APPENDIX F

BCF VALUES FOR MAMMAL AND BIRD MEASURMENT RECEPTORS
from Appendix D of EPA, 1999b

FOOD CHAIN MULTIPLIERS
from EPA, 1999a

APPENDIX D

WILDLIFE MEASUREMENT RECEPTOR*BCF*s

Appendix D provides recommended guidance for determining values for compound-specific, media to receptor, bioconcentration factors (*BCF*s) for wildlife measurement receptors. Wildlife measurement receptor *BCF*s should be based on values reported in the scientific literature, or estimated using physical and chemical properties of the compound. Guidance on use of *BCF* values in the screening level ecological risk assessment is provided in Chapter 5.

Section D-1.0 provides the general guidance recommended to select or estimate compound *BCF* values for wildlife measurement receptors. Sections D-1.0 through D-1.3 further discuss determination of *BCF*s for specific media and receptors. References cited in Sections D-1.1 through D-1.3 are located following Section D-1.3.

For the compounds commonly identified in risk assessments for combustion facilities (identified in Chapter 2) and the mammal and bird example measurement receptors listed in Chapter 4, *BCF* values have been determined following the guidance in Sections D-1.0 through D-1.3. *BCF* values for these limited number of compounds and pathways are included in this appendix (see Tables D-1 through D-3) to facilitate the completion of screening ecological risk assessments. However, it is expected that *BCF* values for additional compounds and receptors may be required for evaluation on a site specific basis. In such cases, *BCF* values for these additional compounds could be determined following the same guidance (Sections D-1.0 through D-1.3) used in determination of the *BCF* values reported in this appendix. For the calculation of *BCF* values for measurement receptors not represented in Sections D-1.1 through D1-3 (e.g., amphibians and reptiles), an approach consistent to that presented in this appendix could be utilized by applying data applicable to those measurement receptors being evaluated.

For additional discussion on some of the references and equations cited in Sections D-1.0 through D-1.3, the reader is recommended to review the Human Health Risk Assessment Protocol (HHRAP) (U.S. EPA 1998) (see Appendix A-3), and the source documents cited in the reference section of this appendix.

D-1.0 GENERAL GUIDANCE

This section describes general procedures for developing compound-specific *BCF*s from biotransfer factors (*Ba*) for assessing exposure of measurement receptors. A biotransfer factor is the ratio of the compound concentration in fresh (wet) weight animal tissue to the daily intake of compound by the animal through ingestion of food items and media (soil, sediment, surface water). Therefore, as discussed in Chapter 5, biotransfer factors and receptor-specific ingestion rates can be used to calculate food item- and media-to-animal *BCF*s. This approach provides an estimate of biotransfer of compounds from applicable food items and media to measurement receptors ingesting these items.

Biotransfer factors could also be used directly in equations to calculate dose to measurement receptors. However, in order to promote consistency in evaluating exposure across all trophic levels within complex food webs, *BCF*s calculated from *Ba* values are recommended in this guidance for evaluating measurement receptors. The use of *Ba* values to determine *BCF* values, and the use of *BCF* values in general, for the estimation of compound concentrations in measurement receptors may introduce uncertainty. Major factors that influence the uptake of a compound by an animal, and therefore uncertainty, include bioavailability, metabolic rate, type of digestive system, and feeding behavior. Uncertainties also should be considered regarding the development of biotransfer values in comparison to how they are being applied for estimating exposure. For example, biotransfer values may be used to estimate contaminant uptake to species from items ingested that differ from the species and intakes used to empirically develop the values. Also, biotransfer data reported in literature may be specific to tissue or organ analysis versus whole body. As a result, *BCF*s may be under- or over-estimated to an unknown degree.

BCFs for Measurement Receptors Ingesting Food Items *BCF* values for measurement receptors ingesting food items (plants or prey) can be calculated using the compound specific *Ba* value applicable to the animal (e.g., mammal, bird, etc.) and the measurement receptor-specific ingestion rate as follows:

$$BCF_{F\text{-}A} = Ba_A \cdot IR_F \qquad \text{Equation D-1-1}$$

where

$BCF_{F\text{-}A}$	=	Bioconcentration factor for food item (plant or prey)-to-animal (measurement receptor) [(mg COPC/kg FW tissue)/(mg COPC/kg FW food item)]
Ba_A	=	COPC-specific biotransfer factor applicable for the animal (day/kg FW tissue)
IR_F	=	Measurement receptor food item ingestion rate (kg FW/day)

As an example of applying the above equation, *BCF* values for plants-to-wildlife measurement receptors listed in Chapter 4 are provided in Table D-1 at the end of this appendix. Measurement-receptor specific ingestion rates used to calculate *BCF*s are presented in Table 5-1. *Ba* values applicable to the mammal and bird measurement receptors in Table D-1 are discussed in Sections D-1.1 and D-1.2, respectively.

BCFs for Measurement Receptors Ingesting Media *BCF* values for measurement receptors in trophic levels 2, 3, and 4 ingesting media (i.e., soil, surface water, and sediment) can be calculated using the compound specific *Ba* value applicable to the animal (e.g., mammal, bird, etc.) and the measurement receptor-specific ingestion rate as follows:

$$BCF_{M\text{-}A} = Ba_A \cdot IR_M \qquad \text{Equation D-1-2}$$

where

$BCF_{M\text{-}A}$	=	Bioconcentration factor for media-to-animal (measurement receptor) [(mg COPC/kg FW tissue)/(mg COPC/kg WW or DW media)]
Ba_A	=	COPC-specific biotransfer factor applicable for the animal (day/kg FW tissue)

IR_M = Measurement receptor media ingestion rate (WW or DW kg/day)

Equation D-1-2 assumes that Ba_A provides a reasonable estimate of the uptake of a compound from incidental ingestion of abiotic media during foraging.

As an example of applying the above equation, *BCF* values for various wildlife measurement receptors listed in Chapter 4 are provided in Table D-2 (water) and Table D-3 (soil and sediment). Measurement-receptor specific ingestion rates used to calculate *BCF*s are presented in Table 5-1. *Ba* values applicable to the mammal and bird measurement receptors for which values were calculated are discussed in Sections D-1.1 and D-1.2, respectively.

BCFs for Dioxins and Furans As discussed in Chapter 2, the *BCF* values for PCDDs and PCDFs are calculated using bioaccumulation equivalency factors (*BEF*s). Consistent with U.S. EPA (1995b), *BEF*s are expressed relative to the *BCF* for 2,3,7,8-TCDD as follows:

$$BCF_j = BCF_{2,3,7,8-TCDD} \cdot BEF_j \qquad \text{Equation D-1-3}$$

where

BCF_j = Food item-to-animal or media-to-animal *BCF* for *j*th PCDD or PCDF congener for food item-to-animal pathway [(mg COPC/kg FW tissue)/(mg COPC/kg FW plant)]or media-to-animal pathway [(mg COPC/kg FW tissue)/(mg COPC/kg WW media)]

$BCF_{2,3,7,8-TCDD}$ = Food item-to-animal or media-to-animal *BCF* for 2,3,7,8-TCDD

$BEFj$ = Bioaccumulation equivalency factor for *j*th PCDD or PCDF congener (unitless)

The use of *BEF*s for dioxin and furan congeners is further discussed in Chapter 2.

D-1.1 BIOTRANSFER FACTORS FOR MAMMALS (Ba_{mammal})

As discussed in Section D-1.0, calculation of *BCF* values to be used in pathways for mammals ingesting food items and media requires the determination of COPC-specific biotransfer factors for mammal measurement receptors (Ba_{mammal}). This section discusses selection of the Ba_{mammal} values used to calculate the COPC and measurement receptor specific BCF values presented in Tables D-1 through D-3.

Organics For organics (except PCDDs and PCDFs), the following correlation equation from Travis and Arms (1988) was used to derrive Ba_{mammal} values on a FW basis:

$$\log Ba_{mammal} = -7.6 + \log K_{ow} \qquad \text{Equation D-1-4}$$

where

Ba_{mammal}	=	Biotransfer factor for mammals (day/kg FW tissue)
K_{ow}	=	Octanol-water partition coefficient (unitless)

To calculate the values presented in Tables D-1 through D-3, COPC-specific K_{ow} values were obtained from Appendix A-2.

Biotransfer factors obtained from Travis and Arms (1988) were derived from correlation equations developed from data on experiments conducted with beef cattle ingesting food items and media containing compound classes such as DDT, pesticides, PCDDs, PCDFs, and PCBs. As further literature is developed for other species and compounds, the Travis and Arms (1988) correlation equation should be compared for applicability to species and compound, and best fit correlation for estimation of uptake.

PCDDs and PCDFs Ba_{mammal} values for PCDD and PCDFs were derrived from *Ba* values for cattle as presented in:

- U.S. EPA 1995a. "Further Studies for Modeling the Indirect Exposure Impacts from Combustor Emissions." Memorandum from Matthew Lorber, Exposure Assessment Group, and Glenn Rice, Environmental Criteria and Assessment Office, Washington, D.C. January 20.

U.S. EPA (1995a) determined *Ba* values for cattle from McLachlan, Thoma, Reissinger, and Hutzinger (1990). These empirically determined *Ba* values were recommended by U.S. EPA (1995a) over the Travis and Arms (1988) correlation equation for dioxins and furans.

Inorganics For metals (except cadmium, mercury, selenium, and zinc), *Ba* values on a fresh weight basis were obtained from Baes, Sharp, Sjoreen, and Shor (1984). For cadmium, selenium, and zinc, U.S. EPA (1995a) indicated that *Ba* values were derived by dividing uptake slopes [(g compound/kg DW tissue)/(g compound/kg DW feed)], obtained from U.S. EPA (1992), by a daily consumption rate of 20 kilograms DW per day by cows.

For use in calculating *BCF* values presented in Tables D-1 through D-3 of this appendix, dry weight *Ba* values were converted to fresh weight basis by assuming a tissue moisture content (by mass) of 70 percent for cows. Moisture content information was obtained from the following:

- U.S. EPA. 1997a. *Exposure Factors Handbook.* "Food Ingestion Factors". Volume II. EPA/600/P-95/002Fb. August.

- Pennington, J.A.T. 1994. *Food Value of Portions Commonly Used.* Sixteenth Edition. J.B. Lippincott Company, Philadelphia.

Mercuric Compounds Based on assumptions made regarding speciation and fate and transport of mercury from stack emissions (as discussed in Chapter 2), elemental mercury is assumed not to deposit onto soils, water, or plants. Therefore, it is also not available in food items or media for ingestion and subsequent uptake by measurement receptors. As a result, no *BCF* values for elemental mercury are presented in Tables D-1 through D-3 of this appendix. If site-specific field data suggest otherwise, *Ba* values for elemental mercury can be derived from uptake slope factors provided in U.S. EPA (1992) and U.S. EPA (1995a), using the same consumption rates as were discussed earlier for the metals like cadmium, selenium, and zinc.

Ba_{mammal} values for mercuric chloride and methyl mercury were derived from data in U.S. EPA (1997b). U.S. EPA (1997b) provides *Ba* values for mercury in cows, but does not specify the form of mercury. To obtain the *Ba* values for mercuric chloride and methyl mercury presented in Tables D-1 through D-3 of this guidance, consistent with U.S. EPA (1997b) total mercury was assumed to be composed of 87 percent divalent mercury (as mercuric chloride) and 13 percent methyl mercury in herbivore animal tissue. Also, assuming that the *Ba* value provided in U.S. EPA (1997b) is for the total mercury in the animal tissue, then biotransfer factors in U.S. EPA (1997b) can be determined for mercuric chloride and methyl mercury, as follows:

- The default *Ba* value of 0.02 day/kg DW for total mercury obtained from U.S. EPA (1997b) was converted to a fresh weight basis assuming a 70 percent moisture content in cow tissue (U.S. EPA 1997a; Pennington 1994). The fresh weight *Ba* value for total mercury was multiplied by 0.13 to obtain a Ba_{mammal} value for methyl mercury, and by 0.87 to obtain a Ba_{mammal} value for mercuric chloride.

D-1.2 BIOTRANSFER FACTORS FOR BIRDS (Ba_{bird})

As discussed in Section D-1.0, calculation of *BCF* values to be used in pathways for birds ingesting food items and media requires the determination of COPC-specific biotransfer factors for bird measurement receptors (Ba_{bird}). This section discusses selection of the Ba_{bird} values used to calculate the COPC and measurement receptor specific *BCF* values presented in Tables D-1 through D-3.

Organics Ba_{bird} values for organic compounds (except PCDDs and PCDFs) were derived from Ba_{mammal} values by assuming that the lipid content (by mass) of birds and mammals is 15 and 19 percent, respectively. Therefore, Ba_{bird} values presented in Tables D-1 through D-3 were determined by multiplying Ba_{mammal} values by the bird and mammal fat content ratio of 0.8 (15/19).

Notable uncertainties associated with this approach include (1) extent to which specific organic compounds bioconcentrate in fatty tissues, and (2) differences in lipid content, metabolism, and feeding characteristics between species.

PCDDs and PCDFs Ba_{bird} values presented in Tables D-1 through D-3 for PCDD and PCDF congeners were derrived from data provided in the following:

- Stephens, R.D., M. Petreas, and G.H. Hayward. 1995. "Biotransfer and Bioaccumulation of Dioxins and Furans from Soil: Chickens as a Model for Foraging Animals." *The Science of the Total Environment.* Volume 175. Pages 253-273.

Stephens, Petreas, and Hayward (1995) conducted experiments to determine the bioavailability and the rate of PCDDs and PCDFs uptake from soil by foraging chickens. Three groups of White Leghorn chickens were studied—control group, low exposure group, and high exposure group. Eggs, tissues (liver, adipose, and thigh), feed, and feces were analyzed.

Congener specific Ba_{bird} values were derrived from the Stephens, Petreas, and Hayward (1995) study by dividing estimated whole body bioconcentration values for the high exposure group by a daily consumption rate of soil. If congener specific *BCF* values were not reported for the high exposure group, then estimated whole body values were determined using reported data for the low exposure group, if available. A default consumption rate of soil by chicken of 0.02 kg DW/day was determined as follows:

(1) Consumption rate of feed by chicken was obtained from U.S. EPA (1995a), which cites a value of 0.2 kg (DW) feed/day obtained from various literature sources.

(2) The fraction of feed that is soil (0.1) was obtained from Stephens, Petreas, and Hayward (1995).

(3) Feed consumption rate of 0.2 kg/day was multiplied by fraction of feed that is soil (0.1), to obtain the soil consumption rate by chicken of 0.2 x 0.1 = 0.02 kg DW soil/day.

Inorganics For metals (except cadmium, selenium, and zinc), Ba_{bird} values were not available in the literature. For cadmium, selenium, and zinc, U.S. EPA (1995a) cites *Ba* values that were derived by dividing uptake slopes [(g compound/kg dry DW tissue)/(g compound/kg DW feed)], obtained from U.S. EPA (1992), by a daily ingestion rate of 0.2 kilograms DW per day by poultry. To determine *BCF* values presented in Tables D-1 through D-3 in this appendix, reported dry weight *Ba* values were converted to fresh weight basis by assuming a tissue moisture content (by mass) of 75 percent for poultry (U.S. EPA 1997a; Pennington 1994).

Mercuric Compounds Based on assumptions made regarding speciation and fate and transport of mercury from stack emissions (as discussed in Chapter 2), elemental mercury is assumed not to deposit onto soils, water, or plants. Therefore, it is also not available in food items or media for ingestion and subsequent uptake by measurement receptors. As a result, no *BCF* values for elemental mercury are presented in Tables D-1 through D-3 of this appendix. If site-specific field data suggest otherwise, *Ba* values for elemental mercury can be derived from uptake slope factors provided in U.S. EPA (1992) and U.S. EPA (1995a), using the same consumption rates as were discussed earlier for the metals like cadmium, selenium, and zinc.

Ba_{bird} values for mercuric chloride and methyl mercury were derived from data in U.S. EPA (1997b). U.S. EPA (1997b) provides *Ba* values for mercury in poultry, but does not specify the form of mercury. To obtain the *Ba* values for mercuric chloride and methyl mercury presented in Tables D-1 through D-3 of this guidance, consistent with U.S. EPA (1997b) total mercury was assumed to be composed of 87 percent divalent mercury (as mercuric chloride) and 13 percent methyl mercury in herbivore animal tissue. Also, assuming that the *Ba* value provided in U.S. EPA (1997b) is for the total mercury in the animal tissue, then biotransfer factors in U.S. EPA (1997b) can be determined for mercuric chloride and methyl mercury, as follows:

- The default *Ba* value of 0.02 day/kg DW for total mercury obtained from U.S. EPA (1997b) was converted to a fresh weight basis assuming a 75 percent moisture content in poultry tissue (U.S. EPA 1997a; Pennington 1994). The fresh weight *Ba* value for total mercury was multiplied by 0.13 to obtain a Ba_{bird} value for methyl mercury, and by 0.87 to obtain a Ba_{bird} value for mercuric chloride.

REFERENCES
APPENDIX D TEXT

Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. "Review and Analysis of Parameters and Assessing Transport of Environmentally Released Radionuclides through Agriculture." Oak Ridge National Laboratory. Oak Ridge, Tennessee.

McLachlan, M.S., H. Thoma, M. Reissinger, and O. Hutzinger. 1990. "PCDD/F in an Agricultural Food Chain. Part I: PCDD/F Mass Balance of a Lactating Cow." *Chemosphere.* Volume 20. Pages 1013-1020.

Pennington, J.A.T. 1994. *Food Value of Portions Commonly Used.* Sixteenth Edition. J.B. Lippincott Company, Philadelphia.

Stephens, R.D., M. Petreas, and G.H. Hayward. 1995. "Biotransfer and Bioaccumulation of Dioxins and Furans from Soil: Chickens as a Model for Foraging Animals." *The Science of the Total Environment.* Volume 175. Pages 253-273.

Travis, C.C., and A.D. Arms. 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation." *Environmental Science and Technology.* 22:271-274.

U.S. EPA. 1992. *Health Reassessment of Dioxin-Like Compounds, Chapters 1 to 8. Workshop Review Draft.* OHEA. Washington, D.C. EPA/600/AP-92/001a through 001h. August.

U.S. EPA. 1994. "Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes. *Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities.*" April 15.

U.S. EPA 1995a. "Further Studies for Modeling the Indirect Exposure Impacts from Combustor Emissions." Memorandum from Matthew Lorber, Exposure Assessment Group, and Glenn Rice, Indirect Exposure Team, Environmental Criteria and Assessment Office, Washington, D.C. January 20.

U.S. EPA. 1995b. Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors. EPA-820-B-95-005. Office of Water, Washington, D.C. March.

U.S. EPA. 1997a. *Exposure Factors Handbook.* "Food Ingestion Factors". Volume II. EPA/600/P-95/002Fb. August.

U.S. EPA. 1997b. *Mercury Study Report to Congress, Volumes I through VIII.* Office of Air Quality Planning and Standards and ORD. EPA/452/R-97-001. December.

TABLE D-1

BIOCONCENTRATION FACTORS FOR PLANTS TO WILDLIFE MEASUREMENT RECEPTORS

(Page 1 of 3)

Compound	Measurement Receptor													
	American Robin (BCF_{TP-OB})	Canvas Back (BCF_{TP-HB})	Deer Mouse (BCF_{TP-HM})	Least Shrew (BCF_{TP-OM})	Mallard Duck (BCF_{TP-OB})	Marsh Rice Rat (BCF_{TP-OM})	Marsh Wren (BCF_{TP-OB})	Mourning Dove (BCF_{TP-HB})	Muskrat (BCF_{TP-OM})	Northern Bobwhite (BCF_{TP-OB})	Salt-marsh Harvest Mouse (BCF_{TP-HM})	Short-tailed Shrew (BCF_{TP-OM})	Western Meadow Lark (BCF_{TP-OM})	White-footed Mouse (BCF_{TP-OM})
Dioxins and Furans														
2,3,7,8-TCDD	1.53e+02	6.85e+01	3.25e-02	3.37e-02	6.16e+01	2.39e-02	3.19e+02	1.20e+02	1.45e-02	1.20e+02	4.02e-02	3.37e-02	1.45e+02	3.33e-02
1,2,3,7,8-PeCDD	1.41e+02	6.30e+01	2.99e-02	3.10e-02	5.67e+01	2.20e-02	2.93e+02	1.11e+02	1.33e-02	1.11e+02	3.70e-02	3.10e-02	1.33e+02	3.07e-02
1,2,3,4,7,8-HxCDD	4.74e+01	2.12e+01	1.01e-02	1.04e-02	1.91e+01	7.41e-03	9.88e+01	3.72e+01	4.50e-03	3.72e+01	1.25e-02	1.04e-02	4.49e+01	1.03e-02
1,2,3,6,7,8-HxCDD	1.83e+01	8.22e+00	3.91e-03	4.04e-03	7.39e+00	2.87e-03	3.83e+01	1.44e+01	1.74e-03	1.44e+01	4.83e-03	4.04e-03	1.74e+01	4.00e-03
1,2,3,7,8,9-HxCDD	2.14e+01	9.59e+00	4.56e-03	4.71e-03	8.63e+00	3.35e-03	4.46e+01	1.68e+01	2.03e-03	1.68e+01	5.63e-03	4.71e-03	2.03e+01	4.67e-03
1,2,3,4,6,7,8-HpCDD	7.79e+00	3.49e+00	1.66e-03	1.72e-03	3.14e+00	1.22e-03	1.63e+01	6.13e+00	7.40e-04	6.13e+00	2.05e-03	1.72e-03	7.39e+00	1.70e-03
OCDD	1.83e+00	8.22e-01	3.91e-04	4.04e-04	7.39e-01	2.87e-04	3.83e+00	1.44e+00	1.74e-04	1.44e+00	4.83e-04	4.04e-04	1.74e+00	4.00e-04
2,3,7,8-TCDF	1.22e+02	5.48e+01	2.60e-02	2.69e-02	4.93e+01	1.91e-02	2.55e+02	9.61e+01	1.16e-02	9.61e+01	3.22e-02	2.69e-02	1.16e+02	2.67e-02
1,2,3,7,8-PeCDF	3.36e+01	1.51e+01	7.16e-03	7.41e-03	1.36e+01	5.26e-03	7.01e+01	2.64e+01	3.19e-03	2.64e+01	8.85e-03	7.41e-03	3.19e+01	7.34e-03
2,3,4,7,8-PeCDF	2.44e+02	1.10e+02	5.21e-02	5.39e-02	9.86e+01	3.83e-02	5.10e+02	1.92e+02	2.32e-02	1.92e+02	6.44e-02	5.39e-02	2.32e+02	5.34e-02
1,2,3,4,7,8-HxCDF	1.16e+01	5.21e+00	2.47e-03	2.56e-03	4.68e+00	1.82e-03	2.42e+01	9.13e+00	1.10e-03	9.13e+00	3.06e-03	2.56e-03	1.10e+01	2.53e-03
1,2,3,6,7,8-HxCDF	2.90e+01	1.30e+01	6.18e-03	6.40e-03	1.17e+01	4.54e-03	6.06e+01	2.28e+01	2.76e-03	2.28e+01	7.64e-03	6.40e-03	2.75e+01	6.34e-03
2,3,4,6,7,8-HxCDF	1.02e+02	4.59e+01	2.18e-02	2.26e-02	4.13e+01	1.60e-02	2.14e+02	8.05e+01	9.72e-03	8.05e+01	2.70e-02	2.26e-02	9.70e+01	2.23e-02
1,2,3,7,8,9-HxCDF	9.63e+01	4.32e+01	2.05e-02	2.12e-02	3.88e+01	1.51e-02	2.01e+02	7.57e+01	9.14e-03	7.57e+01	2.53e-02	2.12e-02	9.13e+01	2.10e-02
1,2,3,4,6,7,8-HpCDF	1.68e+00	7.54e-01	3.58e-04	3.70e-04	6.78e-01	2.63e-04	3.51e+00	1.32e+00	1.60e-04	1.32e+00	4.43e-04	3.70e-04	1.59e+00	3.67e-04
1,2,3,4,7,8,9-HpCDF	5.96e+01	2.67e+01	1.27e-02	1.31e-02	2.40e+01	9.33e-03	1.24e+02	4.69e+01	5.66e-03	4.69e+01	1.57e-02	1.31e-02	5.65e+01	1.30e-02
OCDF	2.44e+00	1.10e+00	5.21e-04	5.39e-04	9.86e-01	3.83e-04	5.10e+00	1.92e+00	2.32e-04	1.92e+00	6.44e-04	5.39e-04	2.32e+00	5.34e-04
Polynuclear Aromatic Hydrocarbons (PAHs)														
Benzo(a)pyrene	1.19e-02	5.32e-03	2.03e-02	2.10e-02	4.78e-03	1.49e-02	2.47e-02	9.32e-03	9.03e-03	9.32e-03	2.50e-02	2.10e-02	1.12e-02	2.08e-02
Benzo(a)anthracene	4.20e-03	1.88e-03	7.19e-03	7.44e-03	1.69e-03	5.28e-03	8.76e-03	3.30e-03	3.21e-03	3.30e-03	8.89e-03	7.44e-03	3.98e-03	7.37e-03
Benzo(b)fluoranthene	1.40e-02	6.29e-03	2.40e-02	2.48e-02	5.66e-03	1.76e-02	2.93e-02	1.10e-02	1.07e-02	1.10e-02	2.96e-02	2.48e-02	1.33e-02	2.46e-02
Benzo(k)fluoranthene	1.39e-02	6.25e-03	2.39e-02	2.47e-02	5.62e-03	1.75e-02	2.91e-02	1.10e-02	1.06e-02	1.10e-02	2.95e-02	2.47e-02	1.32e-02	2.44e-02
Chrysene	4.84e-03	2.17e-03	8.27e-03	8.56e-03	1.95e-03	6.08e-03	1.01e-02	3.81e-03	3.69e-03	3.81e-03	1.02e-02	8.56e-03	4.59e-03	8.47e-03
Dibenz(a,h)anthracene	3.11e-02	1.39e-02	5.31e-02	5.49e-02	1.25e-02	3.90e-02	6.48e-02	2.44e-02	2.37e-02	2.44e-02	6.57e-02	5.49e-02	2.95e-02	5.44e-02
Indeno(1,2,3-cd)pyrene	7.24e-02	3.25e-02	1.24e-01	1.28e-01	2.92e-02	9.12e-02	1.51e-01	5.69e-02	5.53e-02	5.69e-02	1.53e-01	1.28e-01	6.86e-02	1.27e-01
Polychlorinated Biphenyls (PCBs)														
Aroclor, 1016	2.23e-03	1.00e-03	3.82e-03	3.95e-03	9.01e-04	2.81e-03	4.66e-03	1.76e-03	1.70e-03	1.76e-03	4.72e-03	3.95e-03	2.12e-03	3.91e-03
Aroclor, 1254	1.42e-02	6.35e-03	2.43e-02	2.51e-02	5.71e-03	1.78e-02	2.96e-02	1.11e-02	1.08e-02	1.11e-02	3.00e-02	2.51e-02	1.34e-02	2.49e-02
Nitroaromatics														
1,3-Dinitrobenzene	2.73e-07	1.22e-07	4.67e-07	4.83e-07	1.10e-07	3.43e-07	5.70e-07	2.15e-07	2.08e-07	2.15e-07	5.77e-07	4.83e-07	2.59e-07	4.78e-07
2,4-Dinitrotoluene	8.70e-07	3.90e-07	1.49e-06	1.54e-06	3.51e-07	1.10e-06	1.82e-06	6.84e-07	6.65e-07	6.84e-07	1.85e-06	1.54e-06	8.25e-07	1.53e-06

TABLE D-1

BIOCONCENTRATION FACTORS FOR PLANTS TO WILDLIFE MEASUREMENT RECEPTORS

(Page 2 of 3)

Compound	Measurement Receptor													
	American Robin (BCF_{TP-OB})	Canvas Back (BCF_{TP-HB})	Deer Mouse (BCF_{TP-HM})	Least Shrew (BCF_{TP-OM})	Mallard Duck (BCF_{TP-OB})	Marsh Rice Rat (BCF_{TP-OM})	Marsh Wren (BCF_{TP-OB})	Mourning Dove (BCF_{TP-HB})	Muskrat (BCF_{TP-OM})	Northern Bobwhite (BCF_{TP-OB})	Salt-marsh Harvest Mouse (BCF_{TP-HM})	Short-tailed Shrew (BCF_{TP-OM})	Western Meadow Lark (BCF_{TP-OM})	White-footed Mouse (BCF_{TP-OM})
2,6-Dinitrotoluene	6.79e-07	3.05e-07	1.16e-06	1.20e-06	2.74e-07	8.50e-07	1.42e-06	5.34e-07	5.16e-07	5.34e-07	1.43e-06	1.20e-06	6.44e-07	1.19e-06
Nitrobenzene	5.99e-07	2.69e-07	1.03e-06	1.06e-06	2.42e-07	7.53e-07	1.25e-06	4.71e-07	4.57e-07	4.71e-07	1.27e-06	1.06e-06	5.68e-07	1.05e-06
Pentachloronitrobenzene	3.85e-04	1.72e-04	6.59e-04	6.82e-04	1.55e-04	4.84e-04	8.02e-04	3.02e-04	2.94e-04	3.02e-04	8.15e-04	6.82e-04	3.65e-04	6.76e-04
Phthalate Esters														
Bis(2-ethylhexyl)phthalate	1.41e-03	6.33e-04	2.42e-03	2.50e-03	5.69e-04	1.77e-03	2.95e-03	1.11e-03	1.08e-03	1.11e-03	2.99e-03	2.50e-03	1.34e-03	2.47e-03
Di(n)octyl phthalate	1.88e+01	8.44e+00	3.22e+01	3.33e+01	7.59e+00	2.36e+01	3.93e+01	1.48e+01	1.43e+01	1.48e+01	3.98e+01	3.33e+01	1.78e+01	3.30e+01
Volatile Organic Compounds														
Acetone	5.28e-09	2.37e-09	9.05e-09	9.36e-09	2.13e-09	6.65e-09	1.10e-08	4.15e-09	4.03e-09	4.15e-09	1.12e-08	9.36e-09	5.01e-09	9.27e-09
Acrylonitrile	1.57e-08	7.03e-09	2.68e-08	2.77e-08	6.32e-09	1.97e-08	3.27e-08	1.23e-08	1.19e-08	1.23e-08	3.31e-08	2.77e-08	1.49e-08	2.75e-08
Chloroform	7.82e-07	3.50e-07	1.34e-06	1.39e-06	3.15e-07	9.87e-07	1.63e-06	6.14e-07	5.98e-07	6.14e-07	1.66e-06	1.39e-06	7.41e-07	1.38e-06
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	4.75e-09	2.13e-09	8.15e-09	8.43e-09	1.92e-09	5.99e-09	9.91e-09	3.74e-09	3.63e-09	3.74e-09	1.01e-08	8.43e-09	4.50e-09	8.35e-09
Formaldehyde	1.94e-08	8.68e-09	3.31e-08	3.43e-08	7.81e-09	2.44e-08	4.04e-08	1.52e-08	1.48e-08	1.52e-08	4.10e-08	3.43e-08	1.84e-08	3.40e-08
Vinyl chloride	1.23e-07	5.53e-08	2.11e-07	2.18e-07	4.98e-08	1.55e-07	2.58e-07	9.71e-08	9.40e-08	9.71e-08	2.61e-07	2.18e-07	1.17e-07	2.16e-07
Other Chlorinated Organics														
Hexachlorobenzene	2.80e-03	1.26e-03	4.79e-03	4.95e-03	1.13e-03	3.52e-03	5.85e-03	2.20e-03	2.13e-03	2.20e-03	5.92e-03	4.95e-03	2.66e-03	4.91e-03
Hexachlorobutadiene	4.75e-04	2.13e-04	8.09e-04	8.37e-04	1.92e-04	5.95e-04	9.91e-04	3.74e-04	3.61e-04	3.74e-04	1.00e-03	8.37e-04	4.50e-04	8.29e-04
Hexachlorocyclopentadiene	7.11e-04	3.19e-04	1.22e-03	1.26e-03	2.87e-04	8.94e-04	1.48e-03	5.59e-04	5.42e-04	5.59e-04	1.50e-03	1.26e-03	6.74e-04	1.25e-03
Pentachlorobenzene	1.08e-03	4.84e-04	1.84e-03	1.90e-03	4.35e-04	1.35e-03	2.25e-03	8.48e-04	8.20e-04	8.48e-04	2.27e-03	1.90e-03	1.02e-03	1.89e-03
Pentachlorophenol	1.06e-03	4.76e-04	1.81e-03	1.87e-03	4.28e-04	1.33e-03	2.21e-03	8.34e-04	8.07e-04	8.34e-04	2.24e-03	1.87e-03	1.01e-03	1.85e-03
Pesticides														
4,4-DDE	1.59e-02	7.13e-03	2.72e-02	2.81e-02	6.41e-03	2.00e-02	3.32e-02	1.25e-02	1.21e-02	1.25e-02	3.36e-02	2.81e-02	1.51e-02	2.78e-02
Heptachlor	9.10e-04	4.08e-04	1.56e-03	1.61e-03	3.67e-04	1.15e-03	1.90e-03	7.16e-04	6.95e-04	7.16e-04	1.93e-03	1.61e-03	8.63e-04	1.60e-03
Hexachlorophene	3.06e-01	1.37e-01	5.22e-01	5.40e-01	1.23e-01	3.84e-01	6.37e-01	2.40e-01	2.33e-01	2.40e-01	6.45e-01	5.40e-01	2.90e-01	5.35e-01
Inorganics														
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	5.99e-04	6.20e-04	NA	4.40e-04	NA	NA	2.67e-04	NA	7.41e-04	6.20e-04	NA	6.14e-04
Arsenic	NA	NA	1.20e-03	1.24e-03	NA	8.81e-04	NA	NA	5.34e-04	NA	1.48e-03	1.24e-03	NA	1.23e-03
Barium	NA	NA	8.99e-05	9.30e-05	NA	6.61e-05	NA	NA	4.01e-05	NA	1.11e-04	9.30e-05	NA	9.21e-05
Beryllium	NA	NA	5.99e-04	6.20e-04	NA	4.40e-04	NA	NA	2.67e-04	NA	7.41e-04	6.20e-04	NA	6.14e-04
Cadmium	4.71e-02	2.11e-02	7.19e-05	7.44e-05	1.90e-02	5.28e-05	9.82e-02	3.70e-02	3.21e-05	3.70e-02	8.89e-05	7.44e-05	4.46e-02	7.37e-05
Chromium (hexavalent)	NA	NA	3.30e-03	3.41e-03	NA	2.42e-03	NA	NA	1.47e-03	NA	4.08e-03	3.41e-03	NA	3.38e-03

