1.53E-02
Red Fox	95	Ingestion	6.25E-03	1.68E-02
Red Fox	99	Ingestion	7.63E-03	2.05E-02
Short Tail Weasel	50	Ingestion	1.27E-03	1.56E-03
Short Tail Weasel	75	Ingestion	2.40E-03	2.96E-03
Short Tail Weasel	90	Ingestion	3.27E-03	4.03E-03
Short Tail Weasel	95	Ingestion	4.13E-03	5.09E-03
Short Tail Weasel	99	Ingestion	6.31E-03	7.78E-03
Short Tailed Shrew	50	Ingestion	3.85E-03	2.48E-03
Short Tailed Shrew	75	Ingestion	7.25E-03	4.66E-03
Short Tailed Shrew	90	Ingestion	9.35E-03	6.02E-03
Short Tailed Shrew	95	Ingestion	1.05E-02	6.78E-03
Short Tailed Shrew	99	Ingestion	1.42E-02	9.13E-03
White Tailed Deer	50	Ingestion	2.27E-03	1.21E-02
White Tailed Deer	75	Ingestion	4.14E-03	2.20E-02
White Tailed Deer	90	Ingestion	5.41E-03	2.87E-02
White Tailed Deer	95	Ingestion	5.88E-03	3.12E-02
White Tailed Deer	99	Ingestion	6.52E-03	3.46E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Endrin

CAS: 72-20-8

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
American Kestrel	50	Ingestion	3.33E-04	1.05E-02
American Kestrel	75	Ingestion	4.04E-04	1.28E-02
American Kestrel	90	Ingestion	4.69E-04	1.48E-02
American Kestrel	95	Ingestion	5.07E-04	1.60E-02
American Kestrel	99	Ingestion	5.60E-04	1.77E-02
American Robin	50	Ingestion	1.99E-04	6.28E-03
American Robin	75	Ingestion	2.41E-04	7.64E-03
American Robin	90	Ingestion	2.80E-04	8.87E-03
American Robin	95	Ingestion	3.03E-04	9.57E-03
American Robin	99	Ingestion	3.34E-04	1.06E-02
American Woodcock	50	Ingestion	2.99E-04	9.47E-03
American Woodcock	75	Ingestion	3.64E-04	1.15E-02
American Woodcock	90	Ingestion	4.23E-04	1.34E-02
American Woodcock	95	Ingestion	4.56E-04	1.44E-02
American Woodcock	99	Ingestion	5.04E-04	1.59E-02
Belted Kingfisher	50	Ingestion	2.11E-03	6.66E-02
Belted Kingfisher	75	Ingestion	3.46E-03	1.09E-01
Belted Kingfisher	90	Ingestion	4.84E-03	1.53E-01
Belted Kingfisher	95	Ingestion	5.62E-03	1.78E-01
Belted Kingfisher	99	Ingestion	7.32E-03	2.31E-01
Black Bear	50	Ingestion	5.05E-05	1.40E-03
Black Bear	75	Ingestion	6.67E-05	1.86E-03
Black Bear	90	Ingestion	8.21E-05	2.29E-03
Black Bear	95	Ingestion	9.19E-05	2.56E-03
Black Bear	99	Ingestion	1.09E-04	3.04E-03
Canada Goose	50	Ingestion	9.34E-06	2.95E-04
Canada Goose	75	Ingestion	1.13E-05	3.58E-04

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Endrin

CAS: 72-20-8

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Canada Goose	90	Ingestion	1.32E-05	4.16E-04
Canada Goose	95	Ingestion	1.42E-05	4.49E-04
Canada Goose	99	Ingestion	1.57E-05	4.95E-04
Coopers Hawk	50	Ingestion	2.17E-04	6.86E-03
Coopers Hawk	75	Ingestion	2.64E-04	8.34E-03
Coopers Hawk	90	Ingestion	3.06E-04	9.68E-03
Coopers Hawk	95	Ingestion	3.31E-04	1.05E-02
Coopers Hawk	99	Ingestion	3.65E-04	1.15E-02
Coyote	50	Ingestion	1.04E-04	1.64E-03
Coyote	75	Ingestion	1.27E-04	2.00E-03
Coyote	90	Ingestion	1.48E-04	2.32E-03
Coyote	95	Ingestion	1.59E-04	2.50E-03
Coyote	99	Ingestion	1.76E-04	2.76E-03
Deer Mouse	50	Ingestion	1.29E-04	4.01E-04
Deer Mouse	75	Ingestion	1.57E-04	4.87E-04
Deer Mouse	90	Ingestion	1.82E-04	5.66E-04
Deer Mouse	95	Ingestion	1.97E-04	6.10E-04
Deer Mouse	99	Ingestion	2.17E-04	6.74E-04
Eastern Cottontail	50	Ingestion	1.25E-05	1.08E-04
Eastern Cottontail	75	Ingestion	1.51E-05	1.31E-04
Eastern Cottontail	90	Ingestion	1.75E-05	1.53E-04
Eastern Cottontail	95	Ingestion	1.89E-05	1.64E-04
Eastern Cottontail	99	Ingestion	2.08E-05	1.81E-04
Great Blue Heron	50	Ingestion	1.06E-03	3.34E-02
Great Blue Heron	75	Ingestion	1.75E-03	5.52E-02
Great Blue Heron	90	Ingestion	2.46E-03	7.78E-02
Great Blue Heron	95	Ingestion	2.86E-03	9.04E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Endrin

CAS: 72-20-8

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Great Blue Heron	99	Ingestion	3.73E-03	1.18E-01
Green Heron	50	Ingestion	1.68E-03	5.32E-02
Green Heron	75	Ingestion	2.74E-03	8.67E-02
Green Heron	90	Ingestion	3.82E-03	1.21E-01
Green Heron	95	Ingestion	4.42E-03	1.40E-01
Green Heron	99	Ingestion	5.74E-03	1.81E-01
Least Weasel	50	Ingestion	3.27E-04	1.22E-03
Least Weasel	75	Ingestion	3.98E-04	1.48E-03
Least Weasel	90	Ingestion	4.62E-04	1.72E-03
Least Weasel	95	Ingestion	4.99E-04	1.85E-03
Least Weasel	99	Ingestion	5.51E-04	2.05E-03
Little Brown Bat	50	Ingestion	4.26E-04	1.08E-03
Little Brown Bat	75	Ingestion	5.18E-04	1.32E-03
Little Brown Bat	90	Ingestion	6.01E-04	1.53E-03
Little Brown Bat	95	Ingestion	6.49E-04	1.65E-03
Little Brown Bat	99	Ingestion	7.17E-04	1.82E-03
Long Tailed Weasel	50	Ingestion	2.54E-04	1.38E-03
Long Tailed Weasel	75	Ingestion	3.08E-04	1.68E-03
Long Tailed Weasel	90	Ingestion	3.58E-04	1.95E-03
Long Tailed Weasel	95	Ingestion	3.87E-04	2.11E-03
Long Tailed Weasel	99	Ingestion	4.27E-04	2.32E-03
Mallard Duck	50	Ingestion	5.44E-05	1.72E-03
Mallard Duck	75	Ingestion	6.70E-05	2.12E-03
Mallard Duck	90	Ingestion	7.82E-05	2.47E-03
Mallard Duck	95	Ingestion	8.50E-05	2.69E-03
Mallard Duck	99	Ingestion	9.78E-05	3.09E-03
Meadow Vole	50	Ingestion	1.90E-05	5.96E-05