TABLE D-1

BIOCONCENTRATION FACTORS FOR PLANTS TO WILDLIFE MEASUREMENT RECEPTORS

Compound	Measurement Receptor													
	American Robin (BCF_{TP-OB})	Canvas Back (BCF_{TP-HB})	Deer Mouse (BCF_{TP-HM})	Least Shrew (BCF_{TP-OM})	Mallard Duck (BCF_{TP-OB})	Marsh Rice Rat (BCF_{TP-OM})	Marsh Wren (BCF_{TP-OB})	Mourning Dove (BCF_{TP-HB})	Muskrat (BCF_{TP-OM})	Northern Bobwhite (BCF_{TP-OB})	Salt-marsh Harvest Mouse (BCF_{TP-HM})	Short-tailed Shrew (BCF_{TP-OM})	Western Meadow Lark (BCF_{TP-OM})	White-footed Mouse (BCF_{TP-OM})
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	1.80e-04	1.86e-04	NA	1.32e-04	NA	NA	8.02e-05	NA	2.22e-04	1.86e-04	NA	1.84e-04
Mercuric chloride	1.06e-02	4.76e-03	3.13e-03	3.24e-03	4.28e-03	2.30e-03	2.21e-02	8.34e-03	1.39e-03	8.34e-03	3.87e-03	3.24e-03	1.01e-02	3.21e-03
Methylmercury	1.59e-03	7.13e-04	4.68e-04	4.84e-04	6.41e-04	3.44e-04	3.32e-03	1.25e-03	2.08e-04	1.25e-03	5.78e-04	4.84e-04	1.51e-03	4.79e-04
Nickel	NA	NA	3.60e-03	3.72e-03	NA	2.64e-03	NA	NA	1.60e-03	NA	4.45e-03	3.72e-03	NA	3.68e-03
Selenium	5.02e-01	2.25e-01	1.36e-03	1.41e-03	2.02e-01	1.00e-03	1.05e+00	3.95e-01	6.07e-04	3.95e-01	1.68e-03	1.41e-03	4.76e-01	1.39e-03
Silver	NA	NA	1.80e-03	1.86e-03	NA	1.32e-03	NA	NA	8.02e-04	NA	2.22e-03	1.86e-03	NA	1.84e-03
Thallium	NA	NA	2.40e-02	2.48e-02	NA	1.76e-02	NA	NA	1.07e-02	NA	2.96e-02	2.48e-02	NA	2.46e-02
Zinc	3.89e-03	1.74e-03	5.39e-05	5.58e-05	1.57e-03	3.96e-05	8.11e-03	3.05e-03	2.40e-05	3.05e-03	6.67e-05	5.58e-05	3.68e-03	5.53e-05

Notes:

NA - Indicates insufficient data to determine value

HB - Herbivorous bird
HM - Herbivorous mammal
OB - Omnivorous bird
OM - Omnivorous mammal
TP - Terrestrial plant

– Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 1 of 6)

	Measurement Receptors										
Compound	American Kestrel (BCF_{W-CB})	American Robin (BCF_{W-OB})	Canvas Back (BCF_{W-HB})	Deer Mouse (BCF_{W-HM})	Least Shrew (BCF_{W-OM})	Long-tailed Weasel (BCF_{W-OM})	Mallard Duck (BCF_{W-OB})	Marsh Rice Rat (BCF_{W-OM})	Marsh Wren (BCF_{W-OB})	Mink (BCF_{W-CM})	Mourning Dove (BCF_{W-OM})
Dioxins and Furans											
2,3,7,8-TCDD	4.30e+01	4.71e+01	2.21e+01	8.19e-03	9.34e-03	6.88e-03	2.00e+01	1.03e-02	9.46e+01	5.39e-03	3.75e+01
1,2,3,7,8-PeCDD	3.96e+01	4.34e+01	2.04e+01	7.54e-03	8.59e-03	6.33e-03	1.84e+01	9.44e-03	8.70e+01	4.96e-03	3.45e+01
1,2,3,4,7,8-HxCDD	1.33e+01	1.46e+01	6.86e+00	2.54e-03	2.89e-03	2.13e-03	6.21e+00	3.18e-03	2.93e+01	1.67e-03	1.16e+01
1,2,3,6,7,8-HxCDD	5.16e+00	5.66e+00	2.65e+00	9.83e-04	1.12e-03	8.25e-04	2.40e+00	1.23e-03	1.14e+01	6.47e-04	4.50e-01
1,2,3,7,8,9-HxCDD	6.02e+00	6.60e+00	3.10e+00	1.15e-03	1.31e-03	9.63e-04	2.80e+00	1.44e-03	1.32e+01	7.55e-04	5.25e+00
1,2,3,4,6,7,8-HpCDD	2.19e+00	2.40e+00	1.13e+00	4.18e-04	4.76e-04	3.51e-04	1.02e+00	5.23e-04	4.82e+00	2.75e-04	1.91e+00
OCDD	5.16e-01	5.66e-01	2.65e-01	9.83e-05	1.12e-04	8.25e-05	2.40e-01	1.23e-04	1.14e+00	6.47e-05	4.50e-01
2,3,7,8-TCDF	3.44e+01	3.77e+01	1.77e+01	6.55e-03	7.47e-03	5.50e-03	1.60e+01	8.21e-03	7.57e+01	4.31e-03	3.00e+01
1,2,3,7,8-PeCDF	9.46e+00	1.04e+01	4.87e+00	1.80e-03	2.05e-03	1.51e-03	4.40e+00	2.26e-03	2.08e+01	1.19e-03	8.25e+00
2,3,4,7,8-PeCDF	6.88e+01	7.54e+01	3.54e+01	1.31e-02	1.49e-02	1.10e-02	3.20e+01	1.64e-02	1.51e+02	8.62e-03	6.00e+01
1,2,3,4,7,8-HxCDF	3.27e+00	3.58e+00	1.68e+00	6.23e-04	7.10e-04	5.23e-04	1.52e+00	7.80e-04	7.19e+00	4.10e-04	2.85e+00
1,2,3,6,7,8-HxCDF	8.17e+00	8.95e+00	4.20e+00	1.56e-03	1.77e-03	1.31e-03	3.80e+00	1.95e-03	1.80e+01	1.02e-03	7.12e+00
2,3,4,6,7,8-HxCDF	2.88e+01	3.16e+01	1.48e+01	5.49e-03	6.26e-03	4.61e-03	1.34e+01	6.88e-03	6.34e+01	3.61e-03	2.51e+01
1,2,3,7,8,9-HxCDF	2.71e+01	2.97e+01	1.39e+01	5.16e-03	5.88e-03	4.33e-03	1.26e+01	6.47e-03	5.96e+01	3.40e-03	2.36e+01
1,2,3,4,6,7,8-HpCDF	4.73e-01	5.18e-01	2.43e-01	9.01e-05	1.03e-04	7.57e-05	2.20e-01	1.13e-04	1.04e+00	5.93e-05	4.12e-01
1,2,3,4,7,8,9-HpCDF	1.68e+01	1.84e+01	8.63e+00	3.20e-03	3.64e-03	2.68e-03	7.81e+00	4.00e-03	3.69e+01	2.10e-03	1.46e+01
OCDF	6.88e-01	7.54e-01	3.54e-01	1.31e-04	1.49e-04	1.10e-04	3.20e-01	1.64e-04	1.51e+00	8.62e-05	6.00e-01
Polynuclear Aromatic Hydrocarbons (PAHs)											
Benzo(a)pyrene	3.34e-03	3.67e-03	1.72e-03	5.10e-03	5.81e-03	4.28e-03	1.55e-03	3.75e-03	7.35e-03	3.36e-03	2.92e-03
Benzo(a)anthracene	1.18e-03	1.30e-03	6.08e-04	1.81e-03	2.06e-03	1.52e-03	5.50e-04	1.33e-03	2.60e-03	1.19e-03	1.03e-03
Benzo(b)fluoranthene	3.95e-03	4.34e-03	2.03e-03	6.03e-03	6.88e-03	5.07e-03	1.84e-03	4.44e-03	8.70e-03	3.97e-03	3.46e-03
Benzo(k)fluoranthene	3.92e-03	4.31e-03	2.02e-03	6.00e-03	6.84e-03	5.04e-03	1.83e-03	4.41e-03	8.64e-03	3.95e-03	3.43e-03
Chrysene	1.36e-03	1.50e-03	7.01e-04	2.08e-03	2.37e-03	1.75e-03	6.34e-04	1.53e-03	3.00e-03	1.37e-03	1.19e-03
Dibenz(a,h)anthracene	8.74e-03	9.61e-03	4.50e-03	1.34e-02	1.52e-02	1.12e-02	4.07e-03	9.84e-03	1.93e-02	8.79e-03	7.66e-03
Indeno(1,2,3-cd)pyrene	2.04e-02	2.24e-02	1.05e-02	3.12e-02	3.56e-02	2.62e-02	9.48e-03	2.29e-02	4.49e-02	2.05e-02	1.78e-02
Polychlorinated Biphenyls (PCBs)											
Aroclor 1016	6.28e-04	6.91e-04	3.24e-04	9.61e-04	1.10e-03	8.07e-04	2.93e-04	7.07e-04	1.38e-03	6.32e-04	5.50e-04
Aroclor 1254	3.98e-03	4.38e-03	2.05e-03	6.11e-03	6.96e-03	5.13e-03	1.86e-03	4.48e-03	8.78e-03	4.02e-03	3.49e-03
Nitroaromatics											
1,3-Dinitrobenzene	7.68e-08	8.45e-08	3.96e-08	1.18e-07	1.34e-07	9.87e-08	3.58e-08	8.65e-08	1.69e-07	7.73e-08	6.73e-08
2,4-Dinitrotoluene	2.45e-07	2.69e-07	1.26e-07	3.76e-07	4.28e-07	3.15e-07	1.14e-07	2.76e-07	5.39e-07	2.47e-07	2.14e-07

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 2 of 6)

	Measurement Receptors										
Compound	American Kestrel (BCF_{W-CH})	American Robin (BCF_{W-OH})	Canvas Back (BCF_{W-HB})	Deer Mouse (BCF_{W-HM})	Least Shrew (BCF_{W-OM})	Long-tailed Weasel (BCF_{W-OM})	Mallard Duck (BCF_{W-OH})	Marsh Rice Rat (BCF_{W-OM})	Marsh Wren (BCF_{W-OH})	Mink (BCF_{W-CM})	Mourning Dove (BCF_{W-OM})
2,6-Dinitrotoluene	1.91e-07	2.10e-07	9.84e-08	2.91e-07	3.32e-07	2.44e-07	8.90e-08	2.15e-07	4.21e-07	1.92e-07	1.67e-07
Nitrobenzene	1.69e-07	1.85e-07	8.68e-08	2.58e-07	2.94e-07	2.17e-07	7.86e-08	1.90e-07	3.72e-07	1.70e-07	1.48e-07
Pentachloronitrobenzene	1.08e-04	1.19e-04	5.57e-05	1.66e-04	1.89e-04	1.39e-04	5.04e-05	1.22e-04	2.38e-04	1.09e-04	9.47e-05
Phthalate Esters											
Bis(2-ethylhexyl)phthalate	3.97e-04	4.37e-04	2.05e-04	6.08e-04	6.93e-04	5.11e-04	1.85e-04	4.47e-04	8.75e-04	4.00e-04	3.48e-04
Di(n)octyl phthalate	5.30e+00	5.82e+00	2.73e+00	8.10e+00	9.23e+00	6.80e+00	2.47e+00	5.96e+00	1.17e+01	5.33e+00	4.64e+00
Volatile Organic Compounds											
Acetone	1.49e-09	1.63e-09	7.65e-10	2.28e-09	2.60e-09	1.91e-09	6.92e-10	1.67e-09	3.28e-09	1.50e-09	1.30e-09
Acrylonitrile	4.41e-09	4.84e-09	2.27e-09	6.74e-09	7.69e-09	5.66e-09	2.05e-09	1.27e-09	9.71e-09	4.44e-09	3.85e-09
Chloroform	2.20e-07	2.42e-07	1.13e-07	3.38e-07	3.85e-07	2.84e-07	1.02e-07	2.47e-07	4.84e-07	2.22e-07	1.93e-07
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	1.34e-09	1.47e-09	6.88e-10	2.05e-09	2.34e-09	1.72e-09	6.23e-10	1.50e-09	2.95e-09	1.35e-09	1.17e-09
Formaldehyde	5.45e-09	5.99e-09	2.80e-09	8.34e-09	9.51e-09	7.01e-09	2.54e-09	6.13e-09	1.20e-08	5.49e-09	4.77e-09
Vinyl chloride	3.47e-08	3.82e-08	1.79e-08	5.31e-08	6.05e-08	4.46e-08	1.62e-08	3.91e-08	7.65e-08	3.49e-08	3.04e-08
Other Chlorinated Organics											
Hexachlorobenzene	7.88e-04	8.67e-04	4.06e-04	1.21e-03	1.37e-03	1.01e-03	3.67e-04	8.87e-04	1.74e-03	7.93e-04	6.90e-04
Hexachlorobutadiene	1.34e-04	1.47e-04	6.88e-05	2.04e-04	2.32e-04	1.71e-04	6.23e-05	1.51e-04	2.94e-04	1.34e-04	1.17e-04
Hexachlorocyclopentadiene	2.00e-04	2.20e-04	1.03e-04	3.06e-04	3.49e-04	2.57e-04	9.31e-05	2.25e-04	4.40e-04	2.02e-04	1.75e-04
Pentachlorobenzene	3.04e-04	3.34e-04	1.56e-04	4.63e-04	5.28e-04	3.89e-04	1.41e-04	3.42e-04	6.69e-04	3.05e-04	2.66e-04
Pentachlorophenol	2.99e-04	3.28e-04	1.54e-04	4.56e-04	5.19e-04	3.83e-04	1.39e-04	3.36e-04	6.58e-04	3.00e-04	2.61e-04
Pesticides											
4,4-DDE	4.47e-03	4.92e-03	2.30e-03	6.83e-03	7.79e-03	5.74e-03	2.08e-03	5.03e-03	9.85e-03	4.50e-03	3.92e-03
Heptachlor	2.56e-04	2.82e-04	1.32e-04	3.92e-04	4.47e-04	3.29e-04	1.19e-04	2.88e-04	5.64e-04	2.58e-04	2.24e-04
Hexachlorophene	8.59e-02	9.45e-02	4.42e-02	1.31e-01	1.50e-01	1.10e-01	4.00e-02	9.67e-02	1.89e-01	8.65e-02	7.53e-02
Inorganics											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	1.51e-04	1.72e-04	1.27e-04	NA	NA	NA	9.93e-05	NA
Arsenic	NA	NA	NA	3.02e-04	3.44e-04	2.53e-04	NA	NA	NA	1.99e-04	NA
Barium	NA	NA	NA	2.26e-05	2.58e-05	1.90e-05	NA	NA	NA	1.49e-05	NA
Beryllium	NA	NA	NA	1.51e-04	1.72e-04	1.27e-04	NA	NA	NA	9.93e-05	NA
Cadmium	1.32e-02	1.46e-02	6.82e-03	1.81e-05	2.06e-05	1.52e-05	6.17e-03	1.49e-02	2.92e-02	1.19e-05	1.16e-02
Chromium (hexavalent)	NA	NA	NA	8.30e-04	9.46e-04	6.97e-04	NA	NA	NA	5.46e-04	NA

Compound	Measurement Receptors										
	American Kestrel (BCF_{W-CB})	American Robin (BCF_{W-OB})	Canvas Back (BCF_{W-HB})	Deer Mouse (BCF_{W-HM})	Least Shrew (BCF_{W-OM})	Long-tailed Weasel (BCF_{W-OM})	Mallard Duck (BCF_{W-OB})	Marsh Rice Rat (BCF_{W-OM})	Marsh Wren (BCF_{W-OB})	Mink (BCF_{W-CM})	Mourning Dove (BCF_{W-OM})
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	4.53e-05	5.16e-05	3.80e-05	NA	NA	NA	2.98e-05	NA
Mercuric Chloride	2.99e-03	3.27e-03	1.54e-03	7.88e-04	8.98e-04	6.63e-04	1.39e-03	2.99e-03	6.57e-03	5.18e-04	2.61e-03
Methylmercury	4.48e-04	4.90e-04	2.30e-04	1.18e-04	1.34e-04	9.91e-05	2.08e-04	5.05e-04	9.85e-04	7.74e-05	3.90e-04
Nickel	NA	NA	NA	9.05e-04	1.03e-03	7.60e-04	NA	NA	NA	5.96e-04	NA
Selenium	1.41e-01	1.55e-01	7.27e-02	3.42e-04	3.90e-04	2.88e-04	6.58e-02	1.59e-01	3.11e-01	2.25e-04	1.24e-01
Silver	NA	NA	NA	4.53e-04	5.16e-04	3.80e-04	NA	NA	NA	2.98e-04	NA
Thallium	NA	NA	NA	6.03e-03	6.88e-03	5.07e-03	NA	NA	NA	3.97e-03	NA
Zinc	1.09e-03	1.20e-03	5.63e-04	1.36e-05	1.55e-05	1.14e-05	5.09e-04	1.23e-03	2.41e-03	8.93e-06	9.57e-04

Notes:

NA - Indicates insufficient data to determine value

HB - Herbivorous bird
HM - Herbivorous mammal
OB - Omnivorous bird
OM - Omnivorous mammal
TP - Terrestrial plant

Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 4 of 6)

Compound	Measurement Receptors										
	Muskrat (BCF_{W-OM})	Northern Bobwhite (BCF_{W-OB})	Northern Harrier (BCF_{W-CM})	Red Fox (BCF_{W-CM})	Red-tailed Hawk (BCF_{W-HM})	Salt-marsh Harvest Mouse (BCF_{W-HM})	Short-tailed Shrew (BCF_{W-OM})	Spotted Sandpiper (BCF_{W-CSB})	Swift Fox (BCF_{W-OM})	Western Meadow Lark (BCF_{W-OM})	White-footed Mouse (BCF_{W-OM})
Dioxins and Furans											
2,3,7,8-TCDD	5.33e-03	3.75e+01	2.06e+01	4.69e-03	2.06e+01	8.60e-03	8.18e-03	5.99e+01	5.07e-03	4.51e+01	8.24e-03
1,2,3,7,8-PeCDD	4.90e-03	3.45e+01	1.90e+01	4.31e-03	1.90e+01	7.91e-03	7.53e-03	5.51e+01	4.66e-03	4.15e+01	7.58e-03
1,2,3,4,7,8-HxCDD	1.65e-03	1.16e+01	6.39e+00	1.45e-03	6.39e+00	2.67e-03	2.54e-03	1.86e+01	1.57e-03	1.40e+01	2.55e-03
1,2,3,6,7,8-HxCDD	6.40e-05	4.50e+00	2.47e+00	5.62e-04	2.47e+00	1.03e-03	9.82e-04	7.18e+00	6.08e-04	5.41e+00	9.89e-04
1,2,3,7,8,9-HxCDD	7.46e-04	5.25e+00	2.88e+00	6.56e-04	2.88e+00	1.20e-03	1.15e-03	8.38e+00	7.10e-04	6.31e+00	1.15e-03
1,2,3,4,6,7,8-HpCDD	2.72e-04	1.91e+00	1.05e+00	2.39e-04	1.05e+00	4.39e-04	4.17e-04	3.05e+00	2.59e-04	2.30e+00	4.20e-04
OCDD	6.40e-05	4.50e-01	2.47e-01	5.62e-05	2.47e-01	1.03e-04	9.82e-05	7.18e-01	6.08e-05	5.41e-01	9.89e-05
2,3,7,8-TCDF	4.26e-03	3.00e+01	1.65e+01	3.75e-03	1.65e+01	6.88e-03	6.55e-03	4.79e+01	4.06e-03	3.61e+01	6.59e-03
1,2,3,7,8-PeCDF	1.17e-03	8.25e+00	4.53e+00	1.03e-03	4.53e+00	1.89e-03	1.80e-03	1.32e+01	1.12e-03	9.91e+00	1.81e-03
2,3,4,7,8-PeCDF	8.53e-03	6.00e+01	3.30e+01	7.50e-03	3.30e+01	1.38e-02	1.31e-02	9.58e+01	8.11e-03	7.21e+01	1.32e-02
1,2,3,4,7,8-HxCDF	4.05e-04	2.85e+00	1.57e+00	3.56e-04	1.57e+00	6.54e-04	6.22e-04	4.55e+00	3.85e-04	3.42e+00	6.26e-04
1,2,3,6,7,8-HxCDF	1.01e-03	7.12e+00	3.92e+00	8.91e-04	3.92e+00	1.63e-03	1.55e-03	1.14e+01	9.63e-04	8.56e+00	1.57e-03
2,3,4,6,7,8-HxCDF	3.57e-03	2.51e+01	1.38e+01	3.14e-03	1.38e+01	5.76e-03	5.48e-03	4.01e+01	3.40e-03	3.02e+01	5.52e-03
1,2,3,7,8,9-HxCDF	3.36e-03	2.36e+01	1.30e+01	2.95e-03	1.30e+01	5.42e-03	5.15e-03	3.77e+01	3.19e-03	2.84e+01	5.19e-03
1,2,3,4,6,7,8-HpCDF	5.86e-05	4.12e-01	2.27e-01	5.16e-05	2.27e-01	9.46e-05	9.00e-05	6.58e-01	5.58e-05	4.96e-01	9.06e-05
1,2,3,4,7,8,9-HpCDF	2.08e-03	1.46e+01	8.04e+00	1.83e-03	8.04e+00	0.00e+00	3.19e-03	2.33e+01	1.98e-03	1.76e+01	3.21e-03
OCDF	8.53e-05	6.00e-01	3.30e-01	7.50e-05	3.30e-01	1.38e-04	1.31e-04	9.58e-01	8.11e-05	7.21e-01	1.32e-04
Polynuclear aromatic hydrocarbons (PAHs)											
Benzo(a)pyrene	3.32e-03	2.92e-03	1.60e-03	2.92e-03	1.60e-03	5.35e-03	5.09e-03	4.64e-03	3.16e-03	3.49e-03	5.13e-03
Benzo(a)anthracene	1.18e-03	1.03e-03	5.66e-04	1.04e-03	5.66e-04	1.90e-03	1.81e-03	1.64e-03	1.12e-03	1.24e-03	1.82e-03
Benzo(b)fluoranthene	3.93e-03	3.46e-03	1.89e-03	3.45e-03	1.89e-03	6.34e-03	6.03e-03	5.49e-03	3.73e-03	4.13e-03	6.07e-03
Benzo(k)fluoranthene	3.91e-03	3.43e-03	1.88e-03	3.44e-03	1.88e-03	6.30e-03	6.00e-03	5.46e-03	3.72e-03	4.10e-03	6.04e-03
Chrysene	1.35e-03	1.19e-03	6.53e-04	1.19e-03	6.53e-04	2.19e-03	2.08e-03	1.89e-03	1.29e-03	1.42e-03	2.09e-03
Dibenz(a,h)anthracene	8.70e-03	7.66e-03	4.19e-03	7.65e-03	4.19e-03	1.40e-02	1.33e-02	1.22e-02	8.27e-03	9.14e-03	1.34e-02
Indeno(1,2,3-cd)pyrene	2.03e-02	1.78e-02	9.76e-03	1.79e-02	9.76e-03	3.28e-02	3.12e-02	2.83e-02	1.93e-02	2.13e-02	3.14e-02
Polychlorinated biphenyls (PCBs)											
Aroclor 1016	6.25e-04	5.50e-04	3.01e-04	5.50e-04	3.01e-04	1.01e-03	9.60e-04	8.74e-04	5.95e-04	6.57e-04	9.66e-04
Aroclor 1254	3.98e-03	3.49e-03	1.91e-03	3.50e-03	1.91e-03	6.41e-03	6.10e-03	5.54e-03	3.78e-03	4.16e-03	6.14e-03
Nitroaromatics											
1,3-Dinitrobenzene	7.65e-08	6.73e-08	3.68e-08	6.72e-08	3.68e-08	1.23e-07	1.17e-07	1.07e-07	7.27e-08	8.03e-08	1.18e-07
2,4-Dinitrotoluene	2.44e-07	2.14e-07	1.17e-07	2.15e-07	1.17e-07	3.94e-07	3.75e-07	3.41e-07	2.32e-07	2.56e-07	3.78e-07

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 5 of 6)

Compound	Measurement Receptors: Muskrat (BCF_{W-OM})	Northern Bobwhite (BCF_{W-OB})	Northern Harrier (BCF_{W-CM})	Red Fox (BCF_{W-CM})	Red-tailed Hawk (BCF_{W-HM})	Salt-marsh Harvest Mouse (BCF_{W-HM})	Short-tailed Shrew (BCF_{W-OM})	Spotted Sandpiper (BCF_{W-CSB})	Swift Fox (BCF_{W-OM})	Western Meadow Lark (BCF_{W-OM})	White-footed Mouse (BCF_{W-OM})
2,6-Dinitrotoluene	1.89e-07	1.67e-07	9.16e-08	1.67e-07	9.16e-08	3.06e-07	2.91e-07	2.66e-07	1.80e-07	2.00e-07	2.93e-07
Nitrobenzene	1.68e-07	1.48e-07	8.08e-08	1.48e-07	8.08e-08	2.71e-07	2.58e-07	2.35e-07	1.60e-07	1.76e-07	2.59e-07
Pentachloronitrobenzene	1.08e-04	9.47e-05	5.18e-05	9.49e-05	5.18e-05	1.74e-04	1.66e-04	1.50e-04	1.03e-04	1.13e-04	1.67e-04
Phthalate Esters											
Bis(2-ethylhexyl)phthalate	3.96e-04	3.48e-04	1.90e-04	3.48e-04	1.90e-04	6.38e-04	6.07e-04	5.52e-04	3.76e-04	4.15e-04	6.11e-04
Di(n)octyl phthalate	5.27e+00	4.64e+00	2.54e+00	4.64e+00	2.54e+00	8.51e+00	8.09e+00	7.37e+00	5.01e+00	5.54e+00	8.15e+00
Volatile Organic Compounds											
Acetone	1.48e-09	1.30e-09	7.12e-10	1.30e-09	7.12e-10	2.39e-09	2.28e-09	2.07e-09	1.41e-09	1.55e-09	2.29e-09
Acrylonitrile	4.39e-09	3.85e-09	2.11e-09	3.86e-09	2.11e-09	7.08e-09	6.73e-09	6.14e-09	4.17e-09	4.62e-09	6.78e-09
Chloroform	2.20e-07	1.93e-07	1.05e-07	1.93e-07	1.05e-07	3.55e-07	3.38e-07	3.06e-07	2.09e-07	2.30e-07	3.40e-07
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	1.33e-09	1.17e-09	6.41e-10	1.17e-09	6.41e-10	2.15e-09	2.05e-09	1.86e-09	1.27e-09	1.40e-09	2.06e-09
Formaldehyde	5.43e-09	4.77e-09	2.61e-09	4.77e-09	2.61e-09	8.76e-09	8.33e-09	7.58e-09	5.16e-09	5.69e-09	8.39e-09
Vinyl chloride	3.45e-08	3.04e-08	1.66e-08	3.04e-08	1.66e-08	5.58e-08	5.30e-08	4.83e-08	3.29e-08	3.63e-08	5.34e-08
Other Chlorinated Organics											
Hexachlorobenzene	7.84e-04	6.90e-04	3.78e-04	6.90e-04	3.78e-04	1.27e-03	1.20e-03	1.10e-03	7.46e-04	8.24e-04	1.21e-03
Hexachlorobutadiene	1.33e-04	1.17e-04	6.41e-05	1.17e-04	6.41e-05	2.13e-04	2.04e-04	1.86e-04	1.26e-04	1.40e-04	2.05e-04
Hexachlorocyclopentadiene	1.99e-04	1.75e-04	9.58e-05	1.75e-04	9.58e-05	3.22e-04	3.06e-04	2.78e-04	1.90e-04	2.09e-04	3.08e-04
Pentachlorobenzene	3.01e-04	2.66e-04	1.45e-04	2.65e-04	1.45e-04	4.86e-04	4.63e-04	4.22e-04	2.87e-04	3.17e-04	4.66e-04
Pentachlorophenol	2.96e-04	2.61e-04	1.43e-04	2.61e-04	1.43e-04	4.78e-04	4.55e-04	4.15e-04	2.82e-04	3.12e-04	4.58e-04
Pesticides											
4,4-DDE	4.45e-03	3.92e-03	2.14e-03	3.91e-03	2.14e-03	7.18e-03	6.83e-03	6.22e-03	4.23e-03	4.67e-03	6.87e-03
Heptachlor	2.55e-04	2.24e-04	1.23e-04	2.24e-04	1.23e-04	4.12e-04	3.92e-04	3.56e-04	2.43e-04	2.68e-04	3.94e-04
Hexachlorophene	8.55e-02	7.53e-02	4.12e-02	7.52e-02	4.12e-02	1.38e-01	1.31e-01	1.20e-01	8.13e-02	8.98e-02	1.32e-01
Inorganics											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	9.82e-05	NA	NA	8.63e-05	NA	1.58e-04	1.51e-04	NA	9.33e-05	NA	1.52e-04
Arsenic	1.96e-04	NA	NA	1.73e-04	NA	3.17e-04	3.01e-04	NA	1.87e-04	NA	3.03e-04
Barium	1.47e-05	NA	NA	1.29e-05	NA	2.38e-05	2.26e-05	NA	1.40e-05	NA	2.28e-05
Beryllium	9.82e-05	NA	NA	8.63e-05	NA	1.58e-04	1.51e-04	NA	9.33e-05	NA	1.52e-04
Cadmium	1.18e-05	1.16e-02	6.35e-03	1.04e-05	6.35e-03	1.90e-05	1.81e-05	1.84e-02	1.12e-05	1.38e-02	1.82e-05
Chromium (hexavalent)	5.40e-04	NA	NA	4.75e-04	NA	8.71e-04	8.29e-04	NA	5.13e-04	NA	8.34e-04

Table D-2

Bioconcentration Factors for Water to Wildlife Measurement Receptors

(Page 6 of 6)

Compound	Measurement Receptors										
	Muskrat (BCF_{W-OM})	Northern Bobwhite (BCF_{W-OB})	Northern Harrier (BCF_{W-CM})	Red Fox (BCF_{W-CM})	Red-tailed Hawk (BCF_{W-HM})	Salt-marsh Harvest Mouse (BCF_{W-HM})	Short-tailed Shrew (BCF_{W-OM})	Spotted Sandpiper (BCF_{W-CSB})	Swift Fox (BCF_{W-OM})	Western Meadow Lark (BCF_{W-OM})	White-footed Mouse (BCF_{W-OM})
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	2.94e-05	NA	NA	2.59e-05	NA	4.75e-05	4.52e-05	NA	2.80e-05	NA	4.55e-05
Mercuric chloride	5.13e-04	2.61e-03	1.43e-03	4.50e-04	1.43e-03	8.25e-04	7.88e-04	4.16e-03	4.88e-04	3.13e-03	2.99e-03
Methylmercury	7.66e-05	3.90e-04	2.14e-04	6.73e-05	2.14e-04	1.24e-04	1.18e-04	6.23e-04	7.28e-05	4.69e-04	1.18e-04
Nickel	5.89e-04	NA	NA	5.18e-04	NA	9.50e-04	9.04e-04	NA	5.60e-04	NA	9.10e-04
Selenium	2.23e-04	1.24e-01	6.76e-02	1.96e-04	6.76e-02	3.60e-04	3.42e-04	1.96e-01	2.12e-04	1.48e-01	3.44e-04
Silver	2.94e-04	NA	NA	2.59e-04	NA	4.75e-04	4.52e-04	NA	2.80e-04	NA	4.55e-04
Thallium	3.93e-03	NA	NA	3.45e-03	NA	6.34e-03	6.03e-03	NA	3.73e-03	NA	6.07e-03
Zinc	8.83e-06	9.57e-04	5.24e-04	7.77e-06	5.24e-04	1.43e-05	1.36e-05	1.52e-03	8.40e-06	1.14e-03	1.37e-05