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Endrin

CAS: 72-20-8

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Meadow Vole	75	Ingestion	2.31E-05	7.28E-05
Meadow Vole	90	Ingestion	2.74E-05	8.61E-05
Meadow Vole	95	Ingestion	3.02E-05	9.50E-05
Meadow Vole	99	Ingestion	3.92E-05	1.23E-04
Mink	50	Ingestion	1.50E-03	1.24E-02
Mink	75	Ingestion	2.47E-03	2.04E-02
Mink	90	Ingestion	3.47E-03	2.86E-02
Mink	95	Ingestion	4.02E-03	3.32E-02
Mink	99	Ingestion	5.24E-03	4.32E-02
Muskrat	50	Ingestion	9.66E-04	7.71E-03
Muskrat	75	Ingestion	1.60E-03	1.28E-02
Muskrat	90	Ingestion	2.26E-03	1.80E-02
Muskrat	95	Ingestion	2.63E-03	2.10E-02
Muskrat	99	Ingestion	3.44E-03	2.75E-02
Northern Bobwhite	50	Ingestion	7.78E-05	2.46E-03
Northern Bobwhite	75	Ingestion	9.45E-05	2.99E-03
Northern Bobwhite	90	Ingestion	1.10E-04	3.47E-03
Northern Bobwhite	95	Ingestion	1.18E-04	3.75E-03
Northern Bobwhite	99	Ingestion	1.31E-04	4.13E-03
Prairie Vole	50	Ingestion	1.68E-05	6.29E-05
Prairie Vole	75	Ingestion	2.05E-05	7.68E-05
Prairie Vole	90	Ingestion	2.43E-05	9.08E-05
Prairie Vole	95	Ingestion	2.68E-05	1.00E-04
Prairie Vole	99	Ingestion	3.48E-05	1.30E-04
Raccoon	50	Ingestion	1.04E-04	1.32E-03
Raccoon	75	Ingestion	1.29E-04	1.65E-03
Raccoon	90	Ingestion	1.51E-04	1.93E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Endrin

CAS: 72-20-8

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Raccoon	95	Ingestion	1.64E-04	2.09E-03
Raccoon	99	Ingestion	1.91E-04	2.44E-03
Red Fox	50	Ingestion	1.02E-04	1.23E-03
Red Fox	75	Ingestion	1.25E-04	1.50E-03
Red Fox	90	Ingestion	1.45E-04	1.74E-03
Red Fox	95	Ingestion	1.56E-04	1.88E-03
Red Fox	99	Ingestion	1.72E-04	2.08E-03
Red Tailed Hawk	50	Ingestion	1.51E-04	4.79E-03
Red Tailed Hawk	75	Ingestion	1.84E-04	5.83E-03
Red Tailed Hawk	90	Ingestion	2.14E-04	6.76E-03
Red Tailed Hawk	95	Ingestion	2.31E-04	7.30E-03
Red Tailed Hawk	99	Ingestion	2.55E-04	8.06E-03
Short Tail Weasel	50	Ingestion	2.51E-04	1.39E-03
Short Tail Weasel	75	Ingestion	3.05E-04	1.69E-03
Short Tail Weasel	90	Ingestion	3.54E-04	1.96E-03
Short Tail Weasel	95	Ingestion	3.82E-04	2.12E-03
Short Tail Weasel	99	Ingestion	4.22E-04	2.34E-03
Short Tailed Shrew	50	Ingestion	3.16E-04	9.14E-04
Short Tailed Shrew	75	Ingestion	3.85E-04	1.11E-03
Short Tailed Shrew	90	Ingestion	4.47E-04	1.29E-03
Short Tailed Shrew	95	Ingestion	4.82E-04	1.39E-03
Short Tailed Shrew	99	Ingestion	5.32E-04	1.54E-03
Tree Swallow	50	Ingestion	4.41E-04	1.39E-02
Tree Swallow	75	Ingestion	5.36E-04	1.70E-02
Tree Swallow	90	Ingestion	6.23E-04	1.97E-02
Tree Swallow	95	Ingestion	6.72E-04	2.13E-02
Tree Swallow	99	Ingestion	7.42E-04	2.35E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Endrin

CAS: 72-20-8

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Western Meadowlark	50	Ingestion	2.94E-04	9.28E-03
Western Meadowlark	75	Ingestion	3.57E-04	1.13E-02
Western Meadowlark	90	Ingestion	4.15E-04	1.31E-02
Western Meadowlark	95	Ingestion	4.48E-04	1.42E-02
Western Meadowlark	99	Ingestion	4.94E-04	1.56E-02
White Tailed Deer	50	Ingestion	6.36E-06	1.52E-04
White Tailed Deer	75	Ingestion	7.71E-06	1.84E-04
White Tailed Deer	90	Ingestion	8.96E-06	2.14E-04
White Tailed Deer	95	Ingestion	9.65E-06	2.30E-04
White Tailed Deer	99	Ingestion	1.06E-05	2.54E-04

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Hexachlorocyclohexane, beta-