Notes:

NA - Indicates insufficient data to determine value

HB - Herbivorous bird
HM - Herbivorous mammal
OB - Omnivorous bird
OM - Omnivorous mammal
TP - Terrestrial plant

\- Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 1 of 6)

Compound	Measurement Receptors										
	American Kestrel (BCF_{S-CB})	American Robin (BCF_{S-OB})	Canvas Back (BCF_{S-HB})	Deer Mouse (BCF_{S-HM})	Least Shrew (BCF_{S-OM})	Long-tailed Weasel (BCF_{S-OM})	Mallard Duck (BCF_{S-OB})	Marsh Rice Rat (BCF_{S-OM})	Marsh Wren (BCF_{S-OB})	Mink (BCF_{S-CM})	Mourning Dove (BCF_{S-OM})
Dioxins and Furans											
2,3,7,8-TCDD	4.78e-01	4.92e+00	6.26e-01	7.81e-05	7.41e-04	1.62e-04	1.09e+00	1.70e-04	6.74e+00	1.05e-04	2.41e+00
1,2,3,7,8-PeCDD	4.40e-01	4.53e+00	5.76e-01	7.19e-05	6.81e-04	1.49e-04	1.01e+00	1.56e-04	6.20e+00	9.66e-05	2.22e+00
1,2,3,4,7,8-HxCDD	1.48e-01	1.53e+00	1.94e-01	2.42e-05	2.30e-04	5.02e-05	3.39e-01	5.26e-05	2.09e+00	3.25e-05	7.48e-01
1,2,3,6,7,8-HxCDD	5.74e-02	5.90e-01	7.51e-02	9.37e-06	8.89e-05	1.94e-05	1.31e-01	2.04e-05	8.09e-01	1.26e-05	2.89e-02
1,2,3,7,8,9-HxCDD	6.69e-02	6.89e-01	8.77e-02	1.09e-05	1.04e-04	2.27e-05	1.53e-01	2.38e-05	9.44e-01	1.47e-05	3.38e-01
1,2,3,4,6,7,8-HpCDD	2.44e-02	2.51e-01	3.19e-02	3.98e-06	3.78e-05	8.26e-06	5.58e-02	8.66e-06	3.44e-01	5.35e-06	1.23e-01
OCDD	5.74e-03	5.90e-02	7.51e-03	9.37e-07	8.89e-06	1.94e-06	1.31e-02	2.04e-06	8.09e-02	1.26e-06	2.89e-02
2,3,7,8-TCDF	3.83e-01	3.94e+00	5.01e-01	6.25e-05	5.93e-04	1.30e-04	8.75e-01	1.36e-04	5.39e+00	8.40e-05	1.93e+00
1,2,3,7,8-PeCDF	1.05e-01	1.08e+00	1.38e-01	1.72e-05	1.63e-04	3.56e-05	2.41e-01	3.74e-05	1.48e+00	2.31e-05	5.31e-01
2,3,4,7,8-PeCDF	7.65e-01	7.87e+00	1.00e+00	1.25e-04	1.19e-03	2.59e-04	1.75e+00	2.72e-04	1.08e+01	1.68e-04	3.86e+00
1,2,3,4,7,8-HxCDF	3.63e-02	3.74e-01	4.76e-02	5.94e-06	5.63e-05	1.23e-05	8.31e-02	1.29e-05	5.12e-01	7.98e-06	1.83e-01
1,2,3,6,7,8-HxCDF	9.09e-02	9.35e-01	1.19e-01	1.48e-05	1.41e-04	3.08e-05	2.08e-01	3.23e-05	1.28e+00	1.99e-05	4.58e-01
2,3,4,6,7,8-HxCDF	3.20e-01	3.30e+00	4.19e-01	5.23e-05	4.96e-04	1.09e-04	7.33e-01	1.14e-04	4.52e+00	7.03e-05	1.62e+00
1,2,3,7,8,9-HxCDF	3.01e-01	3.10e+00	3.94e-01	4.92e-05	4.67e-04	1.02e-04	6.89e-01	1.07e-04	4.25e+00	6.61e-05	1.52e+00
1,2,3,4,6,7,8-HpCDF	5.26e-03	5.41e-02	6.89e-03	8.59e-07	8.15e-06	1.78e-06	1.20e-02	1.87e-06	7.42e-02	1.15e-06	2.65e-02
1,2,3,4,7,8,9-HpCDF	1.86e-01	1.92e+00	2.44e-01	3.05e-05	2.89e-04	6.32e-05	4.27e-01	6.62e-05	2.63e+00	4.09e-05	9.40e-01
OCDF	7.65e-03	7.87e-02	1.00e-02	1.25e-06	1.19e-05	2.59e-06	1.75e-02	2.72e-06	1.08e-01	1.68e-06	3.86e-02
Polynuclear Aromatic Hydrocarbons (PAHs)											
Benzo(a)pyrene	3.71e-05	3.81e-04	4.85e-05	4.86e-05	4.61e-04	1.01e-04	8.50e-05	6.21e-05	5.22e-04	6.53e-05	1.87e-04
Benzo(a)anthracene	1.32e-05	1.35e-04	1.72e-05	1.73e-05	1.64e-04	3.58e-05	3.01e-05	2.20e-05	1.85e-04	2.32e-05	6.63e-05
Benzo(b)fluoranthene	4.39e-05	4.50e-04	5.74e-05	5.75e-05	5.46e-04	1.19e-04	1.01e-04	7.35e-05	6.18e-04	7.73e-05	2.22e-04
Benzo(k)fluoranthene	4.36e-05	4.48e-04	5.71e-05	5.73e-05	5.43e-04	1.19e-04	1.00e-04	7.30e-05	6.14e-04	7.69e-05	2.20e-04
Chrysene	1.52e-05	1.55e-04	1.98e-05	1.99e-05	1.88e-04	4.12e-05	3.47e-05	2.54e-05	2.13e-04	2.67e-05	7.64e-05
Dibenz(a,h)anthracene	9.73e-05	9.98e-04	1.27e-04	1.27e-04	1.21e-03	2.64e-04	2.23e-04	1.63e-04	1.37e-03	1.71e-04	4.91e-04
Indeno(1,2,3-cd)pyrene	2.27e-04	2.32e-03	2.96e-04	2.98e-04	2.82e-03	6.18e-04	5.19e-04	3.79e-04	3.19e-03	4.00e-04	1.14e-03
Polychlorinated Biphenyls (PCBs)											
Aroclor 1016	6.99e-06	7.17e-05	9.14e-06	9.16e-06	8.69e-05	1.90e-05	1.60e-05	1.17e-05	9.83e-05	1.23e-05	3.53e-05
Aroclor 1254	4.43e-05	4.55e-04	5.80e-05	5.83e-05	5.52e-04	1.21e-04	1.02e-04	7.42e-05	6.24e-04	7.83e-05	2.24e-04
Nitroaromatics											
1,3-Dinitrobenzene	8.55e-10	8.77e-09	1.12e-09	1.12e-09	1.06e-08	2.32e-09	1.96e-09	1.43e-09	1.20e-08	1.51e-09	4.31e-09
2,4-Dinitrotoluene	2.72e-09	2.79e-08	3.56e-09	3.58e-09	3.40e-08	7.43e-09	6.24e-09	4.56e-09	3.83e-08	4.81e-09	1.37e-08
2,6-Dinitrotoluene	2.13e-09	2.18e-08	2.78e-09	2.78e-09	2.63e-08	5.76e-09	4.87e-09	3.56e-09	2.99e-08	3.73e-09	1.07e-08

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

Compound	Measurement Receptors										
	American Kestrel (BCF_{S-CB})	American Robin (BCF_{S-OB})	Canvas Back (BCF_{S-HB})	Deer Mouse (BCF_{S-HM})	Least Shrew (BCF_{S-OM})	Long-tailed Weasel (BCF_{S-OM})	Mallard Duck (BCF_{S-OB})	Marsh Rice Rat (BCF_{S-OM})	Marsh Wren (BCF_{S-OB})	Mink (BCF_{S-CM})	Mourning Dove (BCF_{S-OM})
Nitrobenzene	1.88e-09	1.92e-08	2.45e-09	2.46e-09	2.33e-08	5.10e-09	4.30e-09	3.14e-09	2.64e-08	3.31e-09	9.47e-09
Pentachloronitrobenzene	1.20e-06	1.23e-05	1.57e-06	1.58e-06	1.50e-05	3.28e-06	2.76e-06	2.01e-06	1.69e-05	2.13e-06	6.07e-06
Phthalate Esters											
Bis(2-ethylhexyl)phthalate	4.42e-06	4.53e-05	5.78e-06	5.80e-06	5.50e-05	1.20e-05	1.01e-05	7.40e-06	6.22e-05	7.79e-06	2.23e-05
Di(n)octyl phthalate	5.89e-02	6.04e-01	7.71e-02	7.72e-02	7.32e-01	1.60e-01	1.35e-01	9.86e-02	8.29e-01	1.04e-01	2.97e-01
Volatile Organic Compounds											
Acetone	1.65e-11	1.70e-10	2.16e-11	2.17e-11	2.06e-10	4.51e-11	3.79e-11	2.77e-11	2.33e-10	2.92e-11	8.34e-11
Acrylonitrile	4.91e-11	5.05e-10	6.42e-11	6.43e-11	6.10e-10	1.33e-10	1.12e-10	2.11e-11	6.92e-10	8.64e-11	2.47e-10
Chloroform	2.45e-09	2.51e-08	3.20e-09	3.22e-09	3.06e-08	6.68e-09	5.60e-09	4.09e-09	3.44e-08	4.33e-09	1.23e-08
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	1.49e-11	1.53e-10	1.94e-11	1.96e-11	1.86e-10	4.06e-11	3.41e-11	2.49e-11	2.09e-10	2.63e-11	7.50e-11
Formaldehyde	6.06e-11	6.21e-10	7.92e-11	7.95e-11	7.54e-10	1.65e-10	1.39e-10	1.01e-10	8.52e-10	1.07e-10	3.06e-10
Vinyl chloride	3.86e-10	3.96e-09	5.05e-10	5.06e-10	4.80e-09	1.05e-09	8.85e-10	6.47e-10	5.44e-09	6.80e-10	1.95e-09
Other Chlorinated Organics											
Hexachlorobenzene	8.77e-06	8.99e-05	1.15e-05	1.15e-05	1.09e-04	2.38e-05	2.01e-05	1.47e-05	1.23e-04	1.54e-05	4.42e-05
Hexachlorobutadiene	1.49e-06	1.53e-05	1.95e-06	1.94e-06	1.84e-05	4.02e-06	3.40e-06	2.49e-06	2.10e-05	2.61e-06	7.50e-06
Hexachlorocyclopentadiene	2.22e-06	2.28e-05	2.91e-06	2.92e-06	2.77e-05	6.06e-06	5.09e-06	3.72e-06	3.13e-05	3.92e-06	1.12e-05
Pentachlorobenzene	3.38e-06	3.46e-05	4.42e-06	4.42e-06	4.19e-05	9.16e-06	7.74e-06	5.65e-06	4.75e-05	5.93e-06	1.70e-05
Pentachlorophenol	3.32e-06	3.41e-05	4.34e-06	4.34e-06	4.12e-05	9.01e-06	7.61e-06	5.56e-06	4.67e-05	5.84e-06	1.68e-05
Pesticides											
4,4-DDE	4.98e-05	5.10e-04	6.51e-05	6.52e-05	6.18e-04	1.35e-04	1.14e-04	8.33e-05	7.00e-04	8.76e-05	2.51e-04
Heptachlor	2.85e-06	2.92e-05	3.73e-06	3.74e-06	3.55e-05	7.76e-06	6.53e-06	4.77e-06	4.01e-05	5.03e-06	1.44e-05
Hexachlorophene	9.56e-04	9.81e-03	1.25e-03	1.25e-03	1.19e-02	2.60e-03	2.19e-03	1.60e-03	1.35e-02	1.68e-03	4.82e-03
Inorganics											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	1.44e-06	1.36e-05	2.98e-06	NA	NA	NA	1.93e-06	NA
Arsenic	NA	NA	NA	2.88e-06	2.73e-05	5.97e-06	NA	NA	NA	3.87e-06	NA
Barium	NA	NA	NA	2.16e-07	2.05e-06	4.48e-07	NA	NA	NA	2.90e-07	NA
Beryllium	NA	NA	NA	1.44e-06	1.36e-05	2.98e-06	NA	NA	NA	1.93e-06	NA
Cadmium	1.47e-04	1.51e-03	1.93e-04	1.73e-07	1.64e-06	3.58e-07	3.37e-04	2.47e-04	2.07e-03	2.32e-07	7.43e-04
Chromium (hexavalent)	NA	NA	NA	7.91e-06	7.50e-05	1.64e-05	NA	NA	NA	1.06e-05	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

Compound	Measurement Receptors										
	American Kestrel (BCF_{S-CB})	American Robin (BCF_{S-OB})	Canvas Back (BCF_{S-HB})	Deer Mouse (BCF_{S-HM})	Least Shrew (BCF_{S-OM})	Long-tailed Weasel (BCF_{S-OM})	Mallard Duck (BCF_{S-OB})	Marsh Rice Rat (BCF_{S-OM})	Marsh Wren (BCF_{S-OB})	Mink (BCF_{S-CM})	Mourning Dove (BCF_{S-OM})
Lead	NA	NA	NA	4.32e-07	4.09e-06	8.95e-07	NA	NA	NA	5.80e-07	NA
Mercuric chloride	3.32e-05	3.42e-04	4.35e-05	7.52e-06	7.10e-05	1.56e-05	7.60e-05	5.57e-05	4.68e-04	1.01e-05	1.68e-04
Methylmercury	4.98e-06	5.12e-05	6.52e-06	1.12e-06	1.06e-05	2.33e-06	1.14e-05	8.34e-06	7.02e-05	1.51e-06	2.51e-05
Nickel	NA	NA	NA	8.63e-06	8.18e-05	1.79e-05	NA	NA	NA	1.16e-05	NA
Selenium	1.57e-03	1.61e-02	2.05e-03	3.27e-06	3.10e-05	6.77e-06	3.60e-03	2.63e-03	2.21e-02	4.39e-06	7.92e-03
Silver	NA	NA	NA	4.32e-06	4.09e-05	8.95e-06	NA	NA	NA	5.80e-06	NA
Thallium	NA	NA	NA	5.75e-05	5.46e-04	1.19e-04	NA	NA	NA	7.73e-05	NA
Zinc	1.22e-05	1.25e-04	1.59e-05	1.29e-07	1.23e-06	2.69e-07	2.79e-05	2.04e-05	1.71e-04	1.74e-07	6.13e-05

Notes:

NA - Indicates insufficient data to determine value

HB - Herbivorous bird
HM - Herbivorous mammal
OB - Omnivorous bird
OM - Omnivorous mammal
S - Soil/Sediment

– Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 4 of 6)

	Measurement Receptors										
Compound	Muskrat (BCF_{S-OM})	Northern Bobwhite (BCF_{S-OB})	Northern Harrier (BCF_{S-CM})	Red Fox (BCF_{S-CM})	Red-tailed Hawk (BCF_{S-HM})	Salt-marsh Harvest Mouse (BCF_{S-HM})	Short-tailed Shrew (BCF_{S-OM})	Spotted Sandpiper (BCF_{S-CSB})	Swift Fox (BCF_{S-OM})	Western Meadow Lark (BCF_{S-OM})	White-footed Mouse (BCF_{S-OM})
Dioxins and Furans											
2,3,7,8-TCDD	3.48e-05	4.13e+00	3.42e+00	8.19e-05	3.42e+00	9.66e-05	7.41e-04	1.43e+01	9.41e-05	4.78e+00	1.47e-04
1,2,3,7,8-PeCDD	3.20e-05	3.80e+00	3.15e+00	7.53e-05	3.15e+00	8.88e-05	6.81e-04	1.31e+01	8.66e-05	4.40e+00	1.35e-04
1,2,3,4,7,8-HxCDD	1.08e-05	1.28e+00	1.06e+00	2.54e-05	1.06e+00	2.99e-05	2.30e-04	4.43e+00	2.92e-05	1.48e+00	4.55e-05
1,2,3,6,7,8-HxCDD	4.18e-07	4.95e-01	4.11e-01	9.82e-06	4.11e-01	1.16e-05	8.89e-05	1.71e+00	1.13e-05	5.74e-01	1.76e-05
1,2,3,7,8,9-HxCDD	4.87e-06	5.78e-01	4.79e-01	1.15e-05	4.79e-01	1.35e-05	1.04e-04	2.00e+00	1.32e-05	6.69e-01	2.05e-05
1,2,3,4,6,7,8-HpCDD	1.78e-06	2.11e-01	1.75e-01	4.17e-06	1.75e-01	4.92e-06	3.78e-05	7.28e-01	4.80e-06	2.44e-01	7.48e-06
OCDD	4.18e-07	4.95e-02	4.11e-02	9.82e-07	4.11e-02	1.16e-06	8.89e-06	1.71e-01	1.13e-06	5.74e-02	1.76e-06
2,3,7,8-TCDF	2.79e-05	3.30e+00	2.74e+00	6.55e-05	2.74e+00	7.72e-05	5.93e-04	1.14e+01	7.53e-05	3.83e+00	1.17e-04
1,2,3,7,8-PeCDF	7.66e-06	9.08e-01	7.53e-01	1.80e-05	7.53e-01	2.12e-05	1.63e-04	3.14e+00	2.07e-05	1.05e+00	3.23e-05
2,3,4,7,8-PeCDF	5.57e-05	6.60e+00	5.48e+00	1.31e-04	5.48e+00	1.55e-04	1.19e-03	2.28e+01	1.51e-04	7.65e+00	2.35e-04
1,2,3,4,7,8-HxCDF	2.65e-06	3.14e-01	2.60e-01	6.22e-06	2.60e-01	7.34e-06	5.63e-05	1.09e+00	7.15e-06	3.63e-01	1.12e-05
1,2,3,6,7,8-HxCDF	6.62e-06	7.84e-01	6.50e-01	1.56e-05	6.50e-01	1.83e-05	1.41e-04	2.71e+00	1.79e-05	9.09e-01	2.79e-05
2,3,4,6,7,8-HxCDF	2.33e-05	2.77e+00	2.29e+00	5.48e-05	2.29e+00	6.47e-05	4.96e-04	9.56e+00	6.30e-05	3.20e+00	9.83e-05
1,2,3,7,8,9-HxCDF	2.19e-05	2.60e+00	2.16e+00	5.16e-05	2.16e+00	6.08e-05	4.67e-04	8.99e+00	5.93e-05	3.01e+00	9.24e-05
1,2,3,4,6,7,8-HpCDF	3.83e-07	4.54e-02	3.77e-02	9.00e-07	3.77e-02	1.06e-06	8.15e-06	1.57e-01	1.04e-06	5.26e-02	1.61e-06
1,2,3,4,7,8,9-HpCDF	1.36e-05	1.61e+00	1.33e+00	3.19e-05	1.33e+00	0.00e+00	2.89e-04	5.57e+00	3.67e-05	1.86e+00	5.72e-05
OCDF	5.57e-07	6.60e-02	5.48e-02	1.31e-06	5.48e-02	1.55e-06	1.19e-05	2.28e-01	1.51e-06	7.65e-02	2.35e-06
Polynuclear aromatic hydrocarbons (PAHs)											
Benzo(a)pyrene	2.17e-05	3.19e-04	2.66e-04	5.10e-05	2.66e-04	6.01e-05	4.61e-04	1.11e-03	5.86e-05	3.72e-04	9.13e-05
Benzo(a)anthracene	7.69e-06	1.13e-04	9.41e-05	1.81e-05	9.41e-05	2.13e-05	1.64e-04	3.93e-04	2.08e-05	1.32e-04	3.24e-05
Benzo(b)fluoranthene	2.57e-05	3.78e-04	3.14e-04	6.03e-05	3.14e-04	7.11e-05	5.46e-04	1.31e-03	6.93e-05	4.40e-04	1.08e-04
Benzo(k)fluoranthene	2.55e-05	3.75e-04	3.12e-04	6.00e-05	3.12e-04	7.08e-05	5.43e-04	1.30e-03	6.90e-05	4.37e-04	1.08e-04
Chrysene	8.85e-06	1.30e-04	1.08e-04	2.08e-05	1.08e-04	2.45e-05	1.88e-04	4.53e-04	2.39e-05	1.52e-04	3.73e-05
Dibenz(a,h)anthracene	5.68e-05	8.37e-04	6.97e-04	1.34e-04	6.97e-04	1.58e-04	1.21e-03	2.91e-03	1.54e-04	9.75e-04	2.39e-04
Indeno(1,2,3-cd)pyrene	1.33e-04	1.95e-03	1.62e-03	3.12e-04	1.62e-03	3.68e-04	2.82e-03	6.77e-03	3.59e-04	2.27e-03	5.59e-04
Polychlorinated biphenyls (PCBs)											
Aroclor 1016	4.08e-06	6.01e-05	5.01e-05	9.60e-06	5.01e-05	1.13e-05	8.69e-05	2.09e-04	1.10e-05	7.01e-05	1.72e-05
Aroclor 1254	2.60e-05	3.81e-04	3.17e-04	6.11e-05	3.17e-04	7.20e-05	5.52e-04	1.32e-03	7.02e-05	4.44e-04	1.09e-04
Nitroaromatics											
1,3-Dinitrobenzene	5.00e-10	7.35e-09	6.12e-09	1.17e-09	6.12e-09	1.39e-09	1.06e-08	2.55e-08	1.35e-09	8.57e-09	2.10e-09
2,4-Dinitrotoluene	1.60e-09	2.34e-08	1.95e-08	3.75e-09	1.95e-08	4.43e-09	3.40e-08	8.14e-08	4.32e-09	2.73e-08	6.73e-09

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

(Page 5 of 6)

	Measurement Receptors										
Compound	Muskrat (BCF_{S-OM})	Northern Bobwhite (BCF_{S-OB})	Northern Harrier (BCF_{S-CM})	Red Fox (BCF_{S-CM})	Red-tailed Hawk (BCF_{S-HM})	Salt-marsh Harvest Mouse (BCF_{S-HM})	Short-tailed Shrew (BCF_{S-OM})	Spotted Sandpiper (BCF_{S-CSB})	Swift Fox (BCF_{S-OM})	Western Meadow Lark (BCF_{S-OM})	White-footed Mouse (BCF_{S-OM})
2,6-Dinitrotoluene	1.24e-09	1.83e-08	1.52e-08	2.91e-09	1.52e-08	3.43e-09	2.63e-08	6.35e-08	3.34e-09	2.13e-08	5.21e-09
Nitrobenzene	1.10e-09	1.61e-08	1.34e-08	2.58e-09	1.34e-08	3.04e-09	2.33e-08	5.61e-08	2.96e-09	1.88e-08	4.62e-09
Pentachloronitrobenzene	7.05e-07	1.04e-05	8.62e-06	1.66e-06	8.62e-06	1.96e-06	1.50e-05	3.60e-05	1.91e-06	1.21e-05	2.97e-06
Phthalate esters											
Bis(2-ethylhexyl)phthalate	2.58e-06	3.80e-05	3.16e-05	6.07e-06	3.16e-05	7.17e-06	5.50e-05	1.32e-04	6.98e-06	4.43e-05	1.09e-05
Di(n)octyl phthalate	3.44e-02	5.07e-01	4.22e-01	8.09e-02	4.22e-01	9.55e-02	7.32e-01	1.76e+00	9.31e-02	5.91e-01	1.45e-01
Volatile organic compounds											
Acetone	9.68e-12	1.42e-10	1.18e-10	2.28e-11	1.18e-10	2.69e-11	2.06e-10	4.94e-10	2.62e-11	1.66e-10	4.08e-11
Acrylonitrile	2.87e-11	4.42e-10	3.51e-11	6.74e-11	3.51e-10	7.95e-11	6.10e-10	1.46e-09	7.75e-11	4.91e-10	1.21e-10
Chloroform	1.44e-09	2.10e-08	1.75e-08	3.38e-09	1.75e-08	3.98e-09	3.06e-08	7.31e-08	3.88e-09	2.45e-08	6.05e-09
Crotonaldehyde	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dioxane	8.72e-12	1.28e-10	1.06e-10	2.05e-11	1.06e-10	2.42e-11	1.86e-10	4.44e-10	2.36e-11	1.49e-10	3.67e-11
Formaldehyde	3.55e-11	5.21e-10	4.34e-10	8.34e-11	4.34e-10	9.83e-11	7.54e-10	1.81e-09	9.58e-11	6.07e-10	1.49e-10
Vinyl chloride	2.26e-10	3.32e-09	2.77e-09	5.31e-10	2.77e-09	6.26e-10	4.80e-09	1.15e-08	6.10e-10	3.87e-09	9.51e-10
Other chlorinated organics											
Hexachlorobenzene	5.12e-06	7.54e-05	6.28e-05	1.20e-05	6.28e-05	1.42e-05	1.09e-04	2.62e-04	1.38e-05	8.79e-05	2.16e-05
Hexachlorobutadiene	8.65e-07	1.28e-05	1.06e-05	2.04e-06	1.06e-05	2.40e-06	1.84e-05	4.44e-05	2.34e-06	1.49e-05	3.65e-06
Hexachlorocyclopentadiene	1.30e-06	1.91e-05	1.59e-05	3.06e-06	1.59e-05	3.61e-06	2.77e-05	6.64e-05	3.52e-06	2.23e-05	5.49e-06
Pentachlorobenzene	1.97e-06	2.90e-05	2.42e-05	4.63e-06	2.42e-05	5.46e-06	4.19e-05	1.01e-04	5.32e-06	3.39e-05	8.30e-06
Pentachlorophenol	1.94e-06	2.86e-05	2.38e-05	4.55e-06	2.38e-05	5.37e-06	4.12e-05	9.93e-05	5.23e-06	3.33e-05	8.16e-06
Pesticides											
4,4-DDE	2.90e-05	4.28e-04	3.56e-04	6.83e-05	3.56e-04	8.06e-05	6.18e-04	1.49e-03	7.85e-05	4.99e-04	1.22e-04
Heptachlor	1.67e-06	2.45e-05	2.04e-05	3.92e-06	2.04e-05	4.62e-06	3.55e-05	8.51e-05	4.51e-06	2.86e-05	7.03e-06
Hexachlorophene	5.59e-04	8.22e-03	6.85e-03	1.31e-03	6.85e-03	1.55e-03	1.19e-02	2.86e-02	1.51e-03	9.58e-03	2.35e-03
Inorganics											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	6.41e-07	NA	NA	1.51e-06	NA	1.78e-06	1.36e-05	NA	1.73e-06	NA	2.70e-06
Arsenic	1.28e-06	NA	NA	3.01e-06	NA	3.56e-06	2.73e-05	NA	3.47e-06	NA	5.40e-06
Barium	9.62e-08	NA	NA	2.26e-07	NA	2.67e-07	2.05e-06	NA	2.60e-07	NA	4.05e-07
Beryllium	6.41e-07	NA	NA	1.51e-06	NA	1.78e-06	1.36e-05	NA	1.73e-06	NA	2.70e-06
Cadmium	7.69e-08	1.27e-03	1.05e-03	1.81e-07	1.05e-03	2.13e-07	1.64e-06	4.40e-03	2.08e-07	1.48e-03	3.24e-07
Chromium (hexavalent)	3.53e-06	NA	NA	8.29e-06	NA	9.78e-06	7.50e-05	NA	9.53e-06	NA	1.49e-05

TABLE D-3

BIOCONCENTRATION FACTORS FOR SOIL/SEDIMENT TO WILDLIFE MEASUREMENT RECEPTORS

Compound	Measurement Receptors										
	Muskrat (BCF_{S-OM})	Northern Bobwhite (BCF_{S-OB})	Northern Harrier (BCF_{S-CM})	Red Fox (BCF_{S-CM})	Red-tailed Hawk (BCF_{S-HM})	Salt-marsh Harvest Mouse (BCF_{S-HM})	Short-tailed Shrew (BCF_{S-OM})	Spotted Sandpiper (BCF_{S-CSB})	Swift Fox (BCF_{S-OM})	Western Meadow Lark (BCF_{S-OM})	White-footed Mouse (BCF_{S-OM})
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	1.92e-07	NA	NA	4.52e-07	NA	5.33e-07	4.09e-06	NA	5.20e-07	NA	8.11e-07
Mercuric chloride	3.35e-06	2.87e-04	2.38e-04	7.88e-06	2.38e-04	9.29e-06	7.10e-05	9.92e-04	9.03e-06	3.32e-04	1.41e-05
Methylmercury	5.00e-07	4.30e-05	3.56e-05	1.18e-06	3.56e-05	1.39e-06	1.06e-05	1.49e-04	1.35e-06	4.98e-05	2.11e-06
Nickel	3.85e-06	NA	NA	9.04e-06	NA	1.07e-05	8.18e-05	NA	1.04e-05	NA	1.62e-05
Selenium	1.46e-06	1.35e-02	1.12e-02	3.42e-06	1.12e-02	4.04e-06	3.10e-05	4.69e-02	3.93e-06	1.57e-02	6.13e-06
Silver	1.92e-06	NA	NA	4.52e-06	NA	5.33e-06	4.09e-05	NA	5.20e-06	NA	8.11e-06
Thallium	2.57e-05	NA	NA	6.03e-05	NA	7.11e-05	5.46e-04	NA	6.93e-05	NA	1.08e-04
Zinc	5.77e-08	1.05e-04	8.71e-05	1.36e-07	8.71e-05	1.60e-07	1.23e-06	3.63e-04	1.56e-07	1.22e-04	2.43e-07

Notes:

NA - Indicates insufficient data to determine value

HB - Herbivorous bird
HM - Herbivorous mammal
OB - Omnivorous bird
OM - Omnivorous mammal
S - Soil/Sediment

– Values provided were determined as specified in the text of Appendix D. *BCF* values for omnivores were determined based on an equal diet. *BCF* values for dioxin and furan congeners determined using BEF values specified in Chapter 2.

FOOD-CHAIN MULTIPLIERS

Log K_{ow}	Trophic Level of Consumer		
	2	3	4
2.0	1.0	1.0	1.0
2.5	1.0	1.0	1.0
3.0	1.0	1.0	1.0
3.1	1.0	1.0	1.0
3.2	1.0	1.0	1.0
3.3	1.0	1.1	1.0
3.4	1.0	1.1	1.0
3.5	1.0	1.1	1.0
3.6	1.0	1.1	1.0
3.7	1.0	1.1	1.0
3.8	1.0	1.2	1.0
3.9	1.0	1.2	1.1
4.0	1.0	1.3	1.1
4.1	1.0	1.3	1.1
4.2	1.0	1.4	1.1
4.3	1.0	1.5	12
4.4	1.0	1.6	1.2
4.5	1.0	1.8	1.3
4.6	1.0	2.0	1.5
4.7	1.0	2.2	1.6
4.8	1.0	2.5	1.9
4.9	1.0	2.8	2.2
5.0	1.0	3.2	2.6
5.1	1.0	3.6	3.2
5.2	1.0	4.2	3.9
5.3	1.0	4.8	4.7
5.4	1.0	5.5	5.8
5.5	1.0	6.3	7.1
5.6	1.0	7.1	8.6

FOOD-CHAIN MULTIPLIERS

Log K_{ow}	Trophic Level of Consumer		
	2	3	4
5.7	1.0	8.0	10
5.8	1.0	8.8	12
5.9	1.0	9.7	14
6.0	1.0	11	16
6.1	1.0	11	18
6.2	1.0	12	20
6.3	1.0	13	22
6.4	1.0	13	23
6.5	1.0	14	25
6.6	1.0	14	26
6.7	1.0	14	26
6.8	1.0	14	27
6.9	1.0	14	27
7.0	1.0	14	26
7.1	1.0	14	25
7.2	1.0	14	24
7.3	1.0	13	23
7.4	1.0	13	21
7.5	1.0	13	19
7.6	1.0	12	17
7.7	1.0	11	14
7.8	1.0	10	12
7.9	1.0	9.2	9.8
8.0	1.0	8.2	7.8
8.1	1.0	7.3	6.0
8.2	1.0	6.4	4.5
8.3	1.0	5.5	3.3
8.4	1.0	4.7	2.4
8.5	1.0	3.9	1.7
8.6	1.0	3.3	1.1

FOOD-CHAIN MULTIPLIERS

Log K_{ow}	Trophic Level of Consumer		
	2	3	4
8.7	1.0	2.7	0.78
8.8	1.0	2.2	0.52
8.9	1.0	1.8	0.35
9.0	1.0	1.5	0.23

Source: U.S. EPA. 1995k. "Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation factors." EPA-820-B-95-005. Office of Water. Washington, D.C. March.

APPENDIX G

Toxicity Reference Values (TRVs)
from Appendix E EPA, 1999b

APPENDIX E

TOXICITY REFERENCE VALUES

Appendix E presents implementation of the recommended approach (described in Chapter 5) for identifying toxicity reference values (*TRVs*) for measurement receptors. Discussion is provided for determining compound-specific *TRV* values for community and wildlife measurement receptors.

Following the guidance in Sections E-1.0 through E-1.2, U.S. EPA OSW has identified default *TRV* values for the measurement receptors of the seven example food webs (listed in Chapter 4) and the compounds commonly identified in ecological risk assessments for combustion facilities (identified in Chapter 2). Section E-1.0 describes the determination of *TRV* values for surface water, sediment, and soil community measurement receptors in the example food webs. Section E-2.0 describes determination of *TRV* values for wildlife measurement receptors in the example food webs. Tables E-1 through E-8 present the default *TRV* values selected, the basis for selection of each value, and the references evaluated in determination of each value.

TRV values for a limited number of compounds are included in this appendix (see Tables E-1 through E-3) to facilitate the completion of screening ecological risk assessments. However, it is expected that *TRV* values for additional compounds and receptors may be required for evaluation on a site specific basis. In such cases, *TRV* values for these additional compounds could be determined following the same guidance used in determination of the *TRV* values reported in this appendix. For the determination of *TRV* values for measurement receptors not specifically represented in Sections E-1.0 through E-2.0 (e.g., amphibians and reptiles), an approach consistent to that presented in this appendix could be utilized by applying data applicable to those measurement receptors being evaluated.

The default *TRVs* provided in Tables E-1 through E-8 are based on values reported in available scientific literature. Toxicity values identified in secondary reference sources were verified, where possible, by reviewing the primary reference source. As noted in Chapter 5, *TRV* values may change as additional toxicity research is conducted and the availability of toxicity data in the scientific literature increases. As a result, U.S. EPA OSW recommends evaluating the latest toxicity data before completing a risk assessment to ensure that the toxicity data used in the risk assessment is the most current. If more appropriate *TRV* values can be documented, they should be used presented to the respective permitting authority for approval.

TRVs were not identified for amphibians and reptiles because of the paucity of toxicological information on these receptors. Additional guidance on determination and use of *TRV* values in the screening level ecological risk assessment is provided in Chapter 5.

E-1.0 *TRVs* FOR COMMUNITY MEASUREMENT RECEPTORS IN SURFACE WATER, SEDIMENT, AND SOIL

TRV values provided in this appendix for community measurement receptors in surface water, sediment, and soil were identified from screening toxicity values developed and/or adopted by federal and/or state regulatory agencies. As discussed in Chapter 5, these screening toxicity values are generally provided in the form of standards, criteria, guidance, or benchmarks. For compounds with no available screening toxicity value, *TRVs* were determined using toxicity values from available scientific literature. The equilibrium partitioning (EqP) approach was used to compute several sediment *TRV*s. Uncertainty factors (UFs) were applied to toxicity values, as necessary, to meet the *TRV* criteria discussed in Chapter 5. The following sections discuss determination of *TRV* values for community receptors in surface water, sediment, and soil.

Freshwater TRVs Freshwater *TRV*s should be used for freshwater and estuarine ecosystems with a salinity less than 5 parts per thousand. Freshwater *TRV*s, based on the dissolved concentration of the compound in surface water, are listed in Table E-1. *TRV*s were identified using the following hierarchy:

1. Federal chronic ambient water quality criteria (AWQC) calculated for with no final residue value (U.S. EPA 1999; 1996b). Federal AWQC for cadmium, copper, lead, nickel, and zinc were multiplied by a chemical-specific conversion factor to determine a *TRV* based on dissolved concentration (U.S. EPA 1999; 1996b).

2. Final chronic values (FCV) for COPCs for which their AWQC included a final residue value (U.S. EPA 1996b).

3. If inadequate data (insufficient number of families of aquatic life with toxicity data) were available to compute an AWQC or FCV, U.S. EPA (1999; 1996b) also reported secondary chronic values (SCV) calculated using the Tier II method in the Great Lakes Water Quality Initiative (GLWQI) (reported in 40 CFR Part 122). This method is similar to the procedures for calculating an FCV. It uses statistically-derived "adjustment factors" to address deficiencies in available data. The adjustment factor decreases as the number of representative families increases.

4. If an AWQC, FCV, or GLWQI Tier II SCV value were not available, toxicity values cited by U.S. EPA (1987) were identified. These toxicity values represent the lowest available values. Further, additional toxicity values available from the AQUIRE database in U.S. EPA's *ECOTOXicology Database System* (U.S. EPA 1996a) were identified. If collected from a secondary source (such as AQUIRE), original studies were obtained and reviewed for accuracy. The toxicity values reported in Table E-1 represent the lowest (most conservative), ecologically relevant, available value.

5. If toxicity data were unavailable, a surrogate *TRV* from a COPC with a similar structure was identified.

6. If no surrogate was available, a *TRV* was not listed. The potential toxicity of a COPC with no *TRV* should be addressed as an uncertainty (see Chapter 6)

Standard AQUIRE report summaries on tests were screened for duration, endpoint, effect, and concentration. Studies were also screened for ecologically relevant effects by focusing on studies that evaluated effects on survival, reproduction, and growth. Aspects of endpoint, duration, and test organism in each toxicity study were evaluated to identify the most appropriate study. Several compounds, most notably metals, had a large number of toxicity values based on various endpoints, organisms, and exposure durations. In these instances, best scientific judgment was used to identify the most appropriate toxicity value (see Chapter 5).

Chronic NOAEL-based values were not adjusted, but rather were carried through unchanged to become the *TRV*. Toxicity values identified as "less than" a particular concentration were divided by 2 to represent an average value because the true value is unknown, and it occurs between 0 and the noted concentration. *UF*s discussed in Chapter 5 were applied to toxicity values not meeting *TRV* criteria.

Saltwater TRVs Saltwater *TRV*s are applicable to marine water bodies and estuarine systems with a salinity greater than 5 ppt. Saltwater *TRV*s are listed in Table E-2. Saltwater water *TRV* development followed the same procedure as described above for freshwater receptors, except no GLWQI Tier II SCVs were available. In addition, if no saltwater *TRV* for a surrogate compound was available, the corresponding freshwater *TRV* was adopted.

Freshwater Sediment TRVs Freshwater sediment *TRV*s are listed in Table E-3. They are applicable to water bodies with a salinity less than 5 ppt. Freshwater sediment *TRV*s were identified from various sets of screening values and ecotoxicity review documents. The lowest available screening values among the following sources were identified:

1. No effect level (NEL) and lowest effect level (LEL) values from "Ontario's Approach to Sediment Assessment and Remediation" (Persaud et al. 1993)

2. Apparent effects threshold (AET) values for the amphipod, *Hyallela azteca*, reported in "Creation of Freshwater Sediment Quality Database and Preliminary Analysis of Freshwater Apparent Effects Thresholds" (Washington State Department of Ecology 1994)

3. Sediment effect concentrations jointly published by the National Biological Service and the U.S. EPA (Ingersoll et al. 1996).

If a screening value was not available in the sources listed above, toxicity studies and other values compiled and reported by Jones, Hull, and Suter (1997) were reviewed to identify possible *TRV*s. Relevant studies were prioritized based on the criteria listed in Chapter 5, and uncertainty factors were applied, as applicable, based on criteria presented (see Chapter 5).

If a screening or sediment toxicity value was not available for an organic COPC, a freshwater sediment *TRV* was computed, using the EqP approach (see Chapter 5), from the compounds corresponding freshwater *TRV* and K_{oc} value. The U.S. EPA Office of Water utilizes the EqP approach to develop sediment quality criteria for nonionic (neutral) organic chemicals (U.S. EPA 1993). The EqP approach assumes that the toxicity of a compound in sediment is a function of the concentration in pore water and that to be nontoxic, the pore water must meet the surface water final chronic value. The EqP approach also assumes that the concentration of a compound in sediment pore water depends on the carbon content of the sediment and the compound's organic carbon partitioning coefficient (U.S. EPA 1993). A *TRV* may be calculated using the following equation (U.S. EPA 1993):

$$TRV_{sed} = K_{oc} \cdot f_{oc} \cdot TRV_{sw} \qquad \text{Equation E-1}$$

where

TRV_{sed} = Sediment *TRV* (μg/kg)

K_{oc}	=	Organic carbon partition coefficient (L/kg)
f_{oc}	=	Fraction of organic carbon in sediment (unitless)—default value = 4% (0.04)
TRV_{sw}	=	Corresponding surface water *TRV* (µg/L)

Marine Sediment TRVs Marine sediment *TRVs* are listed in Table E-4. They are applicable to sediments of marine water bodies and estuarine systems with a salinity greater than 5 ppt. Marine sediment *TRVs* were developed following the procedures used to identify the freshwater sediment *TRVs*. Screening values were compiled from the following sources:

1. No observed effect level (NOEL) sediment quality assessment guidelines for State of Florida coastal waters (MacDonald 1993).

2. Marine and estuarine effects range low (ERL) values from "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments" (Long et al. 1995)

3. ERL values from "The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program" (Long and Morgan 1991)

4. Marine sediment quality criteria from "Sediment Management Standards" (Washington State Department of Ecology 1991)

Screening values were adopted directly as *TRVs*. If a screening value was not available in the sources listed above, toxicity values from a search of the scientific literature and those compiled and reported by Hull and Suter (1994) were reviewed to identify possible *TRVs*. Original studies were obtained, where possible, and toxicity values were verified. Relevant studies were prioritized based on the criteria listed in Chapter 5, and uncertainty factors were applied, as appropriate, based on criteria (see Chapter 5). If a screening or ecologically relevant sediment toxicity value from the scientific literature were not available for an organic COPC, a marine sediment *TRV* was computed, using the EqP approach, from the COPC's corresponding saltwater *TRV* and K_{oc} value (see Equation E-1).

Terrestrial Plant TRVs The terrestrial plant *TRVs* listed in Table E-5 are based on bulk soil exposures. Available terrestrial plant toxicity values from the scientific literature were used to develop presented *TRV* values. Toxicity values were first identified from the following secondary sources:

1. Studies cited in *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision* (Efroymson, Will, Suter, and Wooten 1997). Available studies were obtained and reviewed for accuracy of toxicity values. UFs were applied depending on study endpoint and available information.

2. Toxicity values in the Phytotox database in U.S. EPA's *ECOTOXicology Database* System. Available studies were obtained and toxicity values were verified. UFs were applied depending on study endpoint and available information.

3. Toxicity values in U.S. EPA Region 5 *Ecological Data Quality Levels (EDQL) Database* (PRC 1995). The database contains media-specific EDQLs for the RCRA Appendix IX constituents (40 CFR Part 264). The EDQLs represent conservative media concentrations

protective of media receptors and wildlife that might be exposed through food chains based in these media. Available studies were obtained and toxicity values were verified. UFs were applied depending on study endpoint and available information.

Original studies were obtained, where possible, and prioritized based on criteria listed in Chapter 5. Uncertainty factors were applied, as appropriate, based on criteria (discussed in Chapter 5) to develop *TRV* values. For COPCs without toxicity data, the *TRV* for a surrogate COPC was adopted. If an appropriate surrogate *TRV* was not available, no *TRV* value was identified. Generally, review of toxicity data available in the scientific literature indicates that limited *TRVs* are available for organic compounds; while *TRVs* for metals are available.

Soil Invertebrate TRVs The soil invertebrate *TRVs* listed in Table E-6 are based on bulk soil exposures. Available soil invertebrate toxicity values from the scientific literature were used to develop *TRVs* for these receptors. Soil invertebrate toxicity values were first identified from the following secondary sources:

1. Studies cited in *Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process* (Will and Suter II 1995a). Available studies were obtained and toxicity values were verified. UFs were applied depending on study endpoint and available information.

2. Scientific literature was searched for toxicity values for outstanding compounds. Relevant studies were obtained, toxicity values were verified, and UFs were applied as described.

Original studies were obtained, where possible, and prioritized based on criteria listed in Chapter 5. Uncertainty factors were applied, as appropriate, based on criteria to develop *TRVs*. If no toxicity value was available for a COPC, the *TRV* for a surrogate COPC was adopted.

E-2.0 *TRVs* FOR WILDLIFE MEASUREMENT RECEPTORS

TRV values for wildlife measurement receptors are listed in Tables E-7 (mammals) and E-8 (birds). *TRVs* were not developed for each avian and mammalian measurement receptor in the seven example food webs because of the paucity of species-specific data. Rather, U.S. EPA OSW focused on identifying a set of avian *TRVs* and a set of mammalian *TRVs* for the classes of compounds listed in Section 2.3. U.S. EPA OSW assumed that, among the literature reviewed for a particular guild, the lowest available toxicity value across orders in class Aves and across orders in class Mammalia would provide a conservative estimate of toxicity. Available mammalian and avian toxicity values from the scientific literature were used to develop *TRVs* for these receptors. Also, as previously noted, *TRV* values were not identified for amphibians and reptiles because of the paucity of toxicological information on these receptors. Wildlife measurement receptors *TRV* values were first identified from the following secondary sources:

1. Toxicity values compiled in *Toxicological Benchmarks for Wildlife: 1996 Revision* (Sample, Opresko, and Suter 1996).

2. Toxicity values listed in the Terretox database of U.S. EPA's *ECOTOXicology Database System* (U.S. EPA 1996b) were screened to identify studies potentially meeting the criteria listed in Chapter 5.

Original studies were compiled, where possible, and reviewed to verify their accuracy based on criteria listed in Chapter 5. In many cases, best scientific judgement was used to screen out studies with poor experimental design (see Chapter 5). Uncertainty factors were applied, as appropriate, to develop *TRVs* based on criteria presented in Chapter 5.

Conversions Some avian and mammalian toxicity data are expressed in terms of compound concentration in the food of the test organism. To convert to daily dose, it is necessary to determine the exposure duration and organism body weight. If the study does not report this information, the results should not be used to compute a *TRV*. If information on exposure duration and organism body weight is available, dietary concentration can be computed to dose using the following generic equation:

$$DD = \frac{C \cdot IR}{BW} \qquad \text{Equation E-2}$$

where

DD	=	COPC dose (mg COPC/kg BW/day)
C	=	Concentration of COPC in diet (mg COPC/kg food)
IR	=	Food ingestion rate (kg/day)
BW	=	Test organism body weight (kg)

REFERENCES
APPENDIX E TEXT

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.* Oak Ridge National Laboratory, Oak Ridge, TN. 128 pp. ES/ER/TM-85/R3. November.

Ingersoll, C.G., P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, D.R. Mount, and R.G. Fox. 1996. "Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod *Hyallela azteca* and the Midge *Chironomous riparius*." *International Association of Great Lakes Research.* Volume 22. Pages 602-623.

Jones, D.S., G.W. Suter II, and R.N. Hull. *1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision.* Oak Ridge National Laboratory, Oak Ridge TN. 34 pp. ES/ER/TM-95/R4. November.

Long, E.R., and L.G. Morgan. 1991. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.* National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum No. 5, OMA52, NOAA National Ocean Service. August.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." *Environmental Management.* Volume 19. Pages 81-97.

MacDonald, D.D. 1993. *Development of an Approach to the Assessment of Sediment Quality in Florida Coastal Waters.* Florida Department of Environmental Regulation. Tallahassee, Florida. January.

Persaud, D., R. Jaaguagi, and A. Hayton. 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario.* Ontario Ministry of the Environment. Queen's Printer of Ontario. March.

Sample, B.E., D.M. Opresko, and G.W Suter II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* Oak Ridge National Laboratory, Oak Ridge, TN. 227 pp. ES/ER/TM-86/R3. June.

U.S. EPA. 1987. *Quality Criteria for Water—Update #2.* EPA 440/5-86-001. Office of Water Regulations and Standards. Washington, D.C. May.

U.S. EPA. 1996a. ECOTOX. *ECOTOXicology Database System. A User's Guide. Version 1.0.* Office of Research and Development. National Health and Environmental Effects Research Laboratory. Mid-Continent Ecology Division. Duluth, MN. March.

U.S. EPA. 1996b. "Ecotox Thresholds." *ECO Update*. EPA 540/F-95/038. Office of Emergency and Remedial Response. January.

U.S. EPA. 1999. *National Recommended Water Quality Criteria-Correction.* EPA 822-Z-99-001. Office of Water. April.

Washington State Department of Ecology. 1991. *Sediment Management Standards*. Washington Administrative Code 173-204.

Washington State Department of Ecology. 1994. *Creation and Analysis of Freshwater Sediment Quality Values in Washington State.* Publication No. 97-32-a. July.

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

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Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Polychlorinateddibenzo-p-dioxins (μg/L)					
2,3,7,8-TCDD	Chronic LOEL	0.000038	0.1	0.0000038	Mehrle et al. (1988). 2,3,7,8-TCDD toxicity value for rainbow trout (*Oncorhynchus mykiss*).
Polynuclear aromatic hydrocarbons (PAH) (μg/L)					
Total high molecular weight (HMW) PAHs	--	--	--	0.014	Benzo(a)pyrene toxicity used as surrogate measure of toxicity. This TRV should be used if assessing the risk of total HMW PAHs.
Benzo(a)pyrene	Tier II value	0.014	Not applicable	0.014	U.S. EPA (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Benzo(a)anthracene	Tier II SCV	0.027	Not applicable	0.027	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Benzo(b)fluoranthene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Benzo(k)fluoranthene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Chrysene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Dibenz(a,h)anthracene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Indeno(1,2,3-cd)pyrene	--	--	--	0.027	Toxicity value not available. Benzo(a)anthracene used as surrogate.
Polychlorinated biphenyls (PCB) (μg/L)					
Aroclor 1016	--	0.19	Not applicable	0.19	Adopted from U.S. EPA (1996) value for Total PCB. Calculated using Great Lakes Water Quality Initiative Tier II methodology.

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

Compound	Toxicity Value: Duration and Endpoint[a]	Toxicity Value: Concentration	Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
Aroclor 1254	--	0.19	Not applicable	0.19	Adopted from U.S. EPA (1996) value for Total PCB. Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Nitroaromatics (μg/L)					
1,3-Dinitrobenzene	Subchronic NOEC	260	0.1	26	van der Schalie (1983). Algal growth test with *Selenastrum capricornutum*.
2,4-Dinitrotoluene	Chronic LOEL	230	0.1	23	U.S. EPA (1987)
2,6-Dinitrotoluene	Chronic NOEC	60	Not applicable	60	Kuhn et al. (1989). Toxicity value for water flea (*Daphnia magna*).
Nitrobenzene	Acute LOEL	27,000	0.01[e]	270	U.S. EPA (1987)
Pentachloronitrobenzene	LC50	1,000	0.01	10	Hashimoto and Nishiuchi (1981). Toxicity value for common carp (*Cyprinus carpio*).
Phthalate esters (μg/L)					
Bis(2-ethylhexyl)phthalate	Tier II SCV	3.0	Not applicable	3.0	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Di(n)octyl phthalate	Chronic NOEL	320	Not applicable	320	McCarthy and Whitmore (1985). Toxicity value for water flea (*D. magna*).
Volatile organic compounds (μg/L)					
Acetone	Tier II SCV	1,500	Not applicable	1,500	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Acrylonitrile	Chronic LOEL	2,600	0.1	260	U.S. EPA (1987)
Chloroform	Tier II SCV	28	Not applicable	28	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

(Page 3 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Crotonaldehyde	Acute LC50	3,500	0.01	35	Dawson et al. (1977). Toxicity value for bluegill sunfish (*Lepomis macrochirus*).
1,4-Dioxane	Acute EC0	6,210,000	0.01	62,100	Bringmann and Kühn (1982). Toxicity value for water flea (*D. magna*).
Formaldehyde	Acute LC50	4,960	0.01	49.6	Reardon and Harrell (1990). No data available for formalehyde. Formalin containing 37 percent formaldehyde used as a surrogate. Endpoint based on formaldehyde concentration.
Vinyl chloride	Subchronic LC100	388,000	0.01[e]	3,880	Brown et al. (1977)
Other chlorinated organics (μg/L)					
Hexachlorobenzene	Proposed chronic criterion	3.68	Not applicable	3.68	U.S. EPA (1987)
Hexachlorobutadiene	Chronic LOEL	9.3	0.1	0.93	U.S. EPA (1987)
Hexachlorocyclopentadiene	Chronic LOEL	5.2	0.1	0.52	U.S. EPA (1987)
Pentachlorobenzene	Tier II value	0.47	Not applicable	0.47	U.S. EPA (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Pentachlorophenol	Chronic criterion	15	Not applicable	15	U.S. EPA (1999). Value expressed as a function of pH and calculated as follows: TRV = exp(1.005(pH)-5.134). A pH of 7.8 is assumed to calculate the displayed value.
Pesticides (μg/L)					
4,4'-DDE	Acute LOEL	1,050	0.01[e]	10.5	U.S. EPA (1987)
Heptachlor	Chronic criterion	0.0038	Not applicable	0.0038	U.S. EPA (1987)

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Hexachlorophene	Subchronic NOEC	8.8	0.1	0.88	Call et al. (1989). Toxicity value for fathead minnow (*P. promelas*).
Inorganics (mg/L) [f]					
Aluminum	FCV	0.087	Not applicable	0.087	U.S. EPA (1988)
Antimony	Proposed chronic criterion	0.03	Not applicable	0.03	U.S. EPA (1987)
Arsenic (trivalent)	Chronic criterion	0.15	Not applicable	0.15	U.S. EPA (1999)
Barium	Tier II SCV	0.004	Not applicable	0.004	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Beryllium	Tier II SCV	0.00066	Not applicable	0.00066	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Cadmium	Chronic criterion	0.0022 (dissolved)	Not applicable	0.0022	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: $TRV = \exp(m_c[\ln(hardness)]+b_c)$ where $m_c = 0.7852$ and $b_c = -2.715$. Criterion was converted to dissolved concentration using the following conversion factor: 1.101672-[(ln hardness)(0.041838]. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.
Chromium (hexavalent)	Chronic criterion	0.011	Not applicable	0.011	U.S. EPA (1999).
Copper	Chronic criterion	0.009 (dissolved)	Not applicable	0.009	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: $TRV = \exp(m_c[\ln(hardness)]+b_c)$ where $m_c = 0.8545$ and $b_c = -1.702$. Criterion was converted to dissolved concentration using a conversion factor of 0.960. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

(Page 5 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Total Cyanide	Chronic criterion	0.0052	Not applicable	0.0052	U.S. EPA (1999). This value is expressed as mg free cyanide (as CN)/L.
Lead	Chronic criterion	0.0025 (dissolved)	Not applicable	0.0025	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: TRV = $\exp(m_c[\ln(\text{hardness})]+b_c)$ where m_c = 1.273 and b_c = -4.705. Criterion was converted to dissolved concentration using the following conversion factor: 1.46203-[(ln hardness)(0.145712]. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.
Mercuric chloride	Chronic criterion	0.00077	Not applicable	0.00077	U.S. EPA (1999). This value was from data for inorganic mercury (II).
Methyl mercury	Tier II SCV	0.0000028	Not applicable	0.0000028	Suter and Tsao (1996). Calculated using Great Lakes Water Quality Initiative Tier II methodology.
Nickel	Chronic criterion	0.052 (dissolved)	Not applicable	0.052	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: TRV = $\exp(m_c[\ln(\text{hardness})]+b_c)$ where m_c = 0.8460 and b_c = 0.0584. Criterion was converted to dissolved concentration using a conversion factor of 0.997. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.
Selenium	Chronic criterion	0.005	Not applicable	0.005	U.S. EPA (1999)
Silver	Proposed chronic criterion	0.00012	Not applicable	0.00012	U.S. EPA (1987)
Thallium	Chronic LOEL	0.04	0.1	0.004	U.S. EPA (1987)

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

Compound	Toxicity Value		Uncertainty Factor[b]	TRV[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Zinc	Chronic criterion	0.118 (dissolved)	Not applicable	0.118	U.S. EPA (1999). Value expressed as a function of water hardness and calculated as follows: TRV = $\exp(m_c[\ln(\text{hardness})]+b_c)$ where $m_c = 0.8473$ and $b_c = 0.884$. Criterion was converted to dissolved concentration using a conversion factor of 0.986. A assumed hardness of 100 mg/L and a conversion from mg/L to μg/L were used to calculate the displayed value.

Notes:

a The duration of exposure is defined as chronic if it represents about 10 percent or more of the test animals lifetime expectancy. Acute exposures represent single exposures or multiple exposures occurring within a short time. For evaluating exposure duration, the following general guidelines were used. For invertebrates and other lower trophic level aquatic biota: (1) chronic duration lasted for 7 or more days, (2) subchronic duration lasted from 3 to 6 days, and (3) acute duration lasted 2 days or less. For fish: (1) chronic duration lasted for more than 90 days, (2) subchronic duration lasted from 14 to 90 days, and (3) acute duration lasted less than 2 weeks.

b Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion of the use of uncertainty factors.

c TRV was calculated by multiplying the toxicity value with the uncertainty factor.

d The references refer to the source of the toxicity value. Complete reference citations are provided below.

e Best scientific judgment used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, experimental design, and availability of toxicity data.

f TRVs for metals are based on the dissolved metal concentration. According to U.S. EPA (1993) policy, concentrations of dissolved metal more closely approximate the bioavailable fraction of metal in the water column.

EC0	=	Effective concentration for zero percent of the test organisms.
FCV	=	Final Chronic Value
HMW	=	High molecular weight
LC50	=	Lethal concentration for 50 percent of the test organisms.
LC100	=	Lethal concentration for 100 percent of the test organisms.
LOEL	=	Lowest Observed Effect Level
NOEC	=	No Observed Effect Concentration
NOEL	=	No Observed Effect Level
SCV	=	Secondary Chronic Value
TRV	=	Toxicity Reference Value

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

REFERENCES

Bringmann, V.G. and R. Kühn. 1982. "Results of Toxic Action of Water Pollutants on *Daphnia magna* Straus Tested by an Improved Standardized Procedure." *Z. Wasser Abwasser Forsch.* 15. Nr.1. S. 1-6.

Brown, E.R., T. Sinclair, L. Keith, P. Beamer, J.J. Hazdra, V. Nair, and O. Callaghan. 1977. "Chemical Pollutants in Relation to Diseases in Fish." *Annals NewYork Academy of Sciences.* Volume 298. Pages 535-546.

Call, D.J. S.H. Poirier, C.A. Lindberg, S.L. Harting, T.P. Markee, L.T. Brooke, N. Zarvan, and C.E. Northcott. 1989. "Toxicity of Selected Uncoupling and Acetylcholinesterase-Inhibiting Pesticides to the Fathead Minnow (*Pimephales promelas*)." *Pesticides in Terrestrial and Aquatic Environments.* Virginia Polytechnic Institute and State University, Blacksburg, VA. Pages 317-336.

Dawson, G.W., A.L. Jennings, D. Drozdowski, and E. Rider. 1977. "The Acute Toxicity of 47 Industrial Chemicals to Fresh and Saltwater Fishes." *Journal of Hazardous Materials.* Volume 1. Pages 303-318.

Hashimoto, Y., and Y. Nishiuchi. 1981. "Establishment of Bioassay Methods for the Evaluation of Acute Toxicity of Pesticides to Aquatic Organisms." *Journal of Pesticide Science.* Volume 6. Pages 257-264. (Japanese, with English abstract).

Kuhn, R., M. Pattard, K-D. Pernak, and A. Winter. 1989. "Results of the Harmful Effects of Water Pollutants to *Daphnia magna* in the 21 Day Reproduction Test." *Water Research.* Volume 23. Pages 501-510.

McCarthy, J.F., and D.K. Whitmore. 1985. "Chronic Toxicity of Di-n-butyl and Di-n-octyl Phthalate to *Daphnia magna* and the Fathead Minnow." *Environmental Toxicology and Chemistry.* Volume 4. Pages 167-179.

Mehrle, P.M., D.R. Buckler, E.E. Little, L.M. Smith, J.D. Petty, P.H. Peterman, D.L. Stalling, G.M. DeGraeve, J.J. Coyle, and W.J. Adams. 1988. "Toxicity and Bioconcentration of 2,3,7,8-Tetrachlorodibenzodioxin and 2,3,7,8-Tetrachlorodibenzofuran in Rainbow Trout." *Environmental Toxicology and Chemistry.* Volume 7. Pages 47-62.

Reardon, I.S., and R.M. Harrell. 1990. "Acute Toxicity of Formalin and Copper Sulfate to Striped Bass Fingerlings Held in Varying Salinities." *Aquaculture.* Volume 87. Pages 255-270.

Suter II, G.W., and C.L. Tsao. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota.* ES/ER/TM-96/R2. Environmental Sciences Division, Oak Ridge National Laboratory. Oak Ridge, Tennessee. June.

U.S. EPA. 1988. *Ambient Water Quality Criteria for Aluminum—1988.* EPA 440/5-86-008. Office of Water Regulations and Standards. Washington, D.C. August.

U.S. EPA. 1987. *Quality Criteria for Water—Update #2.* EPA 440/5-86-001. Office of Water Regulations and Standards. Washington, D.C. May.

TABLE E-1

FRESHWATER TOXICITY REFERENCE VALUES

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U.S. EPA. 1993. *Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria.* Memorandum from Martha G. Protho to Water Management Division Directors and Environmental Service Directors, Regions 1 through 10. October 1.

U.S. EPA. 1996. "Ecotox Thresholds." *ECO Update.* EPA 540/F-95/038. Office of Emergency and Remedial Response. January.

U.S. EPA. 1999. *National Recommended Water Quality Criteria-Correction.* EPA 822-Z-99-001. Office of Water. April.

van der Schalie, W.H. 1983. *The Acute and Chronic Toxicity of 3,5-Dinitroaniline, 1,3-Dinitrobenzene, and 1,3,5-Trinitrobenzene to Freshwater Aquatic Organisms.* Technical Report 8305. U.S. Army Medical Bioengineering Research and Development Laboratory. Fort Detrick, Frederick, Maryland. 53 p.

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Polychlorinateddibnzo-p-dioxins (μg/L)					
2,3,7,8-TCDD	LOEC	0.000038	0.1	0.0000038	No saltwater data were available, therefore, corresponding freshwater toxicity value was used (rainbow trout, *Oncorhynchus mykiss*) from Mehrle et al. (1988). 2,3,4,5-TCDD toxicity value used.
Polynuclear aromatic hydrocarbons (PAH) (μg/L)					
Total high molecular weight (HMW) PAHs	Acute LC50	>50	0.01[e]	0.5	Rossi and Neff (1978) evaluated toxicity of three HMW (three or more aromatic rings) PAHs to the polychaete, *Neanthes arenaceodentata*. LC50 of each HMW PAH exceeded 50 μg/L. This TRV should be used if assessing the risk of total HMW PAHs.
Benzo(a)pyrene	Acute LC50	>50	0.01[e]	0.5	Rossi and Neff (1978). Toxicity value for polychaete (*N. arenaceodentata*).
Benzo(a)anthracene	Acute LC50	>50	0.01[e]	0.5	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Benzo(b)fluoranthene	Acute LC50	>50	0.01[e]	0.5	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Benzo(k)fluoranthene	Acute LC50	>50	0.01[e]	0.5	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Chrysene	Acute LC50	>50	0.01[e]	0.5	Rossi and Neff (1978). Toxicity of several PAHs was evaluted. LC50 of each individual HMW PAH exceeded 50 μg/L.
Dibenz(a,h)anthracene	Acute LC50	>50	0.01[e]	0.5	Rossi and Neff (1978). Toxicity of several PAHs was evaluted. LC50 of individual HMW PAHs exceeded 50 μg/L.
Indeno(1,2,3-cd)pyrene	Acute LC50	>50	0.01[e]	0.5	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Polychlorinated biphenyls (PCB) (μg/L)					
Aroclor 1016	--	0.03	Not applicable	0.03	U.S. EPA (1987) chronic criterion for ambient water quality.

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Aroclor 1254	--	0.03	Not applicable	0.03	U.S. EPA (1987) chronic criterion for ambient water quality.
Nitroaromatics (μg/L)					
1,3-Dinitrobenzene	--	--	--	66.8	Toxicity data not available. TRV for nitrobenzene used as surrogate.
2,4-Dinitrotoluene	Chronic criterion	370	Not applicable	370	U.S. EPA (1987)
2,6-Dinitrotoluene	--	--	--	370	Toxicity data not available. TRV for 2,4-dinitrotoluene used as surrogate.
Nitrobenzene	Acute criterion	6,680	0.01	66.8	U.S. EPA (1987)
Pentachloronitrobenzene	Acute LC50	1,000	0.01	10	No toxicity value or surrogate TRV available, therefore, corresponding freshwater toxicity value (common carp, *Cyprinus carpio*) from Hashimoto and Nishiuchi (1981) adopted.
Phthalate esters (μg/L)					
Bis(2-ethylhexyl)phthalate	Acute LC50	>170	0.01	1.7	Adams et al. (1995). Toxicity value for sheepshead minnow (*Cyprinodon variegatus*).
Di(n)octyl phthalate	NOEL	320	Not applicable	320	No toxicity value or surrogate TRV available, therefore, corresponding freshwater toxicity value used (water flea, *D. magna*) from McCarthy and Whitmore (1985).
Volatile organic compounds (μg/L)					
Acetone	Acute LC50	2,100,000	0.01	21,000	Price et al. (1974). Toxicity value for brine shrimp (*Artemia* sp.).
Acrylonitrile	Acute LC50	10,000	0.01	100	Portmann and Wilson (1971). Toxicity value for common shrimp (*Crangon crangon*).