CAS: 319-85-7

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Black Bear	50	Ingestion	1.16E-05	5.67E-05
Black Bear	75	Ingestion	1.35E-05	6.59E-05
Black Bear	90	Ingestion	1.49E-05	7.29E-05
Black Bear	95	Ingestion	1.56E-05	7.66E-05
Black Bear	99	Ingestion	1.66E-05	8.13E-05
Coyote	50	Ingestion	3.30E-05	9.14E-05
Coyote	75	Ingestion	3.84E-05	1.06E-04
Coyote	90	Ingestion	4.25E-05	1.18E-04
Coyote	95	Ingestion	4.43E-05	1.23E-04
Coyote	99	Ingestion	4.69E-05	1.30E-04
Deer Mouse	50	Ingestion	4.25E-05	2.32E-05
Deer Mouse	75	Ingestion	4.95E-05	2.71E-05
Deer Mouse	90	Ingestion	5.47E-05	2.99E-05
Deer Mouse	95	Ingestion	5.69E-05	3.11E-05
Deer Mouse	99	Ingestion	6.01E-05	3.29E-05
Eastern Cottontail	50	Ingestion	5.53E-06	8.46E-06
Eastern Cottontail	75	Ingestion	6.44E-06	9.85E-06
Eastern Cottontail	90	Ingestion	7.07E-06	1.08E-05
Eastern Cottontail	95	Ingestion	7.29E-06	1.12E-05
Eastern Cottontail	99	Ingestion	7.67E-06	1.17E-05
Least Weasel	50	Ingestion	1.03E-04	6.73E-05
Least Weasel	75	Ingestion	1.20E-04	7.83E-05
Least Weasel	90	Ingestion	1.33E-04	8.68E-05
Least Weasel	95	Ingestion	1.38E-04	9.04E-05
Least Weasel	99	Ingestion	1.46E-04	9.56E-05
Little Brown Bat	50	Ingestion	1.34E-04	6.00E-05
Little Brown Bat	75	Ingestion	1.56E-04	6.97E-05

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Hexachlorocyclohexane, beta-

CAS: 319-85-7

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Little Brown Bat	90	Ingestion	1.73E-04	7.73E-05
Little Brown Bat	95	Ingestion	1.80E-04	8.05E-05
Little Brown Bat	99	Ingestion	1.90E-04	8.51E-05
Long Tailed Weasel	50	Ingestion	7.98E-05	7.65E-05
Long Tailed Weasel	75	Ingestion	9.28E-05	8.89E-05
Long Tailed Weasel	90	Ingestion	1.03E-04	9.86E-05
Long Tailed Weasel	95	Ingestion	1.07E-04	1.03E-04
Long Tailed Weasel	99	Ingestion	1.13E-04	1.09E-04
Meadow Vole	50	Ingestion	8.99E-06	4.97E-06
Meadow Vole	75	Ingestion	1.13E-05	6.26E-06
Meadow Vole	90	Ingestion	1.41E-05	7.79E-06
Meadow Vole	95	Ingestion	1.68E-05	9.28E-06
Meadow Vole	99	Ingestion	2.65E-05	1.47E-05
Mink	50	Ingestion	9.04E-05	1.31E-04
Mink	75	Ingestion	1.31E-04	1.90E-04
Mink	90	Ingestion	1.71E-04	2.47E-04
Mink	95	Ingestion	1.93E-04	2.80E-04
Mink	99	Ingestion	2.43E-04	3.53E-04
Muskrat	50	Ingestion	4.65E-05	6.54E-05
Muskrat	75	Ingestion	7.08E-05	9.94E-05
Muskrat	90	Ingestion	9.37E-05	1.32E-04
Muskrat	95	Ingestion	1.06E-04	1.49E-04
Muskrat	99	Ingestion	1.40E-04	1.97E-04
Prairie Vole	50	Ingestion	8.04E-06	5.29E-06
Prairie Vole	75	Ingestion	1.01E-05	6.67E-06
Prairie Vole	90	Ingestion	1.26E-05	8.27E-06
Prairie Vole	95	Ingestion	1.50E-05	9.84E-06

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Hexachlorocyclohexane, beta-

CAS: 319-85-7

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Prairie Vole	99	Ingestion	2.36E-05	1.55E-05
Raccoon	50	Ingestion	4.23E-05	9.51E-05
Raccoon	75	Ingestion	5.29E-05	1.19E-04
Raccoon	90	Ingestion	6.46E-05	1.45E-04
Raccoon	95	Ingestion	7.25E-05	1.63E-04
Raccoon	99	Ingestion	9.81E-05	2.20E-04
Red Fox	50	Ingestion	3.26E-05	6.92E-05
Red Fox	75	Ingestion	3.80E-05	8.05E-05
Red Fox	90	Ingestion	4.20E-05	8.90E-05
Red Fox	95	Ingestion	4.38E-05	9.28E-05
Red Fox	99	Ingestion	4.63E-05	9.81E-05
Short Tail Weasel	50	Ingestion	7.89E-05	7.68E-05
Short Tail Weasel	75	Ingestion	9.17E-05	8.94E-05
Short Tail Weasel	90	Ingestion	1.02E-04	9.91E-05
Short Tail Weasel	95	Ingestion	1.06E-04	1.03E-04
Short Tail Weasel	99	Ingestion	1.12E-04	1.09E-04
Short Tailed Shrew	50	Ingestion	1.00E-04	5.09E-05
Short Tailed Shrew	75	Ingestion	1.16E-04	5.92E-05
Short Tailed Shrew	90	Ingestion	1.29E-04	6.55E-05
Short Tailed Shrew	95	Ingestion	1.34E-04	6.83E-05
Short Tailed Shrew	99	Ingestion	1.42E-04	7.22E-05
White Tailed Deer	50	Ingestion	2.58E-06	1.08E-05
White Tailed Deer	75	Ingestion	3.00E-06	1.26E-05
White Tailed Deer	90	Ingestion	3.28E-06	1.38E-05
White Tailed Deer	95	Ingestion	3.41E-06	1.43E-05
White Tailed Deer	99	Ingestion	3.55E-06	1.49E-05

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Manganese

CAS: 7439-96-5

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
American Kestrel	50	Ingestion	6.63E+01	6.79E-02
American Kestrel	75	Ingestion	8.96E+01	9.17E-02
American Kestrel	90	Ingestion	1.13E+02	1.16E-01
American Kestrel	95	Ingestion	1.28E+02	1.31E-01
American Kestrel	99	Ingestion	1.58E+02	1.62E-01
American Robin	50	Ingestion	6.15E+01	6.29E-02
American Robin	75	Ingestion	8.30E+01	8.50E-02
American Robin	90	Ingestion	1.05E+02	1.07E-01
American Robin	95	Ingestion	1.19E+02	1.21E-01
American Robin	99	Ingestion	1.46E+02	1.50E-01
American Woodcock	50	Ingestion	1.14E+01	1.17E-02
American Woodcock	75	Ingestion	1.54E+01	1.57E-02
American Woodcock	90	Ingestion	1.94E+01	1.99E-02
American Woodcock	95	Ingestion	2.19E+01	2.24E-02
American Woodcock	99	Ingestion	2.70E+01	2.76E-02
Belted Kingfisher	50	Ingestion	3.64E+01	3.73E-02
Belted Kingfisher	75	Ingestion	4.81E+01	4.92E-02
Belted Kingfisher	90	Ingestion	6.02E+01	6.17E-02
Belted Kingfisher	95	Ingestion	6.71E+01	6.86E-02
Belted Kingfisher	99	Ingestion	8.31E+01	8.51E-02
Black Bear	50	Ingestion	1.01E+01	2.81E-01
Black Bear	75	Ingestion	1.36E+01	3.77E-01
Black Bear	90	Ingestion	1.72E+01	4.76E-01
Black Bear	95	Ingestion	1.94E+01	5.38E-01
Black Bear	99	Ingestion	2.39E+01	6.62E-01
Canada Goose	50	Ingestion	1.04E+00	1.07E-03
Canada Goose	75	Ingestion	1.40E+00	1.43E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Manganese

CAS: 7439-96-5

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Canada Goose	90	Ingestion	1.76E+00	1.80E-03
Canada Goose	95	Ingestion	1.98E+00	2.03E-03
Canada Goose	99	Ingestion	2.42E+00	2.48E-03
Coopers Hawk	50	Ingestion	4.12E-01	4.21E-04
Coopers Hawk	75	Ingestion	5.40E-01	5.52E-04
Coopers Hawk	90	Ingestion	6.78E-01	6.94E-04
Coopers Hawk	95	Ingestion	7.63E-01	7.81E-04
Coopers Hawk	99	Ingestion	9.07E-01	9.29E-04
Coyote	50	Ingestion	4.39E+00	6.87E-02
Coyote	75	Ingestion	5.89E+00	9.23E-02
Coyote	90	Ingestion	7.43E+00	1.16E-01
Coyote	95	Ingestion	8.39E+00	1.31E-01
Coyote	99	Ingestion	1.03E+01	1.62E-01
Deer Mouse	50	Ingestion	3.88E+01	1.20E-01
Deer Mouse	75	Ingestion	5.23E+01	1.62E-01
Deer Mouse	90	Ingestion	6.61E+01	2.05E-01
Deer Mouse	95	Ingestion	7.48E+01	2.31E-01
Deer Mouse	99	Ingestion	9.23E+01	2.86E-01
Eastern Cottontail	50	Ingestion	1.70E+00	1.47E-02
Eastern Cottontail	75	Ingestion	2.27E+00	1.96E-02
Eastern Cottontail	90	Ingestion	2.82E+00	2.45E-02
Eastern Cottontail	95	Ingestion	3.21E+00	2.78E-02
Eastern Cottontail	99	Ingestion	3.89E+00	3.36E-02
Great Blue Heron	50	Ingestion	6.16E+00	6.31E-03
Great Blue Heron	75	Ingestion	8.78E+00	8.98E-03
Great Blue Heron	90	Ingestion	1.17E+01	1.20E-02
Great Blue Heron	95	Ingestion	1.36E+01	1.40E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Manganese

CAS: 7439-96-5

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Great Blue Heron	99	Ingestion	1.82E+01	1.87E-02
Green Heron	50	Ingestion	2.61E+01	2.68E-02
Green Heron	75	Ingestion	3.49E+01	3.58E-02
Green Heron	90	Ingestion	4.39E+01	4.49E-02
Green Heron	95	Ingestion	4.86E+01	4.98E-02
Green Heron	99	Ingestion	6.27E+01	6.41E-02
Least Weasel	50	Ingestion	6.64E+00	2.46E-02
Least Weasel	75	Ingestion	8.91E+00	3.30E-02
Least Weasel	90	Ingestion	1.12E+01	4.16E-02
Least Weasel	95	Ingestion	1.27E+01	4.70E-02
Least Weasel	99	Ingestion	1.56E+01	5.78E-02
Little Brown Bat	50	Ingestion	1.34E+02	3.40E-01
Little Brown Bat	75	Ingestion	1.81E+02	4.60E-01
Little Brown Bat	90	Ingestion	2.29E+02	5.80E-01
Little Brown Bat	95	Ingestion	2.59E+02	6.57E-01
Little Brown Bat	99	Ingestion	3.20E+02	8.10E-01
Long Tailed Weasel	50	Ingestion	5.01E+00	2.72E-02
Long Tailed Weasel	75	Ingestion	6.72E+00	3.65E-02
Long Tailed Weasel	90	Ingestion	8.46E+00	4.59E-02
Long Tailed Weasel	95	Ingestion	9.56E+00	5.19E-02
Long Tailed Weasel	99	Ingestion	1.17E+01	6.37E-02
Mallard Duck	50	Ingestion	1.25E+01	1.28E-02
Mallard Duck	75	Ingestion	1.70E+01	1.74E-02
Mallard Duck	90	Ingestion	2.15E+01	2.21E-02
Mallard Duck	95	Ingestion	2.42E+01	2.48E-02
Mallard Duck	99	Ingestion	3.06E+01	3.13E-02
Meadow Vole	50	Ingestion	1.73E+00	5.43E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Manganese

CAS: 7439-96-5

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Meadow Vole	75	Ingestion	2.31E+00	7.23E-03
Meadow Vole	90	Ingestion	2.86E+00	8.97E-03
Meadow Vole	95	Ingestion	3.26E+00	1.02E-02
Meadow Vole	99	Ingestion	3.93E+00	1.23E-02
Mink	50	Ingestion	1.49E+01	1.23E-01
Mink	75	Ingestion	2.02E+01	1.66E-01
Mink	90	Ingestion	2.55E+01	2.09E-01
Mink	95	Ingestion	2.88E+01	2.37E-01
Mink	99	Ingestion	3.77E+01	3.10E-01
Muskrat	50	Ingestion	5.20E+00	4.13E-02
Muskrat	75	Ingestion	7.48E+00	5.95E-02
Muskrat	90	Ingestion	1.01E+01	8.07E-02
Muskrat	95	Ingestion	1.18E+01	9.42E-02
Muskrat	99	Ingestion	1.60E+01	1.27E-01
Northern Bobwhite	50	Ingestion	1.87E+01	1.92E-02
Northern Bobwhite	75	Ingestion	2.52E+01	2.58E-02
Northern Bobwhite	90	Ingestion	3.18E+01	3.26E-02
Northern Bobwhite	95	Ingestion	3.60E+01	3.69E-02
Northern Bobwhite	99	Ingestion	4.44E+01	4.54E-02
Prairie Vole	50	Ingestion	1.54E+00	5.75E-03
Prairie Vole	75	Ingestion	2.05E+00	7.65E-03
Prairie Vole	90	Ingestion	2.55E+00	9.50E-03
Prairie Vole	95	Ingestion	2.90E+00	1.08E-02
Prairie Vole	99	Ingestion	3.50E+00	1.30E-02
Raccoon	50	Ingestion	2.09E+01	2.65E-01
Raccoon	75	Ingestion	2.86E+01	3.63E-01
Raccoon	90	Ingestion	3.62E+01	4.59E-01