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

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Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Chloroform	Acute LC 50	18,000	0.01	180	Anderson and Luster (1980). Toxicity value for Rainbow trout (*Salmo gairdnari*).
Crotonaldehyde	Acute LC50	1,300	0.01	13	Dawson et al. (1977). Toxicity value for inland silverside (*Menidia beryllina*).
1,4-Dioxane	Acute LC50	6,700,000	0.01	67,000	Dawson et al. (1977). Toxicity value for inland silverside (*M. beryllina*).
Formaldehyde	Acute LC50	4,960	0.01	49.6	No toxicity value or surrogate TRV available for this constituent, therefore, corresponding freshwater toxicity value used (Striped bass, *Morone saxatilis*) from Reardon and Harell (1990). No data available for formadehyde. Formalin containing 37 percent formaldehyde used as surrogate. TRV expressed on formaldehyde basis.
Vinyl chloride	Subchronic LC100	388,000	0.01[e]	3,880	No toxicity value of surrogate TRV available, therefore, corresponding freshwater toxicity value used (Northern pike, *Esox lucius*) from Brown et al. (1977).
Other chlorinated organics (μg/L)					
Hexachlorobenzene	Acute EC50	>1,000	0.01	10	Zaroogian (1981). Toxicity value for American oyster (*Crassostrea virginica*).
Hexachlorobutadiene	Acute LOEL	32	0.01[e]	0.32	U.S. EPA (1987)
Hexachlorocyclopentadiene	Acute LOEL	7.0	0.01[e]	0.07	U.S. EPA (1987)
Pentachlorobenzene	Subchronic NOEC	18	0.1	1.8	Hansen and Cripe (1991). Toxicity value for sheepshead minnow (*Cyprinodon variegatus*).
Pentachlorophenol	Chronic criterion	7.9	Not applicable	7.9	U.S. EPA (1987)
Pesticides (μg/L)					

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 4 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
4,4'-DDE	Acute LOEL	14	0.01[e]	0.14	U.S. EPA (1987)
Heptachlor	Chronic criterion	0.0036	Not applicable	0.0036	U.S. EPA (1987)
Hexachlorophene	Acute LC50	3.3	0.01	0.033	Calleja et al. (1994). Toxicity value for brine shrimp (*Artemia salina*).
Inorganics (mg/L)					
Aluminum	Acute LT50	0.271	0.01	0.00271	Study examined influence of pH and temperature on acute (48-hour) toxicity (as time to mortality) of aluminum to smoltifying Atlantic salmon (*Salmo salar*). Endpoint concentration based on sum of inorganic and organic aluminum for exposure at pH 6.5 (Poleo and Muniz 1993).
Antimony	Proposed chronic criterion	0.5	Not applicable	0.5	U.S. EPA (1987)
Arsenic (trivalent)	Chronic criterion	0.036	Not applicable	0.036	U.S. EPA (1987)
Barium	Subchronic LC50	>500.	0.01[e]	5.0	U.S. EPA (1978)
Beryllium	Tier II SCV	0.00066	Not applicable	0.00066	No toxicity value or surrogate TRV available, therefore, corresponding freshwater TRV adopted. Suter and Tsao (1996); value calculated using Great Lakes Water Quality Initiative Tier II methodology.
Cadmium	Chronic criterion	0.0093	Not applicable	0.0093	U.S. EPA (1987)
Chromium (hexavalent)	Chronic criterion	0.05	Not applicable	0.05	U.S. EPA (1987)
Copper	Chronic criterion	0.0031	Not applicable	0.0031	U.S. EPA 1999. When the concentration of dissolved organic carbon is elevated, copper is substantially less toxic and use of a water effects ratio may be appropriate.

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

(Page 5 of 8)

Compound	Toxicity Value		Uncertainty Factor[b]	Toxicity Reference Value[c]	Reference and Notes [d]
	Duration and Endpoint[a]	Concentration			
Total Cyanide	Chronic criterion	0.001	Not applicable	0.001	U.S. EPA (1987)
Lead	Chronic criterion	0.0081	Not applicable	0.0081	U.S. EPA (1999)
Mercuric chloride	Chronic criterion	0.00094	Not applicable	0.00094	U.S. EPA (1999). This value was from data for inorganic mercury (II).
Methyl mercury	Subchronic NOAEL	0.030	0.1	0.003	Sharp and Neff (1982). Toxicity value for mummichog (*Fundulus heteroclitus*).
Nickel	Chronic criterion	0.0082	Not applicable	0.0082	U.S. EPA (1999)
Selenium	Chronic criterion	0.071	Not applicable	0.071	U.S. EPA (1987)
Silver	Chronic criterion/ proposed criterion	0.0023	Not applicable	0.0023	U.S. EPA (1987)
Thallium	Acute LOEL	2.13	0.01[e]	0.02	U.S. EPA (1987)
Zinc	Chronic criterion	0.081	1.0	0.081	U.S. EPA (1999)

Notes:

a The duration of exposure is defined as chronic if it represents about 10 percent or more of the test animals lifetime expectancy. Acute exposures represent single exposures or multiple exposures occurring within a short time. For evaluating exposure duration, the following general guidelines were used. For invertebrates and other lower trophic level aquatic biota: (1) chronic duration lasted for 7 or more days, (2) subchronic duration lasted from 3 to 6 days, and (3) acute duration lasted 2 days or less. For fish: (1) chronic duration lasted for more than 90 days, (2) subchronic duration lasted from 14 to 90 days, and (3) acute duration lasted less than 2 weeks.

b Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion of the use of uncertainty factors.

c TRV was calculated by multiplying the toxicity value with the uncertainty factor.

d The references refer to the source of the toxicity value. Complete reference citations are provided at the end of this appendix.

e Best scientific judgment used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion of the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, experimental design, and availability of toxicity data.

EC50	=	Effective concentration for 50 percent of the test organisms.
FCV	=	Final Chronic Values
HMV	=	High molecular weight
LC50	=	Lethal concentration for 50 percent of the test organisms.
LC100	=	Lethal concentration for 100 percent of the test organisms.
LOEC	=	Lowest Observed Effect Concentration
LOEL	=	Lowest Observed Effect Level
LT50	=	Lethal threshold concentration for 50 percent of the test organisms.
NOAEL	=	No Observed Adverse Effect Level
NOEL	=	No Observed Effect Level
SCV	=	Secondary Chronic Value
TRV	=	Toxicity Reference Value

TABLE E-2

MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

REFERENCES

Adams, W.J., G.R. Biddinger, K.A. Robillard, and J. W. Gorsuch. 1995. "A Summary of the Acute Toxicity of 14 Phthalate Esters to Representative Aquatic Organisms." *Environmental Toxicology and Chemistry.* Volume 14. Pages 1569-1574.

Brown, E.R., T. Sinclair, L. Keith, P. Beamer, J.J. Hazdra, V. Nair, and O. Callaghan. 1977. "Chemical Pollutants in Relation to Diseases in Fish."

Annals NewYork Academy of Sciences. Volume 298. Pages 535-546. Calleja, M.C., G. Persoone, and P. Geladi. 1994. "Comparative Acute Toxicity of the First 50 Multicentre Evaluation of In Vitro Cytotoxicity Chemicals to Aquatic Non-Vertebrates." *Archives of Environmental Contamination and Toxicology.* Volume 26. Pages 69-78.

Dawson, G.W., A.L. Jennings, D. Drozdowski, and E. Rider. 1977. "The Acute Toxicity of 47 Industrial Chemicals to Fresh and Saltwater Fishes." *Journal of Hazardous Materials*. Volume 1. Pages 303-318.

Hansen, D.J., and G.M. Cripe. 1991. "Interlaboratory Comparison of the Early Life-Stage Toxicity Test Using Sheepshead Minnows (*Cyprinodon variegates*)". *Aquatic Toxicology and Risk Assessment.* Vol. 14, ASTM STP 1124, Philadelphia, PA. Pages 354-375. As cited in AQUIRE 1997

Hashimoto, Y., and Y. Nishiuchi. 1981. "Establishment of Bioassay Methods for the Evaluation of Acute Toxicity of Pesticides to Aquatic Organisms." *Journal of Pesticide Science.* Volume 6. Pages 257-264. (Japanese, with English abstract).

McCarthy, J.F., and D.K. Whitmore. 1985. "Chronic Toxicity of Di-n-butyl and Di-n-octyl Phthalate to *Daphnia magna* and the Fathead Minnow." *Environmental Toxicology and Chemistry*. Volume 4. Pages 167-179.

Mehrle, P.M., D.R. Buckler, E.E. Little, L.M. Smith, J.D. Petty, P.H. Peterman, D.L. Stalling, G.M. DeGraeve, J.J. Coyle, and W.J. Adams. 1988. "Toxicity and Bioconcentration of 2,3,7,8-Tetrachlorodibenzodioxin and 2,3,7,8-Tetrachlorodibenzofuran in Rainbow Trout." *Environmental Toxicology and Chemistry*. Volume 7. Pages 47-62.

Poleo, A.B.S., and I.P. Muniz. 1993. "The Effect of Aluminum in Soft Water at Low pH and Different Temperatures on Mortality, Ventilation Frequency, and Water Balance in Smoltifying Atlantic Salmon (*Salmo salar*)." *Environmental Biology of Fishes*. Volume 36. Pages 193-203.

Portmann, J.E., and K.W. Wilson. 1971. *The Toxicity of 140 Substances to the Brown Shrimp and Other Marine Animals.* Shellfish Information Leaflet No. 22 (Second Edition). Ministry of Agric. Fish. Food, Fish. Lab. Burnham-on-Crouch, Essex, and Fish Exp. Station Conway, North Wales: 12 P. As cited in AQUIRE 1997.

Price, K.S., G.T. Waggy, and R.A. Conway. 1974. "Brine Shrimp Bioassay and Seawater BOD of Petrochemicals." *Journal of Water Pollution Control Federation*. Volume 46. Pages 63-77.

Reardon, I.S., and R.M. Harrell. 1990. "Acute Toxicity of Formalin and Copper Sulfate to Striped Bass Fingerlings Held in Varying Salinities." *Aquaculture*. Volume 87. Pages 255-270.

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MARINE/ESTUARINE SURFACE WATER TOXICITY REFERENCE VALUES

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Rossi, S.S., and J.M. Neff. 1978. "Toxicity of Polynuclear Aromatic Hydrocarbons to the Polychaete *Neanthes arenaceodentata*." *Marine Pollution Bulletin*. Volume 9. Pages 220-223.

Sharp, J.R. and J.M. Neff. 1982. "The Toxicity of Mercuric Chloride and Methyl Mercuric Chloride to *Fundulus heteroclitus* Embryos in Relation to Exposure Conditions." *Environmental Biology of Fishes*. Volume 7. Pages 277-284.

Suter II, G.W., and C.L. Tsao. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota*. ES/ER/TM-96/R2. Environmental Sciences Division, Oak Ridge National Laboratory. Oak Ridge, Tennessee. June.

U.S. EPA. 1988. *Ambient Water Quality Criteria for Aluminum—1988*. EPA 440/5-86-008. Office of Water Regulations and Standards. Washington, D.C. August.

U.S. EPA. 1987. *Quality Criteria for Water—Update #2*. EPA 440/5-86-001. Office of Water Regulations and Standards. Washington, D.C. May.

U.S. EPA. 1996. "Ecotox Thresholds." *ECO Update*. EPA 540/F-95/038. Office of Emergency and Remedial Response. January.

U.S. EPA. 1999. *National Recommended Water Quality Criteria-Correction*. EPA 822-Z-99-001. Office of Water. April.

Zaroogian, G.E. 1981. *Interlaboratory Comparison—Acute Toxicity Tests Using the 48 Hour Oyster Embryo-Larval Assay*. U.S. EPA, Narragansett, Rhode Island. 17 pages. As cited in U.S. EPA 1997.

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 1 of 7)

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Polychlorinateddibenzo-p-dioxins (μg/kg)				
2,3,7,8-TCDD	0.0000038	2,691,535	0.41	TRV was calculated using equilibrium partitioning (EqP) approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Polynuclear aromatic hydrocarbons (PAH) (μg/kg)				
Total high molecular weight (HMW) PAH	Not applicable	Not applicable	170	TRV is ERL value computed by Ingersoll et al. (1996) based on 28-day amphipod (*Hyalella azteca*) toxicity tests. This TRV may be used if risk of total HMW PAHs is assessed.
Benzo(a)pyrene	Not applicable	Not applicable	84	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Benzo(a)anthracene	Not applicable	Not applicable	19	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Benzo(b)fluoranthene	Not applicable	Not applicable	37	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Benzo(k)fluoranthene	Not applicable	Not applicable	37	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Chrysene	Not applicable	Not applicable	30	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Dibenz(a,h)anthracene	Not applicable	Not applicable	10	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Indeno(1,2,3-cd)pyrene	Not applicable	Not applicable	30	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 2 of 7)

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Polychlorinated biphenyls (PCB) (μg/kg)				
Aroclor 1016	Not applicable	Not applicable	50	TRV is an ERL value for Total PCB calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Aroclor 1254	Not applicable	Not applicable	50	TRV is an ERL value for Total PCB calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Nitroaromatics (μg/kg)				
1,3-Dinitrobenzene	26	20.6	21.4	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
2,4-Dinitrotoluene	23	51	46.9	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
2,6-Dinitrotoluene	60	41.9	100.6	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Nitrobenzene	270	119	1285.2	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachloronitrobenzene	10	5,890	2356	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Phthalate esters (μg/kg)				
Bis(2-ethylhexyl)phthalate	3	111,000	1.33×10^{4}	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Di(n)octyl phthalate	320	9.03×10^{8}	1.16×10^{10}	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

(Page 3 of 7)

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Volatile organic compounds (μg/kg)				
Acetone	1,500	0.951	57.1	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Acrylonitrile	260	2.22	23.1	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Chloroform	28	53.0	59.4	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Crotonaldehyde	35	Not available	Not calculated	No TRV was calculated because no K_{oc} or K_{ow} values were identified for this constituent.
1,4-Dioxane	62,100	0.876	2176.0	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Formaldehyde	49.6	2.62	5.2	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Vinyl chloride	3,880	11.1	1722.7	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Other chlorinated organics (μg/kg)				
Hexachlorobenzene	Not applicable	Not applicable	20	TRV is an LEL value (Persaud et al. 1993).
Hexachlorobutadiene	0.93	6,940	258.2	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Hexachlorocyclopentadiene	0.52	9,510	197.8	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Pentachlorobenzene	0.47	32,148	604.4	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachlorophenol	Not applicable	Not applicable	7,000	TRV is an AET value for *H. azteca* (Washington State Department of Ecology 1994).
Pesticides (μg/kg)				
4,4'-DDE	Not applicable	Not applicable	5	TRV is an LEL value (Persaud et al. 1993). p,p'-DDE used as a surrogate.
Heptachlor	Not applicable	Not applicable	0.3	TRV is an NEL value (Persaud et al. 1993). The NEL was selected because no LEL was available.
Hexachlorophene	0.88	1,800,000	63,360	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Inorganics (mg/kg)				
Aluminum	Not applicable	Not applicable	14,000	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.
Antimony	Not applicable	Not applicable	64.0	TRV is an AET for *H. azteca* (Washington State Department of Ecology 1994).
Arsenic	Not applicable	Not applicable	6.0	TRV is an LEL value (Persaud et al. 1993).
Barium	Not applicable	Not applicable	20	TRV is a U.S. EPA Region 5 guideline value for classification of sediments for determining the suitability of dredged sediments for open water disposal, as cited in Hull and Suter II (1994).
Beryllium	Not applicable	Not applicable	Not available	Regulatory or toxicity value not available.
Cadmium	Not applicable	Not applicable	0.6	TRV is an LEL value (Persaud et al. 1993).

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

Compound	Freshwater TRV [a]	K_{oc} Value [b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Chromium (total)	Not applicable	Not applicable	26	TRV is an LEL value (Persaud et al. 1993).
Copper	Not applicable	Not applicable	16	TRV is an LEL value (Persaud et al. 1993).
Total Cyanide	Not applicable	Not applicable	0.1	TRV is a U.S. EPA Region 5 guideline value for classification of sediments for determining the suitability of dredged sediments for open water disposal, as cited in Hull and Suter II (1994).
Lead	Not applicable	Not applicable	31	TRV is an LEL value (Persaud et al. 1993).
Mercuric chloride	Not applicable	Not applicable	0.2	No toxicity data available for divalent inorganic mercury. Total mercury used as surrogate for divalent inorganic mercury. TRV is an LEL value (Persaud et al. 1993).
Methyl mercury	Not applicable	Not applicable	0.2	No toxicity data available for methyl mercury. Total mercury used as surrogate for methylmercury. TRV is an LEL value (Persaud et al. 1993).
Nickel	Not applicable	Not applicable	16	TRV is an LEL value (Persaud et al. 1993).
Selenium	Not applicable	Not applicable	0.1	TRV is an AET for *H. azteca* (Washington State Department of Ecology 1994).
Silver	Not applicable	Not applicable	4.5	TRV is an AET for *H. azteca* (Washington State Department of Ecology 1994).
Thallium	Not applicable	Not applicable	Not available	Regulatory value or toxicity value not available.
Zinc	Not applicable	Not applicable	110	TRV is an ERL value calculated by Ingersoll et al. (1996) based on 28-day *H. azteca* toxicity tests.

TABLE E-3

FRESHWATER SEDIMENT TOXICITY REFERENCE VALUES

Notes:

a Toxicity reference values are in units of micrograms per kilogram (μg/kg) and milligrams per kilograms (mg/kg) for organic and inorganic constituents, respectively.

b Values are in units of liters per kilogram (L/kg). K_{oc} = Organic carbon normalized sorption coefficient. References and equations used to calculate K_{oc} values are provided in Appendix A.

c The references refer to the study from which the TRV was identified. Complete reference citations are provided below.

d Freshwater sediment TRV calculated with the following equation:

$$\text{Freshwater sediment TRV} = \text{Freshwater TRV (Table E-1)} * K_{oc} * f_{oc,bs}$$

where,

K_{oc} = organic carbon partition coefficient, and

$f_{oc,bs}$ = fraction of organic carbon in bed sediment, assumed to be 4 percent = 0.04.

K_{oc} values discussed in Appendix A.

AET	=	Apparent Effects Threshold
ERL	=	Effects Range-Low
EqP	=	Equilibrium Partitioning
HMV	=	High molecular weight
LEL	=	Lowest Effect Level
NEL	=	No Effect Level
TRV	=	Toxicity Reference Value

REFERENCES

Default TRVs for sediments in freshwater habitats were identified from the three sets of freshwater toxicity values presented below. While some compound-specific freshwater sediment toxicity information is available in the scientific literature, available toxicity values were not used because of the compexity in understanding the role of naturally-occurring sediment features (such as grain size, ammonia, sulfide, soil type, and organic carbon content) in toxicity to benthic invertebrates. Among these sets of value, the lowest available toxicity value for a particular compound was adopted as the TRV. In many cases, a default TRV was calculated from the corresponding freshwater TRV using EPA's equilibrium partitioning approach, assuming a 4 percent organic carbon content.

Hull, R.N. and G.W. Suter II. 1994. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1994 Revision.* ES/ER/TM-95/R1. Environmental Sciences Division, Oak Ridge National Laboratory. Oak Ridge, Tennessee. June.

Ingersoll, C.G., P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, D.R. Mount, and R.G. Fox. 1996. "Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod *Hyallela azteca* and the Midge *Chironomous riparius*." *International Association of Great Lakes Research.* Volume 22. Pages 602-623.

Persaud, D., R. Jaaguagi, and A. Hayton. 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario.* Ontario Ministry of the Environment. Queen's Printer of Ontario. March.

U.S. EPA. 1993. *Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning.* Office of Water. EPA-822-R-93-011. September.

Washington State Department of Ecology. 1991. *Sediment Management Standards.* Washington Administrative Code 173-204.

Washington State Department of Ecology. 1994. *Creation and Analysis of Freshwater Sediment Quality Values in Washington State.* Publication No. 97-32-a. July.

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes[c]
Ploychlorinateddibenzo-p-dioxins (μg/kg)				
2,3,7,8-TCDD	0.0000038	2,691,535	0.41	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04.[d]
Polynuclear aromatic hydrocarbons (PAH) (μg/kg)				
Total high molecular weight (HMW) PAH	Not applicable	Not applicable	870	Recommended NOEL for Florida Department of Environmental Regulation (DER) (MacDonald 1993). This TRV may be used in risk of total HMW PAHs is assessed.
Benzo(a)pyrene	Not applicable	Not applicable	230	Recommended NOEL for Florida DER (MacDonald 1993).
Benzo(a)anthracene	Not applicable	Not applicable	160	Recommended NOEL for Florida DER (MacDonald 1993).
Benzo(b)fluoranthene	0.5	836,000	418,000	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04.[d]
Benzo(k)fluoranthene	Not applicable	Not applicable	240	TRV is a LEL value from Persaud et al. (1993).
Chrysene	Not applicable	Not applicable	220	Recommended NOEL for Florida DER (MacDonald 1993).
Dibenz(a,h)anthracene	Not applicable	Not applicable	31	Recommended NOEL for Florida DER (MacDonald 1993).
Indeno(1,2,3-cd)pyrene	Not applicable	Not applicable	1,360	TRV was computed from OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and fractional organic carbon content of 0.04, as follows: TRV = 34 mg/kg * 0.04 * 1000 μg/mg.

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Polychlorinated biphenyls (PCB) (μg/kg)				
Aroclor 1016	Not applicable	Not applicable	22.7	TRV is an ERL value for Total PCB from Long et al. (1995).
Aroclor 1254	Not applicable	Not applicable	22.7	TRV is an ERL value for Total PCB from Long et al. (1995).
Nitroaromatics (μg/kg)				
1,3-Dinitrobenzene	66.8	20.6	55.0	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
2,4-Dinitrotoluene	370	51	754.8	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
2,6-Dinitrotoluene	370	41.9	620.1	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Nitrobenzene	66.8	119	318.0	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachloronitrobenzene	10	5,890	2356	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

(Page 3 of 8)

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes[c]
Phthalate esters (µg/kg)				
Bis(2-ethylhexyl)phthalate	Not applicable	Not applicable	470	TRV was calculated using OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and fractional organic carbon content of 0.04, as follows: TRV = 47 mg/kg * 0.04 * 1000 µg/mg.
Di(n)octyl phthalate	Not applicable	Not applicable	580	TRV was calculated using OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and fractional organic carbon content of 0.04, as follows: TRV = 58 mg/kg * 0.04 * 1000 µg/mg.
Volatile organic compounds (µg/kg)				
Acetone	21,000	0.951	798.8	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04.[d]
Acrylonitrile	100	2.22	8.88	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04.[d]
Chloroform	180	53.0	381.6	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04.[d]
Crotonaldehyde	13	Not available	Not computed	No TRV was calculated because no K_{oc} or K_{ow} value was identified.
1,4-Dioxane	67,000	0.876	2348	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04.[d]
Formaldehyde	49.6	2.62	5.2	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04.[d]

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Vinyl chloride	3,880	11.1	1722.7	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Other chlorinated organics (μg/kg)				
Hexachlorobenzene	Not applicable	Not applicable	15.2	TRV was calculated using OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and a fractional OC content of 0.04, as follows: TRV = 0.38 mg/kg * 0.04 * 1000 μg/mg.
Hexachlorobutadiene	Not applicable	Not applicable	156	TRV was calculated using OC-based marine sediment quality criterion from Washington State Department of Ecology (1991) and a fractional OC content of 0.04, as follows: TRV = 3.9 mg/kg * 0.04 * 1000 μg/mg.
Hexachlorocyclopentadiene	0.07	9,510	26.6	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachlorobenzene	1.8	32,148	2315	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Pentachlorophenol	Not applicable	Not applicable	360	TRV is marine sediment quality criterion from Washington State Department of Ecology (1991).
Pesticides (μg/kg)				
4,4'-DDE	Not applicable	Not applicable	1.7	Recommended NOEL for p,p'-DDE for Florida DER (MacDonald 1993).
Heptachlor	0.0036	9,530	1.37	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]
Hexachlorophene	0.033	1,800,000	2376	TRV was calculated using EqP approach (EPA 1993), assuming a fractional organic content of 0.04. [d]

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes[c]
Inorganics (mg/kg)				
Aluminum	Not applicable	Not applicable	Not available	Screening or toxicity value not available.
Antimony	Not applicable	Not applicable	2	TRV is an ERL value (Long and Morgan 1991).
Arsenic	Not applicable	Not applicable	6	TRV is an LEL value for Province of Ontario (Persaud et al. 1993).
Barium	Not applicable	Not applicable	20	TRV is a U.S. EPA Region 5 guideline value for classification of sediments for determining the suitability of dredged material for open water disposal, as cited in Hull and Suter II (1994).
Beryllium	Not applicable	Not applicable	Not available	Screening or toxicity value not available.
Cadmium	Not applicable	Not applicable	1.0	Recommended NOEL for Florida DER (MacDonald 1993).
Chromium (hexavalent)	Not applicable	Not applicable	8.1	TRV is an ERL value for total chromium (Long et al. 1995).
Copper	Not applicable	Not applicable	28	Recommended NOEL for Florida DER (MacDonald 1993).
Total Cyanide	Not applicable	Not applicable	0. 1	TRV is a U.S. EPA Region V guideline value for classification of sediments for determining the suitability of dredged material for open water disposal, as cited in Hull and Suter II (1994).

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

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Compound	Marine/Estuarine Surface Water TRV[a]	K_{oc} Value[b]	Bed Sediment TRV (dry weight)	Reference and Notes [c]
Lead	Not applicable	Not applicable	21.0	Recommended NOEL for Florida DER (MacDonald 1993).
Mercuric chloride	Not applicable	Not applicable	0.1	No toxicity data available for divalent inorganic mercury. Total mercury is used as surrogate. Recommended NOEL for Florida DER (MacDonald 1993).
Methyl mercury	Not applicable	Not applicable	0.1	No toxicity data available for methyl mercury. Total mercury is used as surrogate. Recommended NOEL for Florida DER (MacDonald 1993).
Nickel	Not applicable	Not applicable	20.9	TRV is an ERL value (Long et al. 1995).
Selenium	Not applicable	Not applicable	Not Available	Screening or toxicity value not available.
Silver	Not applicable	Not applicable	0.5	Recommended NOEL for Florida DER (MacDonald 1993).
Thallium	Not appliable	Not applicable	Not available	Screening or toxicity value not available.
Zinc	Not applicable	Not applicable	68	Recommended NOEL for Florida DER (MacDonald 1993).

TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

Notes:

a Sediment TRVs are in units of micrograms per kilogram (μg/kg) and milligrams per kilograms (mg/kg) for organic and inorganic constituents, respectively.
b Values are in units of liters per kilogram (L/kg). K_{oc} = Organic carbon normalized sorption coefficient. References and equations used to calculate values are provided in Appendix A.
c The references refer to the study or studies from which the endpoint and concentrations were identified. Complete reference citations are provided below.
d Sediment TRV calculated with the following equation:

$$\text{Sediment TRV} = \text{Marine/estuarine surface water TRV (Table E-2)} * K_{oc} * f_{oc,bs}$$

where,

K_{oc} = organic carbon partition coefficient, and
$f_{oc,bs}$= fraction of organic carbon in bed sediment, assumed to be 1 percent = 0.01.

K_{oc} values are discussed in Appendix A.

EqP	=	Equilibrium Partitioning
ERL	=	Effects Range-Low
HMW	=	High molecular weight
LEL	=	Lowest Effect Level
NOEL	=	No Observed Effect Level
TRV	=	Toxicity Reference Value

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TABLE E-4

MARINE/ESTUARINE SEDIMENT TOXICITY REFERENCE VALUES

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REFERENCES

Default TRVs for sediments in marine and estuarine habitats were identified from several sets of toxicity values (standards, benchmarks, and guidelines) presented below. While some compound-specific marine/estuarine sediment toxicity information is available in the scientific literature, available toxicity values were not used because of the compexity in understanding the role of naturally-occurring sediment features (such as grain size, ammonia, sulfide, soil type, and organic carbon content) in toxicity to benthic invertebrates. Among these sets of value, the lowest available toxicity value for a particular compound was adopted as the TRV. In many cases, a default TRV was calculated from the corresponding freshwater TRV using EPA's equilibrium partitioning approach, assuming a 4 percent organic carbon content.

Hull, R.N. and G.W. Suter II. 1994. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1994 Revision.* ES/ER/TM-95/R1. Environmental Sciences Division, Oak Ridge National Laboratory. Oak Ridge, Tennessee. June.

Long, E.R., and L.G. Morgan. 1991. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.* National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum No. 5, OMA52, NOAA National Ocean Service. August.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." *Environmental Management.* Volume 19. Pages 81-97.

MacDonald, D.D. 1993. *Development of an Approach to the Assessment of Sediment Quality in Florida Coastal Waters.* Florida Department of Environmental Regulation. Tallahassee, Florida. January.

Persaud, D., R. Jaaguagi, and A. Hayton. 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario.* Ontario Ministry of the Environment. Queen's Printer of Ontario. March.

U.S. EPA. 1993. *Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning.* Office of Water. EPA-822-R-93-011. September.

Washington State Department of Ecology. 1991. *Sediment Management Standards.* Washington Administrative Code 173-204.

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

(Page 1 of 15)

Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Polychlorinateddibenzo-p-dioxins (μg/kg)						
2,3,7,8-TCDD	--	--	--	--	--	Toxicity value not identified.
Polynuclear aromatic hydrocarbons (PAH) (μg/kg)						
Total high molecular weight (HMW) PAH	Chronic NOAEL	Wheat	1,200	Not applicable	1,200	Benzo(a)pyrene toxicity used as representative toxicity of all HMW PAHs. This TRV may be used to characterize risk of total HMW PAHs to terrestrial plants.
Benzo(a)pyrene	Chronic NOAEL	Wheat	1,200	Not applicable	1,200	Sims and Overcash (1983)
Benzo(a)anthracene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.
Benzo(b)fluoranthene	Chronic NOAEL	Wheat	1,200	Not applicable	1,200	Sims and Overcash (1983).
Benzo(k)fluoranthene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.
Chrysene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.
Dibenz(a,h)anthracene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Indeno(1,2,3-cd)pyrene	Not available	--	--	--	1,200	Toxicity value not available. Benzo(a)pyrene used as surrogate.
Polychlorinated biphenyls (PCB) (μg/kg)						
Aroclor 1016	--	--	--	--	10,000	No toxicity value available. Aroclor 1254 TRV adopted as surrogate.
Aroclor 1254	Chronic NOAEL	Soybean shoot weight	10,000	Not applicable	10,000	Value for toxicity of Aroclor 1254 (Weber and Mrozek 1979).
Nitroaromatics (μg/kg)						
1,3-Dinitrobenzene	--	--	--	--	--	Toxicity value not available.
2,4-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
2,6-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
Nitrobenzene	--	--	--	--	--	Toxicity value not available.
Pentachloronitrobenzene	--	--	--	--	--	Toxicity value not available.
Phthalate esters (μg/kg)						
Bis(2-ethylhexyl)phthalate	--	--	--	--	--	Toxicity value not available.
Di(n)octyl phthalate	--	--	--	--	--	Toxicity value not available.
Volatile organic compounds (μg/kg)						

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Acetone	--	--	--	--	--	Toxicity value not available.
Acrylonitrile	--	--	--	--	--	Toxicity value not available.
Chloroform	--	--	--	--	--	Toxicity value not available.
Crotonaldehyde	--	--	--	--	--	Toxicity value not available.
1,4-Dioxane	--	--	--	--	--	Toxicity value not available.
Formaldehyde	--	--	--	--	--	Toxicity value not available.
Vinyl chloride	--	--	--	--	--	Toxicity value not available.
Other chlorinated organics (μg/kg)						
Hexachlorobenzene	--	--	--	--	--	Toxicity value not available.
Hexachlorobutadiene	--	--	--	--	--	Toxicity value not available.
Hexachlorocyclopentadiene	Acute EC50	Lettuce growth	10,000	0.01	100	Hulzebos et al. (1993)
Pentachlorobenzene	--	--	--	--	--	Toxicity value not available.
Pentachlorophenol	Chronic LOAEL	Rice	17,300	0.1	1,730	Nagasawa et al. (1981)
Pesticides (μg/kg)						
4,4'-DDE	--	--	--	--	--	Toxicity value not available.