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Manganese

CAS: 7439-96-5

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Raccoon	95	Ingestion	4.09E+01	5.20E-01
Raccoon	99	Ingestion	5.24E+01	6.66E-01
Red Fox	50	Ingestion	5.47E-01	6.57E-03
Red Fox	75	Ingestion	7.20E-01	8.65E-03
Red Fox	90	Ingestion	9.06E-01	1.09E-02
Red Fox	95	Ingestion	1.02E+00	1.22E-02
Red Fox	99	Ingestion	1.21E+00	1.45E-02
Red Tailed Hawk	50	Ingestion	6.19E+00	6.34E-03
Red Tailed Hawk	75	Ingestion	8.33E+00	8.53E-03
Red Tailed Hawk	90	Ingestion	1.05E+01	1.08E-02
Red Tailed Hawk	95	Ingestion	1.19E+01	1.22E-02
Red Tailed Hawk	99	Ingestion	1.46E+01	1.50E-02
Short Tail Weasel	50	Ingestion	1.82E+01	1.00E-01
Short Tail Weasel	75	Ingestion	2.45E+01	1.35E-01
Short Tail Weasel	90	Ingestion	3.09E+01	1.71E-01
Short Tail Weasel	95	Ingestion	3.50E+01	1.93E-01
Short Tail Weasel	99	Ingestion	4.31E+01	2.38E-01
Short Tailed Shrew	50	Ingestion	4.15E+01	1.20E-01
Short Tailed Shrew	75	Ingestion	5.60E+01	1.61E-01
Short Tailed Shrew	90	Ingestion	7.07E+01	2.03E-01
Short Tailed Shrew	95	Ingestion	7.99E+01	2.30E-01
Short Tailed Shrew	99	Ingestion	9.85E+01	2.84E-01
Tree Swallow	50	Ingestion	1.38E+02	1.41E-01
Tree Swallow	75	Ingestion	1.86E+02	1.90E-01
Tree Swallow	90	Ingestion	2.35E+02	2.40E-01
Tree Swallow	95	Ingestion	2.66E+02	2.72E-01
Tree Swallow	99	Ingestion	3.28E+02	3.35E-01

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Manganese

CAS: 7439-96-5

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Western Meadowlark	50	Ingestion	9.25E+01	9.47E-02
Western Meadowlark	75	Ingestion	1.25E+02	1.28E-01
Western Meadowlark	90	Ingestion	1.58E+02	1.61E-01
Western Meadowlark	95	Ingestion	1.79E+02	1.83E-01
Western Meadowlark	99	Ingestion	2.20E+02	2.25E-01
White Tailed Deer	50	Ingestion	7.68E-01	1.82E-02
White Tailed Deer	75	Ingestion	1.02E+00	2.43E-02
White Tailed Deer	90	Ingestion	1.28E+00	3.04E-02
White Tailed Deer	95	Ingestion	1.44E+00	3.43E-02
White Tailed Deer	99	Ingestion	1.74E+00	4.14E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Black Bear	50	Ingestion	6.20E-03	9.55E-06
Black Bear	75	Ingestion	3.01E-02	4.63E-05
Black Bear	90	Ingestion	4.07E-02	6.26E-05
Black Bear	95	Ingestion	4.39E-02	6.77E-05
Black Bear	99	Ingestion	4.67E-02	7.19E-05
Coyote	50	Ingestion	5.17E-03	4.49E-06
Coyote	75	Ingestion	2.58E-02	2.25E-05
Coyote	90	Ingestion	3.49E-02	3.04E-05
Coyote	95	Ingestion	3.77E-02	3.28E-05
Coyote	99	Ingestion	4.02E-02	3.49E-05
Deer Mouse	50	Ingestion	2.89E-02	4.96E-06
Deer Mouse	75	Ingestion	1.46E-01	2.50E-05
Deer Mouse	90	Ingestion	1.97E-01	3.38E-05
Deer Mouse	95	Ingestion	2.13E-01	3.66E-05
Deer Mouse	99	Ingestion	2.26E-01	3.89E-05
Eastern Cottontail	50	Ingestion	2.17E-02	1.05E-05
Eastern Cottontail	75	Ingestion	9.83E-02	4.73E-05
Eastern Cottontail	90	Ingestion	1.33E-01	6.39E-05
Eastern Cottontail	95	Ingestion	1.43E-01	6.88E-05
Eastern Cottontail	99	Ingestion	1.53E-01	7.36E-05
Least Weasel	50	Ingestion	1.01E-02	2.08E-06
Least Weasel	75	Ingestion	5.11E-02	1.05E-05
Least Weasel	90	Ingestion	6.90E-02	1.42E-05
Least Weasel	95	Ingestion	7.47E-02	1.54E-05
Least Weasel	99	Ingestion	7.94E-02	1.63E-05
Little Brown Bat	50	Ingestion	1.32E-02	1.85E-06
Little Brown Bat	75	Ingestion	6.65E-02	9.35E-06

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Little Brown Bat	90	Ingestion	8.98E-02	1.26E-05
Little Brown Bat	95	Ingestion	9.72E-02	1.37E-05
Little Brown Bat	99	Ingestion	1.03E-01	1.45E-05
Long Tailed Weasel	50	Ingestion	7.85E-03	2.36E-06
Long Tailed Weasel	75	Ingestion	3.96E-02	1.19E-05
Long Tailed Weasel	90	Ingestion	5.35E-02	1.61E-05
Long Tailed Weasel	95	Ingestion	5.79E-02	1.74E-05
Long Tailed Weasel	99	Ingestion	6.15E-02	1.85E-05
Meadow Vole	50	Ingestion	5.89E-02	1.02E-05
Meadow Vole	75	Ingestion	3.24E-01	5.64E-05
Meadow Vole	90	Ingestion	5.21E-01	9.06E-05
Meadow Vole	95	Ingestion	7.05E-01	1.23E-04
Meadow Vole	99	Ingestion	1.24E+00	2.16E-04
Mink	50	Ingestion	7.82E-03	3.56E-06
Mink	75	Ingestion	1.77E-02	8.08E-06
Mink	90	Ingestion	4.11E-02	1.87E-05
Mink	95	Ingestion	6.68E-02	3.05E-05
Mink	99	Ingestion	1.45E-01	6.62E-05
Muskrat	50	Ingestion	1.65E-02	7.28E-06
Muskrat	75	Ingestion	3.36E-02	1.48E-05
Muskrat	90	Ingestion	4.31E-02	1.90E-05
Muskrat	95	Ingestion	4.64E-02	2.05E-05
Muskrat	99	Ingestion	6.07E-02	2.68E-05
Prairie Vole	50	Ingestion	5.32E-02	1.10E-05
Prairie Vole	75	Ingestion	2.92E-01	6.03E-05
Prairie Vole	90	Ingestion	4.67E-01	9.66E-05
Prairie Vole	95	Ingestion	6.27E-01	1.30E-04

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Methyl Ethyl Ketone (MEK)

CAS: 78-93-3

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Prairie Vole	99	Ingestion	1.11E+00	2.29E-04
Raccoon	50	Ingestion	3.04E-02	2.15E-05
Raccoon	75	Ingestion	6.51E-02	4.59E-05
Raccoon	90	Ingestion	8.34E-02	5.89E-05
Raccoon	95	Ingestion	8.99E-02	6.34E-05
Raccoon	99	Ingestion	1.18E-01	8.36E-05
Red Fox	50	Ingestion	8.57E-03	5.71E-06
Red Fox	75	Ingestion	4.29E-02	2.86E-05
Red Fox	90	Ingestion	5.80E-02	3.87E-05
Red Fox	95	Ingestion	6.27E-02	4.18E-05
Red Fox	99	Ingestion	6.67E-02	4.44E-05
Short Tail Weasel	50	Ingestion	7.75E-03	2.38E-06
Short Tail Weasel	75	Ingestion	3.91E-02	1.20E-05
Short Tail Weasel	90	Ingestion	5.28E-02	1.62E-05
Short Tail Weasel	95	Ingestion	5.72E-02	1.75E-05
Short Tail Weasel	99	Ingestion	6.08E-02	1.86E-05
Short Tailed Shrew	50	Ingestion	1.64E-02	2.63E-06
Short Tailed Shrew	75	Ingestion	8.21E-02	1.31E-05
Short Tailed Shrew	90	Ingestion	1.11E-01	1.77E-05
Short Tailed Shrew	95	Ingestion	1.20E-01	1.92E-05
Short Tailed Shrew	99	Ingestion	1.28E-01	2.04E-05
White Tailed Deer	50	Ingestion	7.78E-03	1.03E-05
White Tailed Deer	75	Ingestion	3.49E-02	4.61E-05
White Tailed Deer	90	Ingestion	4.72E-02	6.22E-05
White Tailed Deer	95	Ingestion	5.09E-02	6.71E-05
White Tailed Deer	99	Ingestion	5.44E-02	7.17E-05

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Naled

CAS: 300-76-5

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Black Bear	50	Ingestion	3.48E-05	2.00E-07
Black Bear	75	Ingestion	1.07E-04	6.15E-07
Black Bear	90	Ingestion	1.37E-04	7.85E-07
Black Bear	95	Ingestion	1.48E-04	8.49E-07
Black Bear	99	Ingestion	1.56E-04	8.96E-07
Coyote	50	Ingestion	5.98E-05	1.94E-07
Coyote	75	Ingestion	1.83E-04	5.95E-07
Coyote	90	Ingestion	2.34E-04	7.59E-07
Coyote	95	Ingestion	2.53E-04	8.20E-07
Coyote	99	Ingestion	2.68E-04	8.68E-07
Deer Mouse	50	Ingestion	1.57E-04	1.00E-07
Deer Mouse	75	Ingestion	4.81E-04	3.09E-07
Deer Mouse	90	Ingestion	6.16E-04	3.95E-07
Deer Mouse	95	Ingestion	6.65E-04	4.26E-07
Deer Mouse	99	Ingestion	7.03E-04	4.51E-07
Eastern Cottontail	50	Ingestion	7.37E-05	1.32E-07
Eastern Cottontail	75	Ingestion	2.29E-04	4.10E-07
Eastern Cottontail	90	Ingestion	2.93E-04	5.25E-07
Eastern Cottontail	95	Ingestion	3.16E-04	5.67E-07
Eastern Cottontail	99	Ingestion	3.37E-04	6.05E-07
Least Weasel	50	Ingestion	1.65E-04	1.27E-07
Least Weasel	75	Ingestion	5.07E-04	3.89E-07
Least Weasel	90	Ingestion	6.47E-04	4.97E-07
Least Weasel	95	Ingestion	6.99E-04	5.36E-07
Least Weasel	99	Ingestion	7.41E-04	5.68E-07
Little Brown Bat	50	Ingestion	2.15E-04	1.13E-07
Little Brown Bat	75	Ingestion	6.60E-04	3.47E-07

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Naled

CAS: 300-76-5

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Little Brown Bat	90	Ingestion	8.43E-04	4.42E-07
Little Brown Bat	95	Ingestion	9.10E-04	4.78E-07
Little Brown Bat	99	Ingestion	9.64E-04	5.06E-07
Long Tailed Weasel	50	Ingestion	1.28E-04	1.44E-07
Long Tailed Weasel	75	Ingestion	3.93E-04	4.42E-07
Long Tailed Weasel	90	Ingestion	5.02E-04	5.64E-07
Long Tailed Weasel	95	Ingestion	5.42E-04	6.09E-07
Long Tailed Weasel	99	Ingestion	5.74E-04	6.45E-07
Meadow Vole	50	Ingestion	1.46E-04	9.46E-08
Meadow Vole	75	Ingestion	4.81E-04	3.12E-07
Meadow Vole	90	Ingestion	6.94E-04	4.50E-07
Meadow Vole	95	Ingestion	8.70E-04	5.65E-07
Meadow Vole	99	Ingestion	1.46E-03	9.45E-07
Mink	50	Ingestion	3.64E-05	6.18E-08
Mink	75	Ingestion	8.32E-05	1.42E-07
Mink	90	Ingestion	2.19E-04	3.73E-07
Mink	95	Ingestion	2.98E-04	5.07E-07
Mink	99	Ingestion	4.58E-04	7.78E-07
Muskrat	50	Ingestion	5.57E-05	9.18E-08
Muskrat	75	Ingestion	7.99E-05	1.32E-07
Muskrat	90	Ingestion	9.97E-05	1.64E-07
Muskrat	95	Ingestion	1.33E-04	2.19E-07
Muskrat	99	Ingestion	1.96E-04	3.24E-07
Prairie Vole	50	Ingestion	1.33E-04	1.02E-07
Prairie Vole	75	Ingestion	4.38E-04	3.38E-07
Prairie Vole	90	Ingestion	6.28E-04	4.85E-07
Prairie Vole	95	Ingestion	7.84E-04	6.05E-07