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Heptachlor	Chronic NOAEL	Carrot	1,000	Not applicable	1,000	Ahrens and Kring (1968)
Hexachlorophene	--	--	--	--	--	Toxicity value not available.
Inorganics (mg/kg)						
Aluminum	Subchronic NOAEL	White clover seedling establishmen t	50	0.1[e]	5	Mackay et al. (1990)
Antimony	Not specified	Not specified	5	0.1[e]	0.5	Kabata-Pendias and Pendias (1992)
Arsenic	Chronic LOAEL	Corn yield (weight)	10	0.1	1	Woolson et al. (1971)
Barium	Chronic LOAEL	Barley shoot growth	500	0.01[e]	5	Chaudry et al. (1977)
Beryllium	Not specified	Not specified	10	0.01[e]	0.1	Kabata-Pendias and Pendias (1992)
Cadmium	Chronic LOAEL	Spruce seedling growth	2	0.1[e]	0.2	Burton et al. (1984)
Chromium (hexavalent)	Subchronic EC50	Lettuce growth	1.8	0.01	0.018	Adema and Hazen (1989)
Copper	Chronic LOAEL	Barley	10	0.1	1.0	Toivonem and Hofstra (1979)

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

Compound	Basis for TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Concentration	Uncertainty Factor [b]		
Cyanide, total	--	--	--	--	--	Toxicity value not available.
Lead	Chronic LOAEL	Senna	46	0.1	4.6	Krishnayya and Bedi (1986)
Mercuric chloride	Acute NOEC	Barley	34.9	0.01[e]	0.349	Panda et al. (1992)
Methyl mercury	--	--	--	--	--	Toxicity value not available.
Nickel	Chronic NOAEL	Bush bean shoot growth	25	Not applicable	25	Wallace et al. (1977)
Selenium	Subchronic NOAEL	Alfalfa shoot weight	0.5	0.1	0.05	Wan et al. (1988)
Silver	Not specified	Not specified	2	0.01[e]	0.02	Kabata-Pendias and Pendias (1992)
Thallium	Not specified	Not specified	1	0.01[e]	0.01	Kabata-Pendias and Pendias (1992)
Zinc	Chronic LOAEL	Spring barley	9	0.1	0.9	Davis, Beckett, and Wollan (1978)

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

Notes:

a To evaluate exposure duration, the following general guidelines were used: Chronic duration represents exposures occurring about 10 or more days, including exposure during a critical life stage, such as germination and shoot development. Subchronic duration generally lasts 2 days through several days, however a sensitive life stage is not exposed. Acute duration generally includes exposures occurring 0 to 2 days.

b Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion on the use of uncertainty factors.

c TRV was calculated by multiplying the toxicity value with the uncertainty factor.

d The references refer to the source of the toxicity value. Complete reference citations are provided below.

e Best scientific judgment was used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion on the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, and experimental design.

EC50 = Effective concentration for 50 percent of the test organisms.
HWC = High molecular weight
LOAEL = Lowest Observed Adverse Effects Level
NOAEL = No Observed Adverse Effects Level
NOEC = No Observed Effects Concentration
TRV = Toxicity Reference Value

REFERENCES

Efroymson, Will, Suter II, and Wooten (1997) provides a comprehensive review of ecologically-relevant terrestrial plant toxicity information. This source was reviewed to identify studies to develop TRVs for terrestrial plant. Based on the information presented, one or more references were obtained and reviewed to identify compound-specific toxicity values. For some compounds, the available information identified a single study meeting the requirements for a TRV, as discussed in Chapter 5 (Section 5.4) of the SLERAP. In most cases, each reference was obtained and reviewed to identify a single toxicity value to develop a TRV for each compound. In a few cases where a primary study could not be obtained, a toxicity value is based on a secondary source. As noted below, additional compendia were reviewed to identify toxicity studies to review. For compounds not discussed in Efroymson, Will, Suter II, and Wooten (1997), the scientific literature was searched, and relevant studies were obtained and reviewed. The references reviewed are listed below. The study selected for the TRV is highlighted in bold.

Benzo(a)pyrene

Sims R.C. and Overcash M.R. 1983. "Fate of Polynuclear Aromatic Compounds (PNAs) in Soil-Plant Systems." ***Residue Reviews*****. Volume 88.**

Benzo(k)fluoranthene

Sims R.C. and Overcash M.R. 1983. "Fate of Polynuclear Aromatic Compounds (PNAs) in Soil-Plant Systems." ***Residue Reviews*****. Volume 88.**

Aroclor 1254

Weber, J.B., and E. Mrozek, Jr. 1979. "Polychlorinated Biphenyls: Phytotoxicity, Absorption, and Translocation by Plants, and Inactivation by Activated Carbon." ***Bulletin of Environmental Contamination and Toxicology*****. Volume 23. Pages 412-417. As cited in Will and Suter II (1995b).**

Weber, J. B. and E. Mrozek, Jr. 1979. "Polychlorinated Biphenyls: Phytotoxicity, Absorption and Translocation by Plants, and Inactivation by Activated Carbon". *Bulletin of Environmental Contamination and Toxicology*. Volume 23. Pages 412-17.

Nitroaromatics

McFarlane, C. M., T. Pfleeger, and J. Fletcher. 1990. "Effect, Uptake and Disposition of Nitrobenzene in Several Terrestrial Plants." *Environmental Toxicology and Chemistry*. Volume 9. Pages 513-520.

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

Hexachlorocyclopentadiene

Hulzebos, E.M., D.M.M. Adema, E.M. Dirven-van Breeman, L. Henzen, W.A. van Dis, H.A. Herbold, J.A. Hoekstra, R. Baerselman, and C.A.M. van Gestel. 1993. "Phototoxicity Studies with *Latuca sativa* in soil and soil nutrient solution." *Environmental Toxicology and Chemistry*. Volume 12. Pages 1079-1094.

Pentachlorophenol

Nagasawa, S., and others. 1981. "Concentration of PCP Inhibiting the Development of Roots at the Early Growth Stage of Rice and the Difference of Susceptibilities in Varieties." *Bull. Fac. Agricul.* Shimane Univ. Volume 15. Pages 101-108. As cited in U.S. Fish and Wildlife Service. 1989. *Pentachlorophenol Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*. April.

van Gestel, C. A. M., D. M. M. Adema, and E. M. Dirven-van Breemen. 1996. "Phytotoxicity of Some Chloroanilines and Chlorophenols, in Relation to Bioavailability in Soil." *Water, Air and Soil Pollution.* Volume 88. Pages 119-132.

Heptachlor

Ahrens, J.F., and J.B. Kring. 1968. "Reduction of Residues of Heptachlor and Chlordane in Carrots with Soil Applications of Activated Carbon." *Journal of Economic Entomology*. Volume 61. Pages 1540-1543.

Aluminum

Mackay, A.D., J.R. Caradus, and M.W. Pritchard. 1990. "Variation for Aluminum Tolerance in White Clover." *Plant and Soil.* Volume 123. Pages 101-105.

Godbold, D. L., and C. Kettner. 1991. "Use of Root Elongation Studies to Determine Aluminum and Lead Toxicity in *Picea abies* Seedlings." *Journal Plant Physiology.* Volume 138. Pages 231-235.

Görransson, A. and T. D. Eldhuset. 1991." Effects of Aluminum on Growth and Nutrient Uptake of Small *Picea abies* and *Pinus sylvestris* Plants." *Trees.* Volume 5. Page 136-42.

Llugany, M., C. Poschenrieder, and J. Barcelo. 1995. "Monitoring of Aluminum-Induced Inhibition of Root Elongation in Four Maize Cultivars Differing in Tolerance to Aluminum and Proton Toxicity." *Physiologia Plantarum.* Volume 93. Pages 265-271.

Wheeler, D. M. and J. M. Follet. 1991. "Effect of Aluminum on Onions, Asparagus and Squash." *Journal Plant Nutrients.* Volume 14(9). Page 897-912.

TABLE E-5

TERRESTRIAL PLANT TOXICITY REFERENCE VALUES

Antimony

Kabata-Pendias, A., and H. Pendias. 1992. *Trace Elements in Soils and Plants.* CRC Press, Inc. Boca Raton, Florida.

Arsenic

Woolson, E.A., J.H. Axley, and P.C. Kearney. 1971. "Correlation Between Available Soil Arsenic, Estimated by Six Methods, and Response of Corn (*Zea mays* L.)." *Proceedings of Soil Science Society of America*. Volume 35. Pages 101-105.

Deuel, L. E. and A. R. Swoboda. 1972. "Arsenic Toxicity to Cotton and Soybeans." *Journal of Environmental Quality.* Volume 1. Page 317-20.

Fargasova, A. 1994. "Effect of Pb, Cd, Hg, As, and Cr on Germination and Root Growth of *Sinapis alba* seeds." *Bulletin Environmental Contamination and Toxicology.* Volume 52. Page 452-456.

Rosehart, R. G., and J. Y. Lee. 1973. "The Effect of Arsenic Trioxide on the Growth of White Spruce Seedlings." *Water, Air, and Soil Pollution.* Volume 2. Page 439-443.

Barium

Chaudhry, F.M., A. Wallace, and R.T. Mueller. 1977. "Barium Toxicity in Plants." *Communities in Soil Science and Plant Analysis.* Volume 8. Pages 795-797.

Beryllium

Kabata-Pendias, A., and H. Pendias. 1992. *Trace Elements in Soils and Plants.* CRC Press, Inc. Boca Raton, Florida.

Romney, E. M. and J. D. Childress. 1965. "Effects of Beryllium in Plants and Soil." *Soil Science.* Volume 100(2). Pages 210-17.

Romney, E. M., J. D. Childress, and G. V. Alexander. 1962. "Beryllium and the Growth of Bush Beans." *Science.* Volume 185. Pages 786-87.

Cadmium

Burton, K.W., E. Morgan, and A. Roig. 1984. "The Influence of Heavy Metals Upon the Growth of Sitka-Spruce in South Wales Forests. II. Greenhouse Experiments." *Plant and Soil.* Volume 78. Pages 271-282.

Al-Attar, A. F., M. H. Martin, and G. Nickless. 1988. "Uptake and Toxicity of Cadmium, Mercury and Thallium to *Lolium perenne* Seedlings." *Chemosphere.* Volume 17. Page 1219-1225.

Carlson, R. W., F. A. Bazzaz, and G. L. Rolfe. 1975. "The Effects of Heavy Metals on Plants. II. Net Photosynthesis and Transpiration of Whole Corn and Sunflower Plants Treated with Pb, Cd, Ni, and Tl." *Environ. Res.* Volume 10. Pages 113-120.

Fargasova, A. 1994. "Effect of Pb, Cd, Hg, As, and Cr on Germination and Root Growth of *Sinapis alba* Seeds." *Bulletin of Environmental Contamination and Toxicology.* Volume 52. Page 452-456.

Godbold, D. L., and A. Huttermann. 1985." Effect of Zinc, Cadmium, and Mercury on Root Elongation of *Picea abies* (Karst.) Seedlings and the Significance of These Metals to Forest Die-Back." *Environmental Pollution.* Volume 38. Pages 375–381.

Jalil, A., F. Selles, and J. M. Clarke. 1994. "Growth and Cadmium Accumulation in Two Durum Wheat Cultivars." *Communities in Soil Science and Plant Analysis.* Volume 25 (15&16). Pages 2597-2611.

John, M. K. , C. Van Laerhoven, and H.H. Chuah. 1972. "Factors Affecting Plant Uptake and Phytotoxicity of Cadmium Added to Soils." *Environmental Science Technology.* Volume 6(12). Pages 1005-1009.

Khan, D. H. and B. Frankland. 1983. "Effects of Cadmium and Lead on Radish Plants with Particular Reference to Movement of Metals Through Soil Profile and Plant." *Plant Soil.* Volume 70. Pages 335-345.

Kummerova, M., and R. Brandejsova. 1994. Project TOCOEN. "The Fate of Selected Pollutants in the Environment. Part XIX. The Phytotoxicity of Organic and Inorganic Pollutants--Cadmium. The Effect of Cadmium on the Growth of Germinating Maize Plants." *Toxicological and Environmental Chemistry.* Volume 42. Pages 115-132.

Miles, L. J. and G. R. Parker. 1979. "The Effect of Soil-Added Cadmium on Several Plant Species." *Journal of Environmental Quality.* Volume 8(2). Pages 229-232.

Rascio, N., F. D. Vecchia, M. Ferretti, L. Merlo, and R. Ghisi. 1993. "Some Effects of Cadmium on Maize Plants." *Archives of Environmental Contammination and Toxicology.* Volume 25. Pages 244-249.

Reber, H. H. 1989. "Threshold Levels of Cadmium for Soil Respiration and Growth of Spring Wheat (*Triticum aestivum* L.), and Difficulties with Their Determination." *Biology and Fertility of Soils.* Volume 7. Pages 152-157.

Rehab, F. I., and A. Wallace. 1978. "Excess Trace Metal Effects on Cotton: 6. Nickel and Cadmium in Yolo Loam Soil." *Communities in Soil Science and Plant Analysis.* Volume 9(8). Pages 779-784.

Rehab, F. I., and A. Wallace. 1978. "Excess Trace Metal Effects on Cotton: 5. Nickel and Cadmium in Solution Culture." *Communities in Soil Science and Plant Analysis.* Volume 9(8). Pages 771-778.

Strickland, R. C., W. R. Chaney, and R. J. Lamoreaux. 1979. "Organic Matter Influences Phytotoxicity of Cadmium to Soybeans." *Plant Soil* Volume 53(3). Pages 393-402.

Chromium

Adema, D.M.M., and L. Henzen. 1989. "A Comparison of Plant Toxicities of Some Industrial Chemicals in Soil Culture and Soilless Culture." ***Ecotoxicology and Environmental Safety*****. Volume 18. Pages 219-229.**

Fargasova, A. 1994. "Effect of Pb, Cd, Hg, As, and Cr on Germination and Root Growth of *Sinapis alba* Seeds." Bulletin of Environmental Contamination and Toxicology. Volume 52. Pages 452-456.

McGrath, S. P. 1982. "The Uptake and Translocation of Tri- and Hexa-Valent Chromium and Effects on the Growth of Oat in Flowing Nutrient Solution." *New Phytology.* Volume 92. Pages 381-390.

Smith, S. P. J. Peterson, and K. H. M. Kwan. 1989. "Chromium Accumulation, Transport and Toxicity in Plants." *Toxicology and Environmental Chemistry.* Volume 24. Pages 241-251.

Turner, M. A. and R. H. Rust. 1971. "Effects of Chromium on Growth and Mineral Nutrition of Soybeans." *Soil Science. Soc. Am. Proc.* Volume 35. Pages 755-58.

Wallace, A., G. V. Alexander, and F. M. Chaudhry. 1977. "Phytotoxicity of Cobalt, Vanadium, Titanium, Silver, and Chromium." *Communities in Soil Science and Plant Analysis.* Volume 8(9). Pages 751-56.

Copper

Toivonem, P.M.A., and G. Hofstra. 1979. "The Interaction of Copper and Sulfur Dioxide in Plant Injury." ***Canadian Journal of Plant Sciences*****. Volume 59. Pages 475-479.**

Gupta, D. B. and S. Mukherji. 1977. "Effects of Toxic Concentrations of Copper on Growth and Metabolism of Rice Seedlings." *Z. Pflanzenphysiol. Bd.* Volume 82. Pages 95-106.

Heale, E .L., and D .P. Ormrod. 1982. "Effects of Nickel and Copper on *Acer rubrum*, *Cornus stolonifera*, *Lonicera tatarica*, and *Pinus resinosa*." *Canadian Journal of Botany*. Volume 60. Pages 2674-2681.

Mocquot, B., J. Vangronsveld, H. Clijsters, and M. Mench. 1996. "Copper Toxicity in Young Maize (*Zea mays* L.) Plants: Effects on Growth, Mineral and Chlorophyll Contents, and Enzyme Activities." *Plant and Soil.* Volume 182. Pages 287-300.

Mukherji, S., and B. Das Gupta. 1972. "Characterization of Copper Toxicity in Lettuce Seedlings." *Physiol. Plant*. Volume 27. Pages 126-129.

Wallace, A., G. V. Alexander, and F. M. Chaudhry. 1977. "Phytotoxicity and Some Interactions of the Essential Trace Metals Iron, Manganese, Molybdenum, Zinc, Copper, and Boron." *Communities in Soil Science and Plant Analysis*. Voilume 8(9). Pages 741-50.

Lead

Krishnayya, N.S.R., and S.J. Bedi. 1986. "Effect of Automobile Lead Pollution in Cassis tora L. and Cassia occidentalis L." ***Environmental Pollution*****. Volume 40A. Pages 221-226. As cited in U.S. Fish and Wildlife Service. 1988.** ***Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*****. April. Page 56.**

Carlson, R. W., F. A. Bazzaz, and G. L. Rolfe. 1975. "The Effects of Heavy Metals on Plants. II. Net Photosynthesis and Transpiration of Whole Corn and Sunflower Plants Treated With Pb, Cd, Ni, and Tl." *Environ. Res*. Volume 10. Pages 113-120.

Fargasova, A. 1994. "Effect of Pb, Cd, Hg, As, and Cr on Germination and Root Growth of *Sinapis alba* Seeds." Bulletin of Environmental Contamination and Toxicology. Volume 52. Pages 452-456.

Godbold, D. L., and C. Kettner. 1991. "Use of Root Elongation Studies to Determine Aluminum and Lead Toxicity in *Picea abies* Seedlings." *Journal of Plant Physiology.* Volume 138. Pages 231-235.

Hooper, M. C. 1937. "An Investigation of the Effect of Lead on Plants." *Annals of Applications of Biology*. Volume 24. Pages 690-695.

Khan, D. H. and B. Frankland. 1983. "Effects of Cadmium and Lead on Radish Plants with Particular Reference to Movement of Metals Through Soil Profile and Plant." *Plant Soil.* Volume 70. Pages 335-345.

Liu, D., W. Jiang, W. Wang, F. Zhao, and C. Lu. 1994. "Effects of Lead on Root Growth, Cell Division, and Nucleolus of Allium cepa." *Environmental Pollution.* Volume 86. Pages 1-4.

Rolfe, G. L. and F. A. Bazzaz. 1975." Effect of Lead Contamination on Transpiration and Photosynthesis of Loblolly Pine and Autumn Olive." *Forest Science.* Volume 21(1). Pages 33-35.

Mercuric chloride

Panda, K.K., M. Lenka, and B.B. Panda. 1992. "Monitoring and Assessment of Mercury Pollution in the Vicinity of a Chloralkali Plant. II. Plant-Bioavailability, Tissue-Concentration and Genotoxicity of Mercury from Agricultural Soil Contaminated with Solid Waste Assessed in Barley (*Hordeum vulgare* L.)." *Environmental Pollution*. Volume 76. Pages 33-42.

Al-Attar, A. F., M. H. Martin, and G. Nickless. 1988. "Uptake and Toxicity of Cadmium, Mercury and Thallium to *Lolium perenne* Seedlings." *Chemosphere.* Volume 17. Pages 1219-1225.

Fargasova, A. 1994. "Effect of Pb, Cd, Hg, As, and Cr on Germination and Root Growth of *Sinapis alba* Seeds." *Bulletin of Environmental Contamination and Toxicology*. Volume 52. Pages 452-456.

Godbold, D. L., and A. Huttermann. 1985. "Effect of Zinc, Cadmium, and Mercury on Root Elongation of *Picea abies* (Karst.) Seedlings and the Significance of These Metals to Forest Die-Back." Environmental Pollution. Volume 38. Pages 375–381.

Mukhiya, Y. K., K. C. Gupta, N. Shrotriya, J. K. Joshi, and V. P. Singh. 1983. "Comparative Responses of the Action of Different Mercury Compounds on Barley." *International Journal of Environmental Studies* Volume 20. Pages 323-327.

Suszcynsky, E. M., and J. R. Shann. 1995. "Phytotoxicity and Accumulation of Mercury in Tobacco Subjected to Different Exposure Routes." *Environmental Toxicology and Chemistry.* Volume 14(1). Pages 61-67.

Nickel

Wallace, A., R.M. Romney, J.W. Cha, S.M. Soufi, and F.M. Chaudry. 1977. "Nickel Phytotoxicity in Relationship to Soil pH Manipulation and Chelating Agents." *Commun. Soil Sci. Plant Anal.* Volume 8. Pages 757-764.

Carlson, R. W., F. A. Bazzaz, and G. L. Rolfe. 1975. "The Effects of Heavy Metals on Plants. II. Net Photosynthesis and Transpiration of Whole Corn and Sunflower Plants Treated with Pb, Cd, Ni, and Tl." *Environ. Res.* Volume 10. Pages 113-120.

Heale, E .L., and D .P. Ormrod. 1982. "Effects of Nickel and Copper on *Acer rubrum*, *Cornus stolonifera*, *Lonicera tatarica*, and *Pinus resinosa*." *Canadian Journal of Botany*. Volume 60. Pages 2674-2681.

Khalid, B. Y. and J. Tinsley. 1980. "Some Effects of Nickel Toxicity on Rye Grass." *Plant Soil.* Volume 55. Pages 139-44.

Rehab, F. I., and A. Wallace. 1978. "Excess Trace Metal Effects on Cotton: 6. Nickel and Cadmium in Yolo Loam Soil." *Communities in Soil Science and Plant Analysis.* Volume 9(8). Pages 779-784.

Rehab, F. I., and A. Wallace. 1978. "Excess Trace Metal Effects on Cotton: 5. Nickel and Cadmium in Solution Culture." *Communities in Soil Science and Plant Analysis*. Volume 9(8). Pages 771-778.

Wallace, A., R. M. Romney, J. W. Cha, S. M. Soufi, and F. M. Chaudhry. 1977. "Nickel Phytotoxicity in Relationship to Soil pH Manipulation and Chelating Agents." *Communities in Soil Science and Plant Analysis*. Volume 8(9). Pages 757-64.

Selenium

Wan, H.F., R.L. Mikkelsen, and A.L. Page. 1988. "Selenium Uptake by Some Agricultural Crops from Central California Soils." *Journal of Environmental Quality*. Volume 17. Pages 269-272.

Banuelos, G. S., H. A. Ajwa, L. Wu, X. Guo, S. Akohoue, and S. Zambrzuski. 1997. "Selenium-Induced Growth Reduction in *Brassica* Land Races Considered for Phytoremediation." *Ecotoxicology and Environmental Safety* Volume 36. Pages 282-287

Broyer, T. C., C. M. Johnson, and R. P. Huston. 1972." Selenium and Nutrition of *Astragalus*. I. Effects of Selenite or Selenate Supply on Growth and Selenium Content". *Plant Soil.* Volume 36. Page 635-649.

Singh, M., and N. Singh. 1978. "Selenium Toxicity in Plants and its Detoxication by Phosphorus." *Soil Science.* Volume 126. Pages 255-262.

Silver

Kabata-Pendias, A., and H. Pendias. 1992. *Trace Elements in Soils and Plants.* CRC Press, Inc. Boca Raton, Florida.

Cooper. C. F., and W. C. Jolly. 1970. "Ecological Effects of Silver Iodide and Other Weather Modification Agents: A Review." *Water Resour. Res.* Volume 6. Pages 88-98.

Wallace, A., G. V. Alexander, and F. M. Chaudhry. 1977. "Phytotoxicity of Cobalt, Vanadium, Titanium, Silver, and Chromium." *Communities in Soil Science and Plant Analysis.* Volume 8(9). Pages 751-56.

Thallium

Kabata-Pendias, A., and H. Pendias. 1992. *Trace Elements in Soils and Plants.* CRC Press, Inc. Boca Raton, Florida.

Al-Attar, A. F., M. H. Martin, and G. Nickless. 1988. "Uptake and Toxicity of Cadmium, Mercury and Thallium to *Lolium perenne* Seedlings." *Chemosphere.* Volume 17. Pages 1219-1225.

Carlson, R. W., F. A. Bazzaz, and G. L. Rolfe. 1975. "The Effects of Heavy Metals on Plants. II. Net Photosynthesis and Transpiration of Whole Corn and Sunflower Plants Treated with Pb, Cd, Ni, and Tl." *Environ. Res.* Volume 10. Pages 113-120.

Zinc

Davis, R.D., P.H.T. Beckett, and E. Wollan. 1978. "Critical Levels of Twenty Potentially Toxic Elemenets in Young Spring Barley." *Plant and Soil.* Volume 49. Pages 395-408.

Godbold, D. L., and A. Huttermann. 1985. "Effect of Zinc, Cadmium, and Mercury on Root Elongation of *Picea abies* (Karst.) Seedlings and the Significance of These Metals to Forest Die-Back." *Environmental Pollution.* Volume 38. Pages 375–381.

Lata, K. and B. Veer. 1990. "Phytotoxicity of Zn Amended Soil to *Spinacia* and *Coriandrum.*" *Acta Bot. Indica.* Volume 18. Pages 194-198.

Wallace, A., G. V. Alexander, and F. M. Chaudhry. 1977. "Phytotoxicity and Some Interactions of the Essential Trace Metals Iron, Manganese, Molybdenum, Zinc, Copper, and Boron." *Communities in Soil Science and Plant Analysis.* Volume 8(9). Pages 741-50.

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

Compound	TRV				TRV[c]	Reference and Notes[d]
	Duration and Endpoint[a]	Test Species	Concentration	Uncertainty Factor[b]		
Polychlorinateddibenzo-p-dioxins (μg/kg)						
2,3,7,8-TCDD	Chronic (85-day); no mortality reported at 5,000 μg/kg	Earthworm (*Allolobophora caliginosa*)	5,000	0.1[e]	500	Toxicity value for 2,3,7,8-TCDD (Reinecke and Nash 1984). UF applied to concentration because mortality only endpoint available and data not subjected to statistical analysis.
Polynuclear aromatic hydrocarbons (PAH) (μg/kg)						
Total HMW PAH	Not available	--	--	--	25,000	Benzo(a) pyrene used as surrogate for HMW PAH compounds.
Benzo(a)pyrene	Chronic (28-day) NOAEL for growth	Woodlouse (*Porcellio scaber*)	25,000	Not applicable	25,000	van Straalen and Verweij (1991)
Benzo(a)anthracene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Benzo(b)fluoranthene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Benzo(k)fluoranthene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Chrysene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Dibenz(a,h)anthracene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.
Indeno(1,2,3-cd)pyrene	Not available	--	--	--	25,000	Toxicity value not available. TRV for benzo(a)pyrene used as surrogate.

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

(Page 2 of 12)

Compound	TRV				TRV[c]	Reference and Notes[d]
	Duration and Endpoint[a]	Test Species	Concentration	Uncertainty Factor[b]		
Polychlorinated biphenyls (PCB) (μg/kg)						
Aroclor 1016	Acute median LC50	Earthworm (*Eisenia foetida*)	251,000	0.01	2,510	Rhett et al. (1989).
Aroclor 1254	Acute median LC50	Earthworm (*Eisenia foetida*)	251,000	0.01	2,510	Rhett et al. (1989).
Nitroaromatics (μg/kg)						
1,3-Dinitrobenzene	--	--	--	--	2,260	Toxicity value not available. Nitrobenzene used as surrogate.
2,4-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
2,6-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
Nitrobenzene	Subchronic (14-day) LC50	Earthworm (species uncertain)	226,000	0.01[e]	2,260	Neuhauser et al. (1986).
Pentachloronitrobenzene	--	--	--	--		Toxicity value not available.
Phthalate esters (μg/kg)						
Bis(2-ethylhexyl)phthalate	--	--	--	--	--	Toxicity value not available.
Di(n)octyl phthalate	--	--	--	--	--	Toxicity value not available.
Volatile organic compounds (μg/kg)						
Acetone	--	--	--	--	--	Toxicity value not available.
Acrylonitrile	--	--	--	--	--	Toxicity value not available.

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

Compound	TRV					
	Duration and Endpoint [a]	Test Species	Concentration	Uncertainty Factor [b]	TRV [c]	Reference and Notes [d]
Chloroform	--	--	--	--	--	Toxicity value not available.
Crotonaldehyde	--	--	--	--	--	Toxicity value not available.
1,4-Dioxane	--	--	--	--	--	Toxicity value not available.
Formaldehyde	--	--	--	--	--	Toxicity value not available.
Vinyl chloride	--	--	--	--	--	Toxicity value not available.
Other chlorinated organics (μg/kg)						
Hexachlorobenzene	--	--	--	--	--	Toxicity value not available.
Hexachlorobutadiene	--	--	--	--	--	Toxicity value not available.
Hexachlorocyclopentadiene	--	--	--	--	--	Toxicity value not available.
Pentachlorobenzene	LC50 of unspecified duration	Earthworm (species uncertain)	115,000	0.01[e]	1,150	van Gestel et al. (1991)
Pentachlorophenol	Chronic (21-day) NOAEL for hatching success	Earthworm (*Eisenia andrei*)	10,000	Not applicable	10,000	van Gestel et al. (1988)
Pesticides (μg/kg)						
4,4'-DDE	--	--	--	--	--	Toxicity value not available.
Heptachlor	--	--	--	--	--	Toxicity value not available.
Hexachlorophene	--	--	--	--	--	Toxicity value not available.
Inorganics (mg/kg)						

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

(Page 4 of 12)

Compound	TRV				TRV [c]	Reference and Notes [d]
	Duration and Endpoint [a]	Test Species	Concentration	Uncertainty Factor [b]		
Aluminum	--	--	--	--	--	Toxicity value not available.
Antimony	--	--	--	--	--	Toxicity value not available.
Arsenic	Chronic (56-day); reduced cocoon production reported at single concentration tested	Earthworm (*Eisenia fetida*)	25	0.01[e]	0.25	Fischer and Koszorus (1992)
Barium	--	--	--	--	--	Toxicity value not available.
Beryllium	--	--	--	--	--	Toxicity value not available.
Cadmium	Chronic (4-month) NOAEL for cocoon production	Earthworm (*Dendrobaena rubida*)	10	Not applicable	10	Bengtsson and et al. (1986)
Chromium (hexavalent)	Chronic (60-day); survival reduced 25 percent at lowest tested concentration	Earthworm (*Octochaetus pattoni*)	2	0.1[e]	0.2	Abbasi and Soni (1983)
Copper	Chronic (56-day) NOAEL for cocoon production	Earthworm (*Eisenia fetida*)	32.0	Not applicable	32.0	Spurgeon et al. (1994)
Cyanide, total	--	--	--	--	--	Toxicity value not available.
Lead	Chronic (4-month) NOAEL for cocoon production	Earthworm (*Dendrobaena rubida*)	100	Not applicable	100	Bengtsson et al. 1986

TABLE E-6

SOIL INVERTEBRATE TOXICITY REFERENCE VALUES

Compound	TRV					
	Duration and Endpoint [a]	Test Species	Concentration	Uncertainty Factor [b]	TRV [c]	Reference and Notes [d]
Mercuric chloride	Not available	--	--	--	2.5	Toxicity value not available. TRV for methyl mercury used as a surrogate.
Methyl mercury	Chronic (12-week) NOAEL for segment regeneration and survival	Earthworm (*Eisenia foetida*)	2.5	Not applicable	2.5	Beyer et al. (1985). Wet weight NOAEL of 1 mg/kg converted to corresponding dry weight NOAEL based on 60 percent moisture content. Uncertainty factor of 0.1 used because segment regeneration may not be a sensitive endpoint.
Nickel	Chronic (20-week) NOAEL for cocoon production	Earthworm (*Eisenia foetida*)	100	Not applicable	100	Malecki et al. (1982)
Selenium	Chronic; reduced cocoon production at single tested concentration	Earthworm (*Eisenia foetida*)	77	0.1[e]	7.7	Fischer and Koszorus (1992)
Silver	--	--	--	--	--	Toxicity value not available.
Thallium	--	--	--	--	--	Toxicity value not available.
Zinc	Chronic (56-day) NOEC for cocoon production	Earthworm (*Eisenia fetida*)	199	Not applicable	199	Spurgeon et al. (1994)

Notes:

a	- duration, the following general guidelines were used: Chronic duration represents exposures occurring about 10 or more days, including exposure during a critical life stage encompassing a sensitive endpoint. Subchronic duration generally lasts 2 days through several days, however a sensitive life stage is not exposed. Acute duration generally includes exposures from 0 to 2 days.
b	Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion on the use of uncertainty factors.
c	TRV was calculated by multiplying the toxicity value with the uncertainty factor.
d	The references refer to the source of the toxicity value. Complete reference citations are provided below.
e	Best scientific judgment used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion on the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of measured effect, experimental design, and availability of toxicity data.

HMW	=	High molecular weight
LC50	=	Concentration lethal to 50 percent of the test organisms.
NOAEL	=	No Observed Adverse Effects Level
NOEC	=	No Observed Effects Level
UF	=	Uncertainty Factor
TRV	=	Toxicity Reference Value

REFERENCES

Efroymson, Will, and Suter II (1997) provides a comprehensive review of ecologically-relevant soil invertebrate toxicity information. This source was reviewed to identify studies to develop TRVs for invertebrates. Effects of compounds on microbial communities were not considered. Based on the information presented, one or more references were obtained and reviewed to identify compound-specific toxicity values. For some compounds, the available information identified a single study meeting the requirements for a TRV, as discussed in Section 5.4. In most cases, each reference was obtained and reviewed to identify a single toxicity value to develop a TRV for each compound. In a few cases where a primary study could not be obtained, a toxicity value is based on a secondary source. As noted below, additional compendia were reviewed to identify toxicity studies to review. For compounds not discussed in Efroymson, Will, and Suter II (1997), the scientific literature was searched, and relevant studies were obtained and reviewed. The references reviewed are listed below. The study selected for the TRV is highlighted in bold.

Polychlorinated dibenzo(p)dioxins

Reinecke, A.J., and R.G. Nash. 1984. "Toxicity of 2,3,7,8-TCDD and Short-Term Bioaccumulation by Earthworms (Oligochaeta)." *Soil Biology* Biochemistry. Volume 16. Pages 45-49. As cited in U.S. Fish and Wildlife Service. 1986. *Dioxin Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* Biological Report 85 (1.8). May.