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Naled

CAS: 300-76-5

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Prairie Vole	99	Ingestion	1.30E-03	1.01E-06
Raccoon	50	Ingestion	1.61E-04	4.25E-07
Raccoon	75	Ingestion	2.33E-04	6.13E-07
Raccoon	90	Ingestion	2.82E-04	7.41E-07
Raccoon	95	Ingestion	3.11E-04	8.18E-07
Raccoon	99	Ingestion	4.64E-04	1.22E-06
Red Fox	50	Ingestion	7.14E-05	1.77E-07
Red Fox	75	Ingestion	2.19E-04	5.44E-07
Red Fox	90	Ingestion	2.80E-04	6.96E-07
Red Fox	95	Ingestion	3.02E-04	7.51E-07
Red Fox	99	Ingestion	3.20E-04	7.95E-07
Short Tail Weasel	50	Ingestion	1.27E-04	1.45E-07
Short Tail Weasel	75	Ingestion	3.89E-04	4.44E-07
Short Tail Weasel	90	Ingestion	4.96E-04	5.67E-07
Short Tail Weasel	95	Ingestion	5.36E-04	6.12E-07
Short Tail Weasel	99	Ingestion	5.68E-04	6.49E-07
Short Tailed Shrew	50	Ingestion	1.84E-04	1.10E-07
Short Tailed Shrew	75	Ingestion	5.63E-04	3.36E-07
Short Tailed Shrew	90	Ingestion	7.19E-04	4.29E-07
Short Tailed Shrew	95	Ingestion	7.77E-04	4.63E-07
Short Tailed Shrew	99	Ingestion	8.23E-04	4.91E-07
White Tailed Deer	50	Ingestion	2.69E-05	1.33E-07
White Tailed Deer	75	Ingestion	8.35E-05	4.11E-07
White Tailed Deer	90	Ingestion	1.07E-04	5.26E-07
White Tailed Deer	95	Ingestion	1.15E-04	5.67E-07
White Tailed Deer	99	Ingestion	1.23E-04	6.05E-07

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Total Nitrate Nitrogen

CAS: 14797-55-8

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Black Bear	50	Ingestion	1.22E+00	5.62E-03
Black Bear	75	Ingestion	5.91E+00	2.73E-02
Black Bear	90	Ingestion	1.43E+01	6.61E-02
Black Bear	95	Ingestion	1.82E+01	8.42E-02
Black Bear	99	Ingestion	2.47E+01	1.14E-01
Coyote	50	Ingestion	2.92E+00	7.63E-03
Coyote	75	Ingestion	1.61E+01	4.20E-02
Coyote	90	Ingestion	3.93E+01	1.03E-01
Coyote	95	Ingestion	5.15E+01	1.34E-01
Coyote	99	Ingestion	7.13E+01	1.86E-01
Deer Mouse	50	Ingestion	3.85E+00	1.99E-03
Deer Mouse	75	Ingestion	2.05E+01	1.06E-02
Deer Mouse	90	Ingestion	4.97E+01	2.57E-02
Deer Mouse	95	Ingestion	6.47E+01	3.34E-02
Deer Mouse	99	Ingestion	8.95E+01	4.62E-02
Eastern Cottontail	50	Ingestion	7.95E-01	1.15E-03
Eastern Cottontail	75	Ingestion	2.99E+00	4.32E-03
Eastern Cottontail	90	Ingestion	6.99E+00	1.01E-02
Eastern Cottontail	95	Ingestion	8.91E+00	1.29E-02
Eastern Cottontail	99	Ingestion	1.19E+01	1.71E-02
Least Weasel	50	Ingestion	8.54E+00	5.27E-03
Least Weasel	75	Ingestion	4.87E+01	3.01E-02
Least Weasel	90	Ingestion	1.19E+02	7.37E-02
Least Weasel	95	Ingestion	1.58E+02	9.75E-02
Least Weasel	99	Ingestion	2.19E+02	1.35E-01
Little Brown Bat	50	Ingestion	1.10E+01	4.65E-03
Little Brown Bat	75	Ingestion	6.32E+01	2.67E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Total Nitrate Nitrogen

CAS: 14797-55-8

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Little Brown Bat	90	Ingestion	1.55E+02	6.55E-02
Little Brown Bat	95	Ingestion	2.05E+02	8.65E-02
Little Brown Bat	99	Ingestion	2.84E+02	1.20E-01
Long Tailed Weasel	50	Ingestion	6.68E+00	6.04E-03
Long Tailed Weasel	75	Ingestion	3.80E+01	3.44E-02
Long Tailed Weasel	90	Ingestion	9.29E+01	8.40E-02
Long Tailed Weasel	95	Ingestion	1.23E+02	1.11E-01
Long Tailed Weasel	99	Ingestion	1.70E+02	1.54E-01
Meadow Vole	50	Ingestion	9.90E-01	5.17E-04
Meadow Vole	75	Ingestion	3.16E+00	1.65E-03
Meadow Vole	90	Ingestion	7.80E+00	4.07E-03
Meadow Vole	95	Ingestion	1.00E+01	5.22E-03
Meadow Vole	99	Ingestion	1.32E+01	6.92E-03
Mink	50	Ingestion	7.66E+00	1.05E-02
Mink	75	Ingestion	1.92E+01	2.63E-02
Mink	90	Ingestion	5.42E+01	7.42E-02
Mink	95	Ingestion	6.96E+01	9.53E-02
Mink	99	Ingestion	9.46E+01	1.29E-01
Muskrat	50	Ingestion	4.66E+00	6.19E-03
Muskrat	75	Ingestion	1.06E+01	1.40E-02
Muskrat	90	Ingestion	3.31E+01	4.39E-02
Muskrat	95	Ingestion	4.29E+01	5.70E-02
Muskrat	99	Ingestion	5.94E+01	7.88E-02
Prairie Vole	50	Ingestion	9.09E-01	5.65E-04
Prairie Vole	75	Ingestion	2.87E+00	1.78E-03
Prairie Vole	90	Ingestion	7.11E+00	4.42E-03
Prairie Vole	95	Ingestion	9.11E+00	5.66E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Total Nitrate Nitrogen

CAS: 14797-55-8

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Prairie Vole	99	Ingestion	1.21E+01	7.50E-03
Raccoon	50	Ingestion	1.99E+00	4.22E-03
Raccoon	75	Ingestion	1.01E+01	2.14E-02
Raccoon	90	Ingestion	2.46E+01	5.22E-02
Raccoon	95	Ingestion	3.18E+01	6.73E-02
Raccoon	99	Ingestion	4.34E+01	9.19E-02
Red Fox	50	Ingestion	2.92E+00	5.85E-03
Red Fox	75	Ingestion	1.58E+01	3.17E-02
Red Fox	90	Ingestion	3.88E+01	7.76E-02
Red Fox	95	Ingestion	5.07E+01	1.01E-01
Red Fox	99	Ingestion	7.04E+01	1.41E-01
Short Tail Weasel	50	Ingestion	6.60E+00	6.07E-03
Short Tail Weasel	75	Ingestion	3.76E+01	3.46E-02
Short Tail Weasel	90	Ingestion	9.18E+01	8.45E-02
Short Tail Weasel	95	Ingestion	1.22E+02	1.12E-01
Short Tail Weasel	99	Ingestion	1.68E+02	1.55E-01
Short Tailed Shrew	50	Ingestion	8.88E+00	4.26E-03
Short Tailed Shrew	75	Ingestion	4.86E+01	2.34E-02
Short Tailed Shrew	90	Ingestion	1.19E+02	5.72E-02
Short Tailed Shrew	95	Ingestion	1.56E+02	7.49E-02
Short Tailed Shrew	99	Ingestion	2.16E+02	1.04E-01
White Tailed Deer	50	Ingestion	4.88E-01	1.93E-03
White Tailed Deer	75	Ingestion	1.73E+00	6.85E-03
White Tailed Deer	90	Ingestion	4.13E+00	1.64E-02
White Tailed Deer	95	Ingestion	5.25E+00	2.08E-02
White Tailed Deer	99	Ingestion	7.12E+00	2.82E-02

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Xylenes

CAS: 1330-20-7

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Black Bear	50	Ingestion	1.73E-03	5.99E-03
Black Bear	75	Ingestion	2.03E-03	7.03E-03
Black Bear	90	Ingestion	2.21E-03	7.65E-03
Black Bear	95	Ingestion	2.28E-03	7.88E-03
Black Bear	99	Ingestion	2.39E-03	8.27E-03
Coyote	50	Ingestion	4.57E-03	8.96E-03
Coyote	75	Ingestion	5.33E-03	1.04E-02
Coyote	90	Ingestion	5.82E-03	1.14E-02
Coyote	95	Ingestion	5.98E-03	1.17E-02
Coyote	99	Ingestion	6.26E-03	1.23E-02
Deer Mouse	50	Ingestion	6.55E-03	2.53E-03
Deer Mouse	75	Ingestion	7.64E-03	2.96E-03
Deer Mouse	90	Ingestion	8.32E-03	3.22E-03
Deer Mouse	95	Ingestion	8.57E-03	3.31E-03
Deer Mouse	99	Ingestion	8.94E-03	3.46E-03
Eastern Cottontail	50	Ingestion	2.22E-03	2.40E-03
Eastern Cottontail	75	Ingestion	2.65E-03	2.87E-03
Eastern Cottontail	90	Ingestion	3.09E-03	3.34E-03
Eastern Cottontail	95	Ingestion	3.31E-03	3.58E-03
Eastern Cottontail	99	Ingestion	4.23E-03	4.58E-03
Least Weasel	50	Ingestion	1.41E-02	6.51E-03
Least Weasel	75	Ingestion	1.64E-02	7.59E-03
Least Weasel	90	Ingestion	1.79E-02	8.27E-03
Least Weasel	95	Ingestion	1.84E-02	8.51E-03
Least Weasel	99	Ingestion	1.92E-02	8.90E-03
Little Brown Bat	50	Ingestion	1.83E-02	5.80E-03
Little Brown Bat	75	Ingestion	2.14E-02	6.76E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Xylenes

CAS: 1330-20-7

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Little Brown Bat	90	Ingestion	2.32E-02	7.36E-03
Little Brown Bat	95	Ingestion	2.39E-02	7.58E-03
Little Brown Bat	99	Ingestion	2.50E-02	7.93E-03
Long Tailed Weasel	50	Ingestion	1.09E-02	7.39E-03
Long Tailed Weasel	75	Ingestion	1.27E-02	8.62E-03
Long Tailed Weasel	90	Ingestion	1.38E-02	9.39E-03
Long Tailed Weasel	95	Ingestion	1.42E-02	9.66E-03
Long Tailed Weasel	99	Ingestion	1.49E-02	1.01E-02
Meadow Vole	50	Ingestion	3.24E-03	1.27E-03
Meadow Vole	75	Ingestion	4.05E-03	1.59E-03
Meadow Vole	90	Ingestion	4.87E-03	1.91E-03
Meadow Vole	95	Ingestion	5.38E-03	2.11E-03
Meadow Vole	99	Ingestion	7.51E-03	2.94E-03
Mink	50	Ingestion	1.12E-03	1.15E-03
Mink	75	Ingestion	1.40E-03	1.43E-03
Mink	90	Ingestion	1.78E-03	1.83E-03
Mink	95	Ingestion	2.21E-03	2.27E-03
Mink	99	Ingestion	3.89E-03	3.99E-03
Muskrat	50	Ingestion	8.86E-04	8.81E-04
Muskrat	75	Ingestion	1.07E-03	1.07E-03
Muskrat	90	Ingestion	1.25E-03	1.24E-03
Muskrat	95	Ingestion	1.40E-03	1.39E-03
Muskrat	99	Ingestion	1.91E-03	1.90E-03
Prairie Vole	50	Ingestion	2.95E-03	1.37E-03
Prairie Vole	75	Ingestion	3.68E-03	1.71E-03
Prairie Vole	90	Ingestion	4.42E-03	2.06E-03
Prairie Vole	95	Ingestion	4.89E-03	2.28E-03

Table R-2. Ecological Screening Hazard Quotients for Ingestion

Xylenes

CAS: 1330-20-7

Receptor	Percentile	Pathway	Dose (mg/kg/d)	Pathway HQ
Prairie Vole	99	Ingestion	6.81E-03	3.17E-03
Raccoon	50	Ingestion	3.28E-03	5.20E-03
Raccoon	75	Ingestion	3.81E-03	6.05E-03
Raccoon	90	Ingestion	4.17E-03	6.62E-03
Raccoon	95	Ingestion	4.36E-03	6.93E-03
Raccoon	99	Ingestion	5.12E-03	8.14E-03