Benzo(a)pyrene

van Straallen, N.M., and R.A. Verweij. 1991. "Effects of Benzo(a)pyrene on Food Assimilation and Growth Efficiency in *Porcellio scaber* (Isopoda)." *Bulletin of Environmental Contamination and Toxicology.* Volume 46. Pages 134-140.

van Brummelen, T.C., and S.C. Stuijfzand. 1993. "Effects of benzo(a)pyrene on survival, growth and energy reserves in terrestrial isopods *Oniscus asellus* and *Porcellio scaber*." *Science of the Total Environment. Supplement.* Pages 921-930.

van Straalen, N.M., and R.A. Verweij. 1991. "Effects of benzo(a)pyrene on food assimilation and growth efficiency in *Porcellio scaber* (Isopoda)." *Bulletin of Environmental Contamination and Toxicology.* Volume 46. Pages 134-140.

Polychlorinated biphenyls

Rhett, G., and others. 1989. "Rate and Effects of PCB Accumulation on *Eisenia foetida*." U.S. Army Corps of Engineers. Waterways Experiment Station. Vicksburg, Mississippi. September 21.

Nitrobenzene

Neuhauser, E.F., P.R. Durkin, M.R. Malecki, and M. Anatra. 1986. "Comparative Toxicity of Ten Organic Chemicals to Four Earthworm Species." ***Comparitive Biochemistry and Physiology.*** **Volume 83C. Pages 197-200.**

Pentachlorobenzene

van Gestel, C.A.M., W.-C. Ma, and C.E. Smit. 1991. "Development of QSARs in Terrestrial Ecotoxicology: Earthworm Toxicity and Soil Sorption of Chlorophenols, Chlorobenzenes, and Dichloroaniline." ***The Science of the Total Environment.*** **Volume 109/110. Pages 589-604.**

Pentachlorophenol

van Gestel, C.A.M. and W.-C. Ma. 1988. "Toxicity and Bioaccumulation of Chlorophenols in Earthworms, in Relation to Bioavailability in Soil." ***Ecotoxicology and Environmental Safety.*** **Volume 15. Pages 289-297.**

Fitzgerald, D. G., K. A. Warner, R. P. Lanno, and D. G. Dixon. 1996. "Assessing the Effects of Modifying Factors on Pentachlorophenol Toxicity to Earthworms: Applications of Body Residues." *Environmental Toxicology and Chemistry.* Volume 15. Pages 2299-2304.

Heimbach, F. 1992. "Effects of Pesticides on Earthworm Populations: Comparison of Results from Laboratory and Field Tests." In *Ecotoxicology of Earthworms*. P.W. Greig-Smith et al. (eds). Intercept Ltd., U.K. Pages 100-106.

Kammenga, J.E., C.A.M. van Gestel, and J. Bakker. 1994. "Patterns of Sensitivity to Cadmium and Pentachlorophenol (among nematode species from different taxonomic and ecological groups)." *Archives of Environmental Contamination Toxicology.* Volume 27. Pages 88-94.

van Gestel, C.A.M., W.A. van Dis, E.M. Dirven-van Breemen, P.M. Sparenburg, and R. Baerselman. 1991. "Influence of Cadmium, Copper, and Pentachlorophenol on Growth and Sexual Development of *Eisenia andrei* (Oligochaeta; Annelida)." *Biology and Fertility of Soils.* Volume 12. Pages 117-121.

Arsenic

Fischer, E., and L. Koszorus. 1992. "Sublethal Effects, Accumulation Capacities, and Elimination Rates of As, Hg, and Se in the Manure Worm ***Eisenia fetida*** **(Oligochaeta, Lumbricidae)."** ***Pedobiologia.*** **Volume 36. Pages 172-178.**

Fischer, E., and L. Koszorus. 1992. "Sublethal Effects, Accumulation Capacities and Elimination Rates of As, Hg and Se in the Manure Worm, *Eisenia fetida* (Oligochaeta, Lumbricidae)." *Pedobiologia.* Volume 36. Pages 172-178.

Cadmium

Bengtsson, G., T. Gunnarsson, and S. Rundgren. 1986. "Effects of Metal Pollution on the Earthworm *Dendrobaena rubida* (Sav.) in Acidified Soils." *Water, Air, and Soil Pollution.* Volume 28. Pages 361-383.

Crommentuijr, T., J. Brils, and N.M. van Straaler. 1993. "Influence of Cadmium on Life-History Characteristics of *Folsomia candida* (Willem) in an Artificial Soil Substrate." *Ecotoxicology Environmental Safety.* Volume 26. Pages 216-227.

Russell, L.K., J.I. De Haven, and R.P. Botts. 1981. "Toxic effects of Cadmium on the Garden Snail (*Helix aspersa*)." *Bulletin of Environmental Contamination and Toxicology.* Volume 26. Pages 634-640.

Spurgeon, D.J., S.P. Hopkin, and D.T. Jones. 1994. "Effects of Cadmium, Copper, Lead, and Zinc on Growth, Reproduction, and Survival of the Earthworm *Eisenia fetida* (Savigny): Assessing the Environmental Impact of Point-source Metal Contamination in Terrestrial Ecosystems." *Environmental Pollution.* Volume 84. Pages 123-130.

van Gestel, C.A.M., W.A. van Dis, E.M. Dirven-van Breemen, P.M. Sparenburg, and R. Baerselman. 1991. "Influence of Cadmium, Copper, and Pentachlorophenol on Growth and Sexual development of *Eisenia andrei* (Oligochaeta; Annelida)." *Biology and Fertility of Soils.* Volume 12. Pages 117-121.

van Gestel, C.A.M., E.M. Dirven-van Breemen, and R. Baerselman. 1993. "Accumulation and Elimination of Cadmium, Chromium and Zinc and Effects on Growth and Reproduction in *Eisenia andrei* (Oligochaeta; Annelida)." *Science of the Total Environment. Supplement.* Pages 585-597.

Chromium (Hexavalent)

Abbasi, S.A. and R. Soni. 1983. "Stress-Induced Enhancement of Reproduction in Earthworm, *Octochaetus pattoni*, Exposed to Chromium (VI) and Mercury (II)—Implications in Environmental Management." *International Journal of Environmental Studies.* Volume 22. Pages 43-47.

Molnar, L., E. Fischer, and M. Kallay. 1989. "Laboratory Studies on the Effect, Uptake and Distribution of Chromium in *Eisenia foetida* (Annelida, Oligochaeta)." *Zool. Anz.* Volume 223(1/2). Pages 57-66.

Soni, R., and S.A. Abbasi. 1981. "Mortality and Reproduction inEearthworms *Pheretima posthuma* Exposed to Chromium (VI)." *International Journal of Environmental Studies*. Volume 17. Pages 147-149.

Copper

Spurgeon, D.J., S.P. Hopkin, and D.T. Jones. 1994. "Effects of Cadmium, Copper, Lead, and Zinc on Growth, Reproduction, and Survival of the Earthworm *Eisenia fetida* (Savigny): Assessing the Environmental Impact of Point Source Metal Contamination in Terrestrial Ecosystems." *Environmenal Pollution.* Volume 84. Pages 123-130.

Korthals, G. W., A. D. Alexiev, T. M. Lexmond, J. E. Kammenga, and T. Bongers. 1996. "Long-term Effects of Copper and pH on the Nematode Community in an Agroecosystem." *Environmental Toxicology and Chemistry.* Volume 15. Pages 979–985.

Ma, W.-C. 1984. "Sublethal Toxic Effects of Copper on Growth, Reproduction and Litter Breakdown Activity in the Earthworm *Lumbricus rubellus*, with Observations on the Influence of Temperature and Soil pH." *Environmental Pollution. Series A.* Volume 33. Pages 207-219.

Ma, W.-C. 1988. "Toxicity of Copper to Lumbricid Earthworms in Sandy Agricultural Soils Amended with Cu-enriched Organic Waste Materials." *Ecology Bulletin.* Volume 39. Pages 53-56.

Marigomez, J.A., E. Angulo, and V. Saez. 1986. "Feeding and Growth Responses to Copper, Zinc, Mercury, and Lead in the Terrestrial Gastropod *Arion ater* (Linne)." *Journal of Molluscan Studies.* Volume 52. Pages 68-78.

Streit, B. 1984. "Effects of High Copper Concentrations on Soil Invertebrates (Earthworms and Oribatid Mites): Experimental Results and a Model." *Oecologia.* Volume 64. Pages 381-388.

Streit, B, and A. Jaggy. 1983. "Effect of Soil Type on Copper Toxicity and Copper Uptake in *Octolasium cyaneum* (Lumbricidae)." In: *New Trends in Soil Biology.* Ph. Lebrun et al. (eds). Pages 569-575. Ottignies-Louvain-la-Neuve.

van Gestel, C.A.M., W.A. van Dis, E.M. Dirven-van Breemen, P.M. Sparenburg, and R. Baerselman. 1991. "Influence of Cadmium, Copper, and Pentachlorophenol on Growth and Sexual Development of *Eisenia andrei* (Oligochaeta; Annelida)." *Biology and Fertility of Soils.* Volume 12. Pages 117-121.

van Rhee, J.A. 1975. "Copper Contamination Effects on Earthworms by Disposal of Pig Waste in Pastures." *Progress in Soil Zoology.* Volume 1975. Pages 451-457.

Lead

Bengtsson, G., T. Gunnarsson, and S. Rundgren. 1986. "Effects of Metal Pollution on the Earthworm *Dendrobaena rubida* (Sav.) in Acidified Soils." *Water, Air, and Soil Pollution.* Volume 28. Pages 361-383.

Beyer, W.N., and A. Anderson. 1985. "Toxicity to Woodlice of Zinc and Lead Oxides Added to Soil Litter." *Ambio.* Volume 14(3). Pages 173-174.

Marigomez, J.A., E. Angulo, and V. Saez. 1986. "Feeding and Growth Responses to Copper, Zinc, Mercury, and Lead in the Terrestrial Gastropod *Arion ater* (Linne)." *Journal of Molluscan Studies.* Volume 52. Pages 68-78.

Spurgeon, D.J., S.P. Hopkin, and D.T. Jones. 1994. "Effects of Cadmium, Copper, Lead, and Zinc on Growth, Reproduction, and Survival of the Earthworm *Eisenia fetida* (Savigny): Assessing the Environmental Impact of Point-source Metal Contamination in Terrestrial Ecosystems." *Environmental Pollution.* Volume 84. Pages 123-130.

Mercuric chloride

Abbasi, S.A., and R. Soni. 1983. "Stress-induced Enhancement of Reproduction in Earthworm *Octochaetus pattoni* Exposed to Chromium (VI) and Mercury (II) - Implications in Environmental Management." *International Journal of Environmental Studies.* Volume 22. Pages 43-47.

Fischer, E., and L. Koszorus. 1992. "Sublethal Effects, Accumulation Capacities and Elimination Rates of As, Hg and Se in the Manure Worm, *Eisenia fetida* (Oligochaeta, Lumbricidae)." *Pedobiologia.* Volume 36. Pages 172-178.

Marigomez, J.A., E. Angulo, and V. Saez. 1986. "Feeding and Growth Responses to Copper, Zinc, Mercury, and Lead in the Terrestrial Gastropod *Arion ater* (Linne)." *Journal of Molluscan Studies.* Volume 52. Pages 68-78.

Methyl mercury

Beyer, W.N., E. Cromartie, and G.B. Moment. 1985. "Accumulation of Methyl Mercury in the Earthworm, *Eisenia foetida*, and its Effects on Regeneration." *Bulletin of Environmental Contamination and Toxicology*. Volume 35. Pages 157-162.

Beyer, W.N., E. Cromartie, and G.B. Moment. 1985. "Accumulation of Methylmercury in the Earthworm *Eisenia foetida*, and its Effect on Regeneration." *Bulletin of Environmental Contamination Toxicology*. Volume 35. Pages 157-162.

Nickel

Malecki, M.R., E.F. Neuhauser, and R.C. Loehr. 1982. "The Effect of Metals on the Growth and Reproduction of *Eisenia foetida* (Oligochaeta, Lumbricidae)." *Pedobiologia*. Volume 24. Pages 129-137.

Selenium

Malecki, M.R., E.F. Neuhauser, and R.C. Loehr. 1982. "The Effect of Metals on the Growth and Reproduction of *Eisenia foetida* (Oligochaeta, Lumbricidae)." *Pedobiologia*. Volume 24. Pages 129-137.

Fischer, E., and L. Koszorus. 1992. "Sublethal Effects, Accumulation Capacities and Elimination Rates of As, Hg and Se in the Manure Worm, *Eisenia fetida* (Oligochaeta, Lumbricidae)." *Pedobiologia.* Volume 36. Pages 172-178.

Zinc

Beyer, W.N., and A. Anderson. 1985. "Toxicity to Woodlice of Zinc and Lead Oxides Added to Soil Litter." *Ambio.* Volume 14. Pages 173-174.

Beyer, W.N., G.W. Miller, and E.J. Cromartie. 1984. "Contamination of the O_2 Soil Horizon by Zinc Smelting and its Effect on Woodlouse Survival." *Journal of Environmental Quality*. Volume 13. Pages 247-251.

Marigomez, J.A., E. Angulo, and V. Saez. 1986. "Feeding and Growth Responses to Copper, Zinc, Mercury, and Lead in the Terrestrial Gastropod *Arion ater* (Linne)." *Journal of Molluscan Studies*. Volume 52. Pages 68-78.

Spurgeon, D.J., S.P. Hopkin, and D.T. Jones. 1994. "Effects of Cadmium, Copper, Lead, and Zinc on Growth, Reproduction, and Survival of the Earthworm *Eisenia fetida* (Savigny): Assessing the Environmental Impact of Point Source Metal Contamination in Terrestrial Ecosystems." *Environmental Pollution*. Volume 84. Pages 123-130.

van Gestel, C.A.M., E.M. Dirven-van Breemen, and R. Baerselman. 1993. "Accumulation and Elimination of Cadmium, Chromium and Zinc and Effects on Growth and Reproduction in *Eisenia andrei* (Oligochaeta; Annelida)." *Science of the Total Environment* (Supplement*.)*. Pages 585-597.

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

(Page 1 of 15)

Compound	Basis for Toxicity Reference Value (TRV)				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]		
Polychlorinateddibenzo-p-dioxins (µg/kg BW-day)						
2,3,7,8-TCDD	Chronic (multigenerational) NOAEL for reproduction	Rat	0.001	Not applicable	0.001	Murray et al. (1979). TRV based on toxicity of 2,3,7,8-TCDD.
Polynuclear aromatic hydrocarbons (PAH) (µg/kg BW-day)						
Total high molecular weight (HMW) PAH	--	--	--	--	100	TRV based on benzo(a)pyrene toxicity. This TRV should be assessing the risk of Total HMW PAH.
Benzo(a)pyrene	Acute (10 days) LOAEL (reproductive effects)	Mouse	10,000	0.01	100	Mackenzie and Angevine (1981)
Benzo(a)anthracene	Single dose LOAEL (gastrointestinal effects)	Mouse	16,666	0.01	167	Bock and King (1959)
Benzo(b)fluoranthene	--	--	--	--	--	Toxicity value not available.
Benzo(k)fluoranthene	--	--	--	--	--	Toxicity value not available.
Chrysene	--	--	--	--	--	Toxicity value not available.
Dibenz(a,h)anthracene	Subchronic (15 days) LOAEL (reduced growth rate)	Rat	200	0.01[e]	2	Haddow et al. (1937)
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	Toxicity value not available.

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

Compound	Basis for Toxicity Reference Value (TRV): Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]	TRV	Reference and Notes [d]
Polychlorinated biphenyls (PCB) (μg/kg BW-day)						
Aroclor 1016	Subchronic (14.5 weeks) LOAEL (mortality)	Mink	20.6	0.01	0.206	Aulerich et al. (1985). TRV based on toxicity of 3,4,5-hexachlorobiphenyl.
Aroclor 1254	Subchronic (14.5 weeks) LOAEL (mortality)	Mink	20.6	0.01	0.206	Aulerich et al. (1985). TRV based on toxicity of 3,4,5-hexachlorobiphenyl.
Nitroaromatics (μg/kg BW-day)						
1,3-Dinitrobenzene	Chronic (16 weeks) NOAEL	Rat	1,051	1.0	1,051	Cody et al. (1981)
2,4-Dinitrotoluene	Chronic (24 months) NOAEL	Dog	700	1.0	700	Ellis et al. (1979)
2,6-Dinitrotoluene	Single dose LOAEL (mortality)	Dog	4,000	0.01	400	Lee et al. (1976)
Nitrobenzene	--	--	--	--	--	Toxicity value not available.
Pentachloronitrobenzene	Chronic (2 years) NOAEL	Mouse	458,333	1.0	458,333	National Toxicology Program (1987)
Phthalate esters (μg/kg BW-day)						
Bis(2-ethylhexyl)phthalate	Chronic (2 years) NOAEL	Rat	60,000	1.0	60,000	Carpenter et al. (1953)
Di(n)octyl phthalate	Chronic (105 days) NOAEL	Mouse	7,500,000	1.0	7,500,000	Heindel et al. (1989)
Volatile organic compounds (μg/kg BW-day)						
Acetone	Subchronic (90 days) NOAEL	Albino Rat, male	100,000	0.1	10,000	U.S. EPA (1986)
Acrylonitrile	Chronic (2 years) LOAEL (lesions and other organ effects)	Rat	4,600	0.1	460	Quast et al. (1980)
Chloroform	Chronic (80 weeks) NOAEL	Mouse	60,000	1.0	60,000	Roe et al. (1979)

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

Compound	Basis for Toxicity Reference Value (TRV)				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]		
Crotonaldehyde	Acute (4-hour) LD50	Rat	8,000	0.01	80	Rinehart (1967)
1,4-Dioxane	Chronic (23 months) LOAEL (lung tumors)	Guinea Pig	1,069,767	0.1	106,777	Hoch-Ligeti and Argus (1970)
Formaldehyde	Acute (single dose) LOAEL (mortality)	Rat	230,000	0.01	2,300	Tsuchiya et al. (1975)
Vinyl chloride	Chronic (2 years) NOAEL	Rat	1,700	0.1	170	Feron et al. (1981)
Other chlorinated organics (μg/kg BW-day)						
Hexachlorobenzene	Chronic (>247 days) NOAEL	Rat	1,600	1.0	1,600	Grant et al. (1977)
Hexachlorobutadiene	Chronic (2 years) NOAEL	Rat	200	1.0	200	Kociba et al. (1977)
Hexachlorocyclopentadiene	Subchronic (13 weeks) NOAEL	Rat	38,000	0.1	3,800	Abdo et al. (1984)
Pentachlorobenzene	Chronic (180 days) NOAEL	Rat	7,250	1.0	7,250	Linder et al. (1980)
Pentachlorophenol	Subchronic (62 days) NOAEL	Rat	3,000	0.1	300	Schwetz et al. (1978)
Pesticides (μg/kg BW-day)						
4,4'-DDE	Subchronic (5 weeks) NOAEL	Rat	10,000	0.1	1,000	Kornburst et al. (1986)
Heptachlor	Subchronic (60 days) LOAEL (mortality)	Rat	250	0.01	2.5	Green (1970)
Hexachlorophene	Acute LD50	Rat	560,000	0.01	5600	Meister (1994)
Inorganics (mg/kg BW-day)						
Aluminum	Chronic (>1 year) LOAEL (growth)	Rat	19.3	0.1	1.93	Ondreicka et al. (1966)

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

Compound	Basis for Toxicity Reference Value (TRV)				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]		
Antimony	Chronic (4 years) LOAEL (mortality)	Rat	0.66	0.1	0.066	Schroeder et al. (1970)
Arsenic	Chronic (2 years) NOAEL	Dog	1.25	1.0	1.25	Byron et al. (1967)
Barium	Chronic (16 months) NOAEL	Rat	0.51	1.0	0.51	Perry et al. (1983)
Beryllium	Chronic (>1 year) NOAEL	Rat	0.66	1.0	0.66	Schroeder and Mitchner (1975)
Cadmium	Chronic (>150 days) LOAEL (reproduction)	Mouse	2.52	0.01	0.0252	Schroeder and Mitchner (1971)
Chromium (hexavalent)	Chronic (1 year) NOAEL	Rat	3.5	1.0	3.5	MacKenzie et al. (1958)
Copper	Chronic (357 days) NOAEL	Mink	12.0	1.0	12.0	Aulerich et al. (1982)
Total Cyanide	Chronic (2 years) NOAEL	Rat	24	1.0	24	Howard and Hanzal (1955)
Lead	Chronic (>150 days) LOAEL (mortality)	Mouse	3.75	0.01	0.0375	Schroeder and Mitchner (1971)
Mercuric chloride	Chronic (6 months) NOAEL (reproduction)	Mink	1.01	1.0	1.01	Aulerich et al. (1974)
Methyl mercury	Subchronic (93 days) NOAEL	Rat	0.032	1.0	0.032	Verschuuren et al. (1976)
Nickel	Chronic (2 years) NOAEL	Rat	50	1.0	50	Ambrose et al. (1976)
Selenium	Chronic (>150 days) LOAEL (mortality)	Mouse	0.76	0.1	0.076	Schroeder and Mitchner (1971)
Silver	Chronic (125 days) LOAEL (hypoactivity)	Mouse	3.75	0.1	0.375	Rungby and Danscher (1984)

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

Compound	Basis for Toxicity Reference Value (TRV)				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose [b]	Uncertainty Factor [c]		
Thallium	Subchronic (60 days) LOAEL (testicular function)	Rat	1.31	0.01[h]	0.0131	Formigli et al. (1986)
Zinc	Subchronic (13 weeks) NOAEL	Mouse	104	0.1	10.4	Maita et al. (1981)

Notes:

a The duration of exposure is defined as chronic if it represents about 10 percent or more of the test animal's lifetime expectancy. Acute exposures represent single exposure or multiple exposures occurring within about two weeks or less. Subchronic exposures are defined as multiple exposures occurring for less than 10 percent of the test animal's lifetime expectancy but more that 2 weeks.

b Reported values, which were dose in food or diet, were converted to dose based on body weight and intake rate using Opresko, Sample, and Suter 1996.

c Uncertainty factors are used to extrapolate a toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) for a discussion on the use of uncertainty factors. The TRV was calculated by multiplying the toxicity value by the uncertainty factor.

d The references refer to the study or studies from which the endpoint and doses were identified. Complete reference citations are provided at the end of this table.

e Best scientific judgement used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion of the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, experimental design, and availability of toxicity data.

HMW = High molecular weight
LD50 = Lethal dose to 50 percent of the test organisms.
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
TRV = Toxicity Reference Value

REFERENCES

Sample, Opresko, and Suter II (1996) provides a comprehensive review of ecologically-relevant mammal toxicity information. This source was reviewed to identify studies to develop TRVs for mammals. Based on the information presented, one or more references were obtained and reviewed to identify compound-specific toxicity values. For some compounds, the available information identified a single study meeting the requirements for a TRV, as discussed in Section 5.4. In most cases, each reference was obtained and reviewed to identify a single toxicity value to develop a TRV for each compound. In a few cases where a primary study could not be obtained, a toxicity value is based on a secondary source. As noted below, additional compendia were reviewed to identify toxicity studies to review. For compounds not discussed in Sample, Opresko, and Suter II (1996), the scientific literature was searched, and relevant studies were obtained and reviewed. The references reviewed are listed below. The study selected for the TRV is highlighted in bold.

Polychlorinated dibenzo(p)dioxins

Murray, F.J., F.A. Smith, K.D. Nitschke, C.G. Humiston, R.J. Kociba, and B.A.Schwetz. 1979. "Three-Generation Reproduction Study of Rats Given 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) in the Diet." ***Toxicology and Applied Pharmacology.*** **Volume 50. Pages 241-252.**

U.S. EPA. 1993. *Interim Report on Data and Methods for Assessment of 2,3,7,8-Tetrachlorodibenzop-dioxin Risks to Aquatic Life and Associated Wildlife.* EPA/600/R-93/055. Office of Research and Development. Washington, D.C. March. This report identified the four studies listed below.

Aulerich, R.J., R.K. Ringer, and S. Iwamoto. 1973. "Reproductive Failure and Mortality in Mink Fed on Great Lakes Fish." *Journal of Reproduction and Fertility*. Volume 19. Pages 365-376.

Aulerich, R.J., S.J. Bursian, and A.C. Napolitano. 1988. "Biological Effects of Epidermal Growth Factor and 2,3,7,8-Tetrachlorodibenzo-p-dioxin on Developmental Parameters of Neonatal Mink." *Archives of Environmental Contamination and Toxicology*. Volume 17. Pages 27-31.

Aulerich, R.J., S.J. Bursian, W.J. Breslin, B.A. Olson, and R.K. Ringer. 1985. "Toxicological Manifestations of 2,4,5,2',4',5'-, 2,3,6,2',3',6'-, and 3,4,5,3',4',5'-Hexachlorobiphenyl and Aroclor 1254 in Mink." Journal of Toxicology and Environmental Health. Volume 15. Pages 63-79.

Hochstein, J.R., R.J. Aulerich, and S.J. Bursain. 1988. "Acute Toxicity of 2,3,7,8-Tetrachlorodibenzo-p-dioxin to Mink." *Archives of Environmental Contamination and Toxicology*. Volume 17. Pages 33-37.

Benzo(a)pyrene

MacKenzie, K.M., and D.M. Angevine. 1981. "Infertility in Mice Exposed in Utero to Benzo(a)pyrene." ***Biology of Reproduction.*** **Volume 24. Pages 183-191.**

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

(Page 7 of 15)

Benzo(a)anthracene

Bock, F.G. and D.W. King. 1959. "A Study of the Sensitivity of the Mouse Forestomach Toward Certain Polycyclic Hydrocarbons." ***Journal of the National Cancer Institute.*** **Volume 23. Page 833-839.**

Dibenz(a,h)anthracene

Haddow, A., C.M. Scott, and J.D. Scott. 1937. "The Influence of Certain Carcinogenic and Other Hydrocarbons on Body Growth in the Rat." ***Proceeding R. Soc. London. Series B.*** **Volume 122. Pages 477-507. As cited in IARC Monographs, 1983.**

Polychlorinated biphenyls

Aulerich, R.J., S.J. Bursian, W.J. Breslin, B.A. Olson, and R.K. Ringer. 1985. "Toxicological Manifestations of 2,4,5-, 2',4',5'-, 2,3,6-, 2',3',6'- and 3,4,5-, 3',4',5'- Hexachlorobiphenyl and Aroclor 1254 in Mink." ***Journal of Toxicology and Environmental Health.*** **Volume 15. Pages 63-79.**

Aulerich, R. J. and R. K. Ringer. 1977. "Current Status of PCB Toxicity, Including Reproduction in Mink." *Archives of Environmental Containation and Toxicology*. Volume 6. Page 279.

ATSDR (Agency for Toxic Substances and Disease Registry). 1989. *Toxicological profile for Selected PCBs (Aroclor-1260, -1254, -1248, -1242, -1232, -1221, and -1016)*. ATSDR/TP-88/21.

Barsotti, D. A., R. J. Marlar and J. R. Allen. 1976. "Reproductive Dysfunction in Rhesus Monkeys Exposed to Low Llevels of Polychlorinated Biphenyls (Aroclor 1248)." *Food and Cosmetics Toxicology*. Volume 14. Pages 99-103.

Bleavins, M. R., R. J. Aulerich, and R. K. Ringer. 1980. "Polychlorinated Biphenyls (Aroclors 1016 and 1242): Effect on Survival and Reproduction in Mink and Ferrets." *Archives of Environmental Contamination and Toxicology* Volume 9. Pages 627-635.

Collins, W. T., and C. C. Capen. 1980. "Fine structural lesions and hormonal alterations in thyroid glands of perinatal rats exposed in utero and by milk to polychlorinated biphenyls." *American Journal of Pathology*. Volume 99. Pages 125-142.

Linder, R. E., T. B. Gaines, and R. D. Kimbrough. 1974. "The effect of PCB on rat reproduction." *Food and Cosmetics Toxicology*. Volume 63. Pages 63- 67.

Linzey, A. V. 1987. "Effects of chronic polychlorinated biphenyls exposure on reproductive success of white-footed mice (*Peromyscus leucopus*)." *Archives of Environmental Contamination and Toxicology*. Volume 16. Pages 455-460.

McCoy, G, M. F. Finlay, A. Rhone, K. James, and G. P. Cobb. 1995. "Chronic Polychlorinated Biphenyls Exposure on Three Generations of Oldfield Mice (*Permyscus polionotus*): Effects on Reproduction, Growth, and Body Residues. Archives of. *Environmental Contamination and Toxicology*. Volume 28. Pages 431-435.

Merson, M. H., and R. L. Kirkpatrick. 1976. "Reproductive Performance of Captive White-Footed Mice Fed a Polychlorinated Biphenyl." *Bulletin of Environmental Contamination and Toxicology*. Volume 16. Pages 392-398.

Ringer, R. K., R. J. Aulerich, and M. R. Bleavins. 1981. "Biological Effects of PCBs and PBBs on Mink and Ferrets: a Review." In:*Halogenated Hydrocarbons: Health and Ecological Effects*. M.A.Q. Khan, ed. Permagon Press, Elmsford, NY. Pages 329-343.

Sanders, O.T., and R.L. Kirkpatrick. 1975. "Effects of a Polychlorinated Biphenyl on Sleeping Times, Plasma Corticosteroids, and Testicular Activity of White-Footed Mice." *Environmental Physiology and Biochemistry*. Volume 5. Pages 308-313.

Villeneuve, D.C., D.L. Grant, K. Khera, D.J. Klegg, H. Baer, and W.E.J. Phillips. 1971. "The Fetotoxicity of a Polychlorinated Biphenyl Mixture (Aroclor 1254) in the Rabbit and in the Rat." *Environmental Physiology*. Volume 1. Pages 67-71.

1,3-Dinitrobenzene

Cody, T.E., S. Witherup, L. Hastings, K. Stemmer, and R.T. Christian. 1981. "1,3-Dinitrobenzene: Toxic Effects in Vivo and in Vitro." ***Journal of Toxicology and Environmental Health*****. Volume 7. Pages 829-847.**

2,4-Dinitrotoluene

Ellis, H.V.III, J.H. Hagensen, J.R. Hodgson, J.L. Minor, C-B. Hong, E.R. Ellis, J.D. Girvin, D.O. Helton, B.L. Herndon, and C-C. Lee. 1979. "Mammalian Toxicity of Munitions Compounds. Phase III: Effects of Lifetime Exposure. Part I: 2,4-Dinitrotoluene." Final Report No. 7. Midwest Research Institute. Kansas City, Missouri. Contract No. DAMD 17-74-C-4073, ODC No. ADA077692.

2,6-Dinitrotoluene

Lee, C.C., H.V. Ellis III, J.J. Kowalski, J.R. Hodgsen, R.D. Short, J.C. Bhandari, T.W. Reddig, and J.L. Minor. 1976. "Mammalian Toxicity of Munitions Compounds. Phase II: Effects of Multiple Doses. Part III: 2,6-Dinitrotoluene. Progress Report No. 4." Midwest Research Institute. Project No. 3900-B. Contract No. DAMD-17-74-C-4073. As cited in ATSDR Toxicological Profile for 2,4- Dinitrotoluene and 2,6-Dinitrotoluene. December 1989.

Pentachloronitrobenzene

National Toxicology Program. 1987. "Toxicology and Carcinogenesis Studies of Pentachloronitrobenzene in $B6C3F_1$ Mice." Report No. 325. National Institutes of Health Publication No. 87-2581.

Bis(2)ethylhexylphthalate

Carpenter, C.P., C.S. Weil, H.F. Smyth, Jr. 1953. "Chronic Oral Toxicity of Di(2-ethylhexyl)phthalate for Rats, Guinea Pigs, and Dogs." Drinker, P. (ed.). *Archives of Industrial Hygeine and Occupational Medicine*. Volume 8. Pages 219-226.

Lamb, J. C., IV, R. E. Chapin, J. Teague, A. D. Lawton, and J. R. Reel. 1987. Reproductive effects of four phthalic acid esters in the mouse.*Toxicol. Appl. Pharmacol.* 88: 255-269.

Di(n)octyl phthalate

Heindel, J.J., D.K. Gulati, R.C. Mounce, S.R. Russell, and J.C. Lamb IV. 1989. "Reproductive Toxicity of Three Phthalic Acid Esters in a Continuous Breeding Protocol." *Fundamental and Applied Toxicol*ogy. Volume 12. Pages 508-18.

Acetone

U.S. EPA. 1986. "Ninety-Day Gavage Study in Albino Rats Using Acetone." Office of Solid Waste. Washington, DC. As cited in IRIS Database. January 1995.

Acrylonitrile

Quast J.F. and others. 1980. A Two-Year Toxicity and Oncogenicity Study With Acrylonitrile Incorporated in the Drinking Water of Rats. Toxicol. Res. Lab., Health Environ. Res., Dow Chemical Co. As cited in EPA (1980) *Ambient Water Quality Criteria for Acrylonitrile*.

Chloroform

Roe, F.J.C., A.K. Palmer, A.N. Worden, and N.J. Van Abbe. 1979. "Safety Evaluation of Toothpaste Containing Chloroform. 1. Long-Term Studies in Mice." *Journal of Environmental Pathology and Toxicology*. Volume 2. Pages 799-819.

Crotonaldehyde

Rinehart, W.E. 1967. "The Effect on Rats of Single Exposures to Crotonaldehyde Vapor." ***American Industrial Hygiene Association Journal.*** **Volume 28. Pages 561-566.**

1,4-Dioxane

Hoch-Ligeti, C. and M.F. Argus. 1970. "Effects of Carcinogens on the Lung of Guinea Pigs." In: Proceedings of Biology Division, Oak Ridge National Laboratory, Conference. ***Morphology of Experimental Respiratory Carcinogenesis.*** **(Eds) P. Nettesheir, M.G. Hanna, Jr., and J.W. Deatherase, Jr. U.S. Atomic Energy Commission. December.**

Formaldehyde

Tsuchiya, K., Y. Hayashi, M. Onodera, and T. Hasegawa. 1975. "Toxicity of Formaldehyde in Experimental Animals - Concentrations of the Chemical in the Elution from Dishes of Formaldehyde Resin in Some Vegetables." ***Keio Journal of Medicine.*** **Volume 24. Page 19-37.**

Hurni, H. and H. Ohder. 1973. Reproduction study with formaldehyde and hexamethylenetetramine in Beagle dogs. *Fd. Cosmet. Toxicol.* 11: 459-462.

Vinyl chloride

Feron, V.J., C.F.M. Hendriksen, A.J. Speek, H.P. Til, and B.J. Spit. 1981. "Lifespan Oral Toxicity Study of Vinyl Chloride in Rats." ***Fd. Cosmet. Toxicol.*** **Volume 19. Pages 317-333.**

Quast, J. F., C. G. Humiston, C. E. Wade, et al. 1983. A chronic toxicity and oncogenicity study in rats and subchronic toxicity in dogs on ingested vinylidene chloride. *Fund. Appl. Toxicol.* 3: 55-62.

Hexachlorobenzene

Grant, D.L., W.E.J. Phillips, G.V. Hatina. 1977. "Effect of Hexachlorobenzene on Reproduction in the Rat." ***Archives of Environmental Contamination and Toxicology.*** **Volume 5. Pages 207-216.**

Bleavins, M. R., R. J. Aulerich, and R. K. Ringer. 1984. Effects of chronic dietary hexachlorobenzene exposure on the reproductive performance and survivability of mink and European ferrets. *Arch. Environ. Contam. Toxicol.* 13: 357-365.

Hexachlorbutadiene

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

Kociba, R.J., Keyes, D.G., Jersey, G.C., Ballard, J.J., Dittenber, D.A., Quast, J.F., Wade, C.E., Humiston, C.G., and Schwetz, B.A. 1977. Results of a Two Year Chronic Toxicity Study With Hexachlorobutadiene in Rats." *American Industrial Hygiene Association Journal.* Volume 38. Pages 589-602.

Hexachlorocyclopentadiene

Abdo, K.M., C.A. Montgomery, W.M. Kluwe, D.R. Farnell, and J.D. Prejean. 1984. "Toxicity of Hexachlorocyclopentadiene: Subchronic (13-Week) Administration by Gavage to F344 Rats and B6C3F$_1$ Mice." *Journal of Applied Toxicology.* Volume 4. Pages 75-81.

Pentachlorobenzene

Linder, R., T. Scotti, J. Goldstein, and K. McElroy. 1980. "Acute and Subchronic Toxicity of Pentachlorobenzene." *Journal of Environmental Pathology and Toxicology.* Volume 4. Pages 183-196.

Pentachlorophenol

Schwetz, B.A., J.F. Quast, P.A. Keeler, C.G. Humiston, and R.J. Kociba. 1978. "Results of Two-Year Toxicity and Reproduction Studies on Pentachlorophenol in Rats." In: *Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology.* Rao, K.R. (ed). Pages 301-309. Plenum Press, New York.

4,4'-DDE

Kornbrust, D., B. Gillis, B. Collins, T. Goehl, B. Gupta, and B. Schwetz. 1986. "Effects of 1,1-Dichloro-2,2-bis(p-chlorophenyl)ethylene (DDE) on Lactation in Rats." *Journal of Toxicology and Environmental Health.* Volume 17. Pages 23-36.

Heptachlor

Green, V.A. 1970. "Effects of Pesticides on Rat and Chick Embryo." *Proceedings of the 3rd Annual Conference on Trace Substances in Environmental Health.* University of Missouri Press. Columbia, Missouri.

Crum, J. A., S. J. Bursian, R. J. Aulerich, P. Polin, and W. E. Braselton. 1993. The reproductive effects of dietary heptachlor in mink (*Mustela vison*). *Arch. Environ. Contam. Toxicol.* 24: 156-164.

Hexachlorophene

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

Meister, R.J. (ed.) 1994. *Farm Chemicals Handbook '94.* Meister Publishing Company, Willoughby, Ohio. Volume 80. Page C189.

Aluminum

Schroeder, H.A., and M. Mitchener. 1975. "Life-Term Studies in Rats: Effects of Aluminum, Barium, Beryllium, and Tungsten." *Journal of Nutrition.* Volume 105. Pages 421-427.

Ondreicka, R., E. Ginter, and J. Kortus. 1966. Chronic toxicity of aluminum in rats and mice and its effects on phosphorus metabolism. *Brit. J. Indust. Med.* 23: 305-313.

Antimony

Schroeder, H.A., M. Mitchner, and A.P. Nasor. 1970. "Zirconium, Niobium, Antimony, Vanadium and Lead in Rats: Life Term Studies." *Journal of Nutrition.* Volume 100. Pages 59-68.

Arsenic (trivalent)

Byron, W.R., G.W. Bierbower, J.B. Brouwer, and W.H. Hansen. 1967. "Pathological Changes in Rats and Dogs from Two-Year Feeding of Sodium Arsenite or Sodium Arsenate." *Toxicology and Applied Pharmacology.* Volume 10. Pages 132-147.

Baxley, M. N., R. D. Hood, G. C. Vedel, W. P. Harrison, and G. M. Szczech. 1981. Prenatal toxicity of orally administered sodium arsenite in mice. *Bull. Environ. Contam. Toxicol.* 26: 749-756.

Blakely, B. R., C. S. Sisodia, and T. K. Mukkur. 1980. The effect of methyl mercury, tetrethyl lead, and sodium arsenite on the humoral immune response in mice. *Toxicol. Appl. Pharmacol.* 52: 245-254.

Harrison, J. W., E. W. Packman, and D.D. Abbott. 1958. Acute oral toxicity and chemical and physical properties of arsenic trioxides. *Arch. Ind. Health.* 17: 118-123.

Neiger, R. D. and G. D. Osweiler. 1989. Effect of subacute low level dietary sodium arsenite on dogs. *Fund. Appl. Toxicol.* 13: 439-451.

Robertson, I.D., W. E. Harms, and P. J. Ketterer. 1984. Accidental arsenical toxicity to cattle. *Aust. Vet. J.* 61: 366-367.

Schroeder, H. A. and J. J. Balassa. 1967. Arsenic, germanium, tin, and vanadium in mice: effects on growth, survival and tissue levels. *J. Nutr.* 92: 245-252.

Schroeder, H. A., M. Kanisawa, D. V. Frost, and M. Mitchener. 1968a. Germanium, tin, and arsenic in rats: effects on growth, survival and tissue levels. *J. Nutr.* 96: 37-45.

Barium

Perry, H.M.Jr., S.J. Kopp, M.W. Erlanger, and E.F. Perry. 1983. "Cardiovascular Effects of Chronic Barium Ingestion." ***Proceedings of the 17th Annual Conference on Trace Substances in Environmental Health.*** **University of Missouri Press. Columbia, Missouri.**

Borzelleca, J. F., L. W. Condie, Jr., and J. L. Egle, Jr. 1988. Short-term toxicity (one-and ten-day gavage) of barium chloride in male and female rats. *J. American College of Toxicology*. 7: 675-685.

Beryllium

Schroeder, H.A., and M. Mitchener. 1975. "Life-Term Studies in Rats: Effects of Aluminum, Barium, Beryllium, and Tungsten." ***Journal of Nutrition.*** **Volume 105. Pages 421-427.**

Cadmium

Schroeder, H.A., and M. Mitchner. 1971. "Toxic Effects of Trace Elements on Reproduction of Mice and Rats." ***Archives of Environmental Health.*** **Volume 23. Pages 102-106.**

Baranski, B., I. Stetkiewisc, K. Sitarek, and W. Szymczak. 1983. "Effects of Oral, Subchronic Cadmium Administration on Fertility, Prenatal and Postnatal Progeny Development in Rats." *Archives of Toxicology*. Volume 54. Pages 297 through 302.

Machemer, L., and D. Lorke. 1981. "Embryotoxic Effect of Cadmium on Rats Upon Oral Administration." *Toxicology and Applied Pharmacology*. Volume 58. Pages 438–443.

Sutou, S., K. Yamamoto, H. Sendota, K. Tomomatsu, Y. Shimizu, and M. Sugiyama. 1980a. "Toxicity, Fertility, Teratogenicity, and Dominant Lethal Tests in Rats Administered Cadmium Subchronically. I. Toxicity studies." *Ecotoxicology and Environmental Safety*. Volume 4. Pages 39–50.

Sutou, S., K. Yamamoto, H. Sendota, and M. Sugiyama. 1980b. "Toxicity, Fertility, Teratogenicity, and Dominant Lethal Tests in Rats Administered Cadmium Subchronically. II. Fertility, Teratogenicity, and Dominant Lethal Tests." *Ecotoxicology and Environmental Safety*. Volume 4. Page 51–56.

Webster, W. S. 1978. Cadmium-induced fetal growth retardation in the mouse. *Arch. Environ. Health*. 33:36–43.

Wills, J. H., G. E. Groblewski, and F. Coulston. 1981. Chronic and multigeneration toxicities of small concentrations of cadmium in the diet rats. *Ecotoxicol. Environ. Safety* 5: 452-464.

Chromium

TABLE E-7

MAMMAL TOXICITY REFERENCE VALUES

MacKenzie, R.D., R.U. Byerrum, C.F. Decker, C.A. Hoppert, and R.F. Langham. 1958. "Chronic Toxicity Studies: II. Hexavalent and Trivalent Chromium Administered in Drinking Water to Rats." *American Medical Association Archives of Industrial Health.* Volume 18. Pages 232-234.

Copper

Aulerich, R.J., R.K. Ringer, M.R. Bleavins, and A. Napolitano. 1982. "Effects of Supplemental Dietary Copper on Growth, Reproductive Performance and Kit Survival of Standard Dark Mink and the Acute Toxicity of Copper to Mink." *Journal of Animal Science.* Volume 55. Pages 337-343.

Cyanide

Howard, J.W., and R.F. Hanzal. 1955. "Chronic Toxicity for Rats of Food Treated with Hydrogen Cyanide." *Journal of Agricultural and Food Chemistry.* Volume 3. Pages 325-329.

Tewe, O. O. and J. H. Maner. 1981. Long-term and carry-over effect of dietary inorganic cyanide (KCN) in the life cycle performance and metabolism of rats. *Toxicol. Appl. Pharmacol.* 58: 1-7.

Lead

Schroeder, H.A., M. Mitchner, and A.P. Nasor. 1970. "Zirconium, Niobium, Antimony, Vanadium and Lead in Rats: Life Term Studies." *Journal of Nutrition.* Volume 100. Pages 59-68.

Schroeder, H.A., and M. Mitchner. 1971. "Toxic Effects of Trace Elements on Reproduction of Mice and Rats." *Archives of Environmental Health.* Volume 23. Pages 102-106.

Mercuric chloride

Aulerich, R.J., R.K. Ringer, and S. Iwamoto. 1974. "Effects of Dietary Mercury on Mink." *Archives of Environmental Contamination and Toxicology.* Volume 2. Pages 43-51. As cited in Sample, Opresko, and Suter (1996).

Sample, B.E., D.M. Opresko, G.W. Suter II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* Risk Assessment Program Health Sciences Research Division, Oak Ridge, Tennessee. Prepared for U.S. Department of Energy.

Methyl mercury

Verschuuren, H.G., R. Kroes, E.M. den Tonkelaar, J.M. Berkvens, P.W. Helleman, A.G. Rauws, P.L. Schuller, and G.J. van Esch. 1976. "Toxicity of Methyl Mercury Chloride in Rats. II. Reproduction Study." *Toxicology.* Volume 6. Pages 97-106.

Blakely, B. R., C. S. Sisodia, and T. K. Mukkur. 1980. The effect of methyl mercury, tetrethyl lead, and sodium arsenite on the humoral immune response in mice. *Toxicol. Appl. Pharmacol.* 52: 245-254.

Nobunga, T., H. Satoh, and T. Suzuki. 1979. Effects of sodium selenite on methyl mercury embryotoxicity and teratogenicity in mice. *Toxicol. Appl. Pharmacol.* 47:79–88.

Nickel

Ambrose, A.M., P.S. Larson, J.F. Borzelleca, and G.R. Hennigar, Jr. 1976. "Long Term Toxicologic Assessment of Nickel in Rats and Dogs." *Journal of Food Science and Technology.* Volume 13. Pages 181-187.

Selenium

Schroeder, H.A., and M. Mitchner. 1971. "Toxic Effects of Trace Elements on Reproduction of Mice and Rats." *Archives of Environmental Health.* Volume 23. Pages 102-106.

Chiachun, T., C. Hong, and R. Haifun. 1991. The effects of selenium on gestation, fertility, and offspring in mice. *Biol. Trace Elements Res.* 30: 227–231.

Rosenfeld, I. and O. A. Beath. 1954. Effect of selenium on reproduction in rats. *Proc. Soc. Exp. Biol. Med.* 87: 295–297.

Silver

Rungby, J., and G. Danscher. 1984. "Hypoactivity in Silver Exposed Mice." *Acta. Pharmacol. et Toxicol.* Volume 55. Pages 398-401. As cited in ATSDR Toxicological Profile for Silver. December 1990.

Thallium

Formigli, L., R. Scelsi, P. Poggi, C. Gregotti, A. Di Nucci, E. Sabbioni, L. Gottardi, and L. Manzo. 1986. "Thallium-Induced Testicular Toxicity in the Rat." *Environmental Research.* Volume 40. Pages 531-539.

Zinc

TABLE E-8

BIRD TOXICITY REFERENCE VALUES

(Page 1 of 13)

Maita, K., M. Hirano, K. Mitsumori, K. Takahashi, and Y. Shirasu. 1981. "Subacute Toxicity Studies with Zinc Sulfate in Mice and Rats." ***Journal of Pesticide Science.*** **Volume 6. Pages 327- 336.**

Gasaway, W. C. and I. O. Buss. 1972. Zinc toxicity in the mallard. *J. Wildl. Manage*. 36: 1107-1117.

Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Polychlorinateddibenzo(p)dioxins (µg/kg BW-day)						
2,3,7,8-TCDD	Subchronic (10 weeks) NOAEL	Ring-necked pheasant hen	0.01	Not applicable	0.01	Nosek et al. (1992). TRV based on toxicity of 2,3,7,8-TCDD.
Polynuclear aromatic hydrocarbons (PAH) (µg/kg BW-day)						
Total high molecular weight (HMW) PAH	--	--	--	--	0.14	TRV based on toxicity of benzo(k)fluoranthene. If TRVs are not available for all individual HMW PAHs, this TRV should be used to assess potential risk of Total HMW PAH.
Benzo(a)pyrene	Acute NOAEL	Chicken embryo	100	0.01	1.0	Brunström et al. (1991).
Benzo(a)anthracene	Acute LD50	Chicken embryo	79	0.01	0.79	Brunström et al. (1991).
Benzo(b)fluoranthene	--	--	--	--	0.14	No toxicity data available for benzo(b) fluoranthene. Benzo(k)fluoranthene used as surrogate.
Benzo(k)fluoranthene	Acute LD50	Chicken embryo	14	0.01	0.14	Brunström et al. (1991).
Chrysene	Acute LOAEL	Chicken embryo	100	0.01	1.0	Brunström et al. (1991).
Dibenz(a,h)anthracene	Acute LD50	Chicken embryo	39	0.01	0.39	Brunström et al. (1991).

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BIRD TOXICITY REFERENCE VALUES

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Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Indeno(1,2,3-cd)pyrene	Acute LOAEL	Chicken embryo	100	0.01	1.0	Brunström et al. (1991).
Polychlorinated biphenyls (PCB) (μg/kg BW-day)						
Aroclor 1016	--	--	--	--	--	No toxicity data available. Aroclor 1254 TRV used as surrogate.
Aroclor 1254	Chronic (3 months) LOAEL (embryonic mortality)	Ring dove	720	0.1	72	Peakall et al. (1972). TRV based on toxicity of Aroclor 1254.
Nitroaromatics (μg/kg BW-day)						
1,3-Dinitrobenzene	Acute LD50	Redwing blackbird	42.2	0.01	0.422	Schafer (1972)
2,4-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
2,6-Dinitrotoluene	--	--	--	--	--	Toxicity value not available.
Nitrobenzene	--	--	--	--	--	Toxicity value not available.
Pentachloronitrobenzene	Chronic (35 weeks) NOAEL	Chicken	68,750	Not applicable	68,750	Dunn et al. (1979)
Phthalate esters (μg/kg BW-day)						
Bis(2-ethylhexyl)phthalate	Subchronic (4 weeks) NOAEL	Ring dove	1,110	0.1	111	Peakall (1974)
Di(n)octyl phthalate	--	--	--	--	--	Toxicity value not available.
Volatile organic compounds (μg/kg BW-day)						

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Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Acetone	Acute (5 days) NOAEL	Coturnix quail	5,200,000	0.01[h]	52,000	Hill and Camardese (1986)
Acrylonitrile	--	--	--	--	--	Toxicity value not available.
Chloroform	--	--	--	--	--	Toxicity value not available.
Crotonaldehyde	--	--	--	--	--	Toxicity value not available.
1,4-Dioxane	--	--	--	--	--	Toxicity value not available.
Formaldehyde	--	--	--	--	--	Toxicity value not available.
Vinyl chloride	--	--	--	--	--	Toxicity value not available.
Other chlorinated organics (μg/kg BW-day)						
Hexachlorobenzene	Acute (5 days) NOAEL	Coturnix quail	22,500	0.01	225	Hill and Camardese (1986)
Hexachlorobutadiene	Chronic (3 months) NOAEL	Japanese quail	3185	Not applicable	3185	Schwertz et al. (1974)
Hexachlorocyclopentadiene	--	--	--	--	--	Toxicity value not available.
Pentachlorobenzene	--	--	--	--	--	Toxicity value not available.
Pentachlorophenol	Acute (5 days) NOAEL	Quail	403,000	0.01	4,030	Hill and Camardese (1986)
Pesticides (μg/kg BW-day)						
4,4'-DDE	Acute (5 days) LOAEL (mortality)	Coturnix quail	84,500	0.01	845	Hill and Camardese (1986). Test data for 1,1'-DDE used as a surrogate for 4,4'-DDE.

TABLE E-8

BIRD TOXICITY REFERENCE VALUES

Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Heptachlor	Acute (5 days) LOAEL (mortality)	Quail	6,500	0.01	65	Hill and Camardese (1986)
Hexachlorophene	Acute LD50	Bobwhite quail	575,000	0.01	5,750	Meister (1994)
Inorganics (mg/kg BW-day)						
Aluminum	Chronic (4 -months) NOAEL (reproduction)	Ringed Turtle Dove	110	1.0	100	Carriere et al. (1986)
Antimony	--	--	--	--	--	Toxicity value not available. Ridgeway and Karnofsky (1952) reported LD50 for doses to eggs; however, that value could not be converted to a dose based on post-hatching environmental exposure.
Arsenic	Chronic (7 months) NOAEL	Brown-headed cowbird	2.46	1.0	2.46	U.S. Fish and Wildlife Service (1969)
Barium	Subchronic (4 weeks) NOAEL	One day old chick	208.26	0.1	20.8	Johnson et al. (1960)
Beryllium	--	--	--	--	--	Toxicity value not available.
Cadmium	Chronic (90 days) NOAEL	Mallard drake	1.45	Not applicable	1.45	White and Finley (1978)
Chromium (hexavalent)	Chronic (5 months) NOAEL	Black duck	1.0	Not applicable	1.0	Haseltine et al. (1985). TRV based on trivalent chromium.
Copper	Chronic (10 weeks) NOAEL (growth)	1-day old chicks	46.97	1.0	46.97	Mehring et al. (1960)

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BIRD TOXICITY REFERENCE VALUES

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Compound	Basis for TRV				TRV	Reference and Notes [d]
	Duration and Endpoint [a]	Test Organism	Dose[b]	Uncertainty Factor [c]		
Total Cyanide	Acute LD50	American kestrel	4	0.01	0.04	Wiemeyer et al. (1986). Sodium cyanide is used as a surrogate for total cyanides.
Lead	Acute (7 days) LOAEL (altered enzyme levels)	Ringed turtle dove	25	0.001	0.025	Kendall and Scanlon (1982)
Mercuric chloride	Acute (5 days) LOAEL (mortality)	Coturnix quail	325	0.01	3.25	Hill and Camardese (1986)
Methyl mercury	Chronic (3 generations) LOAEL (mortality)	Mallard	0.064	0.1	0.0064	Heinz (1979)
Nickel	Subchronic (5 days) NOAEL	Coturnix quail	650	0.1	65	Hill and Camardese (1986)
Selenium	Chronic (78 days) NOAEL	Mallard	0.5	1.0	0.5	Heinz et al. (1987)
Silver	Subchronic (14 days) NOAEL	Mallard	1,780	0.1	178	U.S. EPA (1997)
Thallium	Acute LD50	Starling	35	0.01	0.35	Schafer (1972)
Zinc	Chronic (44 weeks) NOAEL	Leghorn hen and New Hampshire rooster	130.9	1.0	130.9	Stahl et al. (1990)

TABLE E-8

BIRD TOXICITY REFERENCE VALUES

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Notes:

a The duration of exposure is defined as chronic if it represents about 10 percent or more of the test animal's lifetime expectancy. Acute exposures represent single exposure or multiple exposures occurring within about two weeks or less. Subchronic exposures are defined as multiple exposures occurring for less than 10 percent of the test animal's lifetime expectancy but more that 2 weeks.

b Reported value which were dose in diet or water were converted to dose based on body weight and intake rate using Opresko, Sample, and Suter (1996).

c Uncertainty factors are used to extrapolate a reported toxicity value to a chronic NOAEL TRV. See Chapter 5 (Section 5.4) of the SLERAP for a discussion on the use of uncertainty factors. The TRV was calculated by multiplying the toxicity value by the uncertainty factor. A "not applicable" uncertainty factor is equivalent to a value equal to 1.0.

d The references refer to the study from which the endpoint and doses were identified. Complete reference citations are provided below.

e Best scientific judgement used to identify uncertainty factor. See Chapter 5 (Section 5.4.1.2) for a discussion on the use of best scientific judgement. Factors evaluated include test duration, ecological relevance of endpoint, experimental design, and availability of toxicity data.

HMW = High molecular weight
LOAEL = Lowest Observed Adverse Effect Level
LD50 = Concentration lethal to 50 percent of the test organisms.
NOAEL = No Observed Adverse Effect Level
TRV = Toxicity Reference Value

REFERENCES

Sample, Opresko, and Suter II (1996) provides a comprehensive review of bird toxicity information. This source was reviewed to identify studies to develop TRVs for birds. Based on the information presented, one or more references were obtained and reviewed to identify compound-specific toxicity values. For some compounds, the available information identified a single study meeting the requirements for a TRV, as discussed in Chapter 5 (Section 5.4) of the SLERAP. In most cases, each reference was obtained and reviewed to identify a single toxicity value to develop a TRV for each compound. As noted below, additional compendia were reviewed to identify toxicity studies to review. In a few cases where a primary study could not be obtained, a toxicity value is based on a secondary source. For compounds not discussed in Sample, Opresko, and Suter II (1996), the scientific literature was searched, and relevant studies were obtained and reviewed. The references reviewed are listed below. The study selected for the TRV is highlighted in bold.

Polychlorinated dibenzo(p)dioxins

Nosek, J.A., S.R. Craven, J.R. Sullivan, S.S. Hurley, and R.E. Peterson. 1992. "Toxicity and Reproductive Effects of 2,3,7,8-Tetrachlorodibenzo-p-dioxin in Ring-Necked Pheasant Hens." *Journal of Toxicology and Environmental Health.* Volume 35. Pages 187-198.

U.S. EPA. 1993. *Interim Report on Data and Methods for Assessment of 2,3,7,8-Tetrachlorodibenzop-dioxin Risks to Aquatic Life and Associated Wildlife.* EPA/600/R-93/055. Office of Research and Development. Washington, D.C. March. This report identified the two studies listed below.

Greig, J.B., G. Jones, W.H. Butler, and J.M. Barnes. 1973. "Toxic Effects of 2,3,7,8-Tetrachlorodibenzo-p-dioxins. *Food and Cosmetics Toxicology.* Volume 11. Pages 585-595.

Hudson, R., R.Tucker, and M. Haegele. 1984. *Handbook of Toxicity of Pesticides to Wildlife.* Second Ed. U.S. Fish and Wildlife, Resources Publication No. 153. Washington, D.C.

Benzo(a)pyrene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." *Archives of Toxicology.* Volume 65. Pages 485-489.

Benzo(a)anthracene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." *Archives of Toxicology.* Volume 65. Pages 485-489.

Benzo(k)fluoranthene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." ***Archives of Toxicology.*** **Volume 65. Pages 485-489.**

Chyrsene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." ***Archives of Toxicology.*** **Volume 65. Pages 485-489.**

Dibenz(a,h)anthracene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." ***Archives of Toxicology.*** **Volume 65. Pages 485-489.**

Indeno(1,2,3-cd)pyrene

Brunström, B., D. Broman, and C. Näf. 1991. "Toxicity and EROD-Inducing Potency of 24 Polycyclic Aromatic Hydrocarbons (PAHs) in Chick Embryos." ***Archives of Toxicology.*** **Volume 65. Pages 485-489.**

Polychlorinated Biphenyls

Peakall, D.B., J.L. Lincer, S.E. Bloom. 1972. "Embryonic Mortality and Chromosomal Alterations Caused by Aroclor 1254 in Ring Doves." ***Environmental Health Perspectives.*** **Volume 1. Pages 103-104.**

Dahlgren, R.B., R.L. Linder, and C.W. Carlson. 1972. "Polychlorinated Biphenyls: Their Effects on Penned Pheasants." *Environmental Health Perspectives*. Volume 1. Pages 89-101.

McLane, M.A.R., and D.L. Hughes. 1980. "Reproductive Success of Screech Owls Fed Aroclor 1248." *Archives of Environmental Contamination and Toxicolog*. Volume 9. Pages 661-665.

1,3-Dinitrobenzene

Schafer, E.W. 1972. "The Acute Oral Toxicity of 369 Pesticidal, Pharmaceutical and Other Chemicals to Wild Birds." ***Toxicological and Applied Pharmacology.*** **Volume 21. Pages 315-330.**

Pentachloronitrobenzene

Dunn, J. S., P. B. Bush, N. H. Booth, R.L. Farrell, D. M. Thomason, and D. D. Goetsch. 1979. Effect of Pentachloronitrobenzene upon Egg Production, Hatchability, and Residue Accumulation in the Tissues of White Leghorn Hens. *Toxicology and Applied Pharmacology.* Volume 48. Pages 425-433.

Bis(2-ethylhexyl)phthalate

Peakall, D.B. 1974. "Effects of Di-n-butyl and Di-2-ethylhexyl Phthalate on the Eggs of Ring Doves. *Bulletin of Environmental Contamination and Toxicology.*" Volume 12. Pages 698-702.

Acetone

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

1,4-Dioxane

Giavini, E., C. Vismara, and L. Broccia. 1985. "Teratogenesis Study of Dioxane in Rats." *Toxicology Letters*. Volume 26. Pages 85-88. This study did not evaluate an ecologically relevant endpoint. Therefore, the data were not used to develop a TRV.

Hexachlorobenzene

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Hexachlorobutadiene

Schwetz, B.A., J.M. Norris, R.J. Kociba, P.A. Keeler, R.F. Cornier, and P.J. Gehring. 1974. "Reproduction Study in Japanese Quail Fed Hexachlorobutadiene for 90 Days." *Toxicology and Applied Pharmacology*. Volume 30. Pages 255-265.

Pentachlorophenol

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

4,4'-DDE

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Mendenhall, V.M., E.E. Klaas, and M.A.R. McLane. 1983. "Breeding Success of Barn Owls (*Tyto alba*) Fed Low Levels of DDE and Dieldrin." *Archives of Environmental Contamination and Toxicology. Volume*12. Pages 235-240.

Shellenberger, T.E. 1978. "A Multi-Generation Toxicity Evaluation of P-P'-DDT and Dieldrin with Japanese Quail. I. Effects on Growth and Reproduction." *Drug Chemistry and Toxicology. Volume* 1. Pages 137-146

Heptachlor

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Hexachlorophene

Meister, R.J. (ed.) 1994. *Farm Chemicals Handbook '94*. Meister Publishing Company, Willoughby, Ohio. Volume 80. Page C189.

Aluminum

Carriere, D., K.L. Fischer, D.B. Peakall, and P. Anghern. 1986. "Effects of Dietary Aluminum Sulphate on Reproductive Success and Growth of Ringed Turtle Doves (*Streptopelia risoria*)." *Canadian Journal of Zoology*. Volume 64. Pages 1500-1505.

Carriere, D., K. Fischer, D. Peakall, and P. Angehrn. 1986. "Effects of Dietary Aluminum in Combination with Reduced Calcium and Phosphorus on the Ring Dove (*Streptopelia risoria*)." *Water, Air, and Soil Pollution*. Volume 30. Pages 757-764.

Antimony

Ridgeway, L.P. and D.A. Karnofsky. 1952. "The Effects of Metals on the Chick Embryo: Toxicity and Production of Abnormalities in Development." *Annals of New York Academy of Sciences*. Volume 55. Pages 203-215.

TABLE E-8

BIRD TOXICITY REFERENCE VALUES

(Page 11 of 13)

Arsenic

U.S. Fish and Wildlife Service. 1969. "Publication 74." Bureau of Sport Fisheries and Wildlife. As cited in Sample, Opresko, and Suter II (1996).

Barium

Johnson, D., Jr., A.L. Mehring, Jr., and H.W. Titus. 1960. "Tolerance of Chickens for Barium." *Proceedings o fthe Society for Experimental Biology and Medicine.* Volume 104. Pages 436-438.

Cadmium

White, D.H., and M.T. Finley. 1978. "Uptake and Retention of Dietary Cadmium in Mallard Ducks." *Environmental Research.* Volume 17. Pages 53-59.

Chromium

Haseltine, S.D., and others. 1985. "Effects of Chromium on Reproduction and Growth of Black Ducks." As cited in U.S. Fish and Wildlife Service. 1986. *Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* January. Page 38.

Copper

Mehring, A.L.Jr., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus. 1960. "The Tolerance of Growing Chickens for Dietary Copper." *Poultry Science.* Volume 39. Pages 713-719.

Cyanide

Wiemeyer, S.N., E.F. Hill, J.W. Carpenter, and A.J. Krynitsky. 1986. "Acute Oral Toxicity of Sodium Cyanide in Birds." *Journal of Wildlife Diseases.* Volume 22. Pages 538-46.

Lead

Kendall, R.J., and P.F. Scanlon. 1982. "The Toxicology of Ingested Lead Acetate in Ringed Turtle Doves *Stretopelia risoria.*" *Environmental Pollution.* Volume 27. Pages 255-262.

Edens, F., W.E. Benton, S J. Bursian, and G.W. Morgan. 1976. "Effect of Dietary Lead on Reproductive Performance in Japanese Quail, *Coturnix coturnix japonica*." *Toxicology and Applied Pharmacology*. Volume 38. Pages 307-314.

Pattee, O.H. 1984. "Eggshell Thickness and Reproduction in American Kestrels Exposed to Chronic Dietary Lead." *Archives of Environmental Contamination and Toxicology*. Volume 13. Pages 29-34.

Mercuric chloride

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Hill, E. F. and C. S. Schaffner. 1976. "Sexual Maturation and Productivity of Japanese Quail Fed Graded Concentrations of Mercuric Chloride." *Poultry Science*. Volume 55. Pages 1449-1459.

Methyl mercury

Heinz, G.H. 1979. "Methylmercury: Reproductive and Behavioral Effects on Three Generations of Mallard Ducks." *Journal of Wildlife Management*. Volume 43. Pages 394-401.

Spann, J.W., G.H. Heinz, M.B. Camardese, E.F. Hill, J.F. Moore, and H.C. Murray. 1986. "Differences in Mortality Among Bobwhite Fed Methylmercury Chloride Dissolved in Various Carriers." *Environmental Toxicology and Chemistry*. Volume 5. Pages 721-724.

Nickel

Hill, E.F., and M.B. Camardese. 1986. "Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix." Fish and Wildlife Service. Technical Report 2.

Cain, B.W., and E.A. Pafford. 1981. "Effects of Dietary Nickel on Survival and Growth of Mallard Ducklings." *Archives of Environmental Contamination and Toxicology*. Volume 10. Pages 737-745.

Selenium

Heinz, G., and others. 1987. "Research at Patuxent Wildlife Research Center." As cited in Sample, Opresko, and Suter II (1996).

Heinz, G.H., D.J. Hoffman, A.J. Krynitsky, and D.M.G. Weller. 1987. "Reproduction in Mallards Fed Selenium." *Environmental Toxicology and Chemistry*. Volume 6. Page 423-433.

Heinz, G.H., D.J. Hoffman, and L.G. Gold. 1989. "Impaired Reproduction of Mallards Fed an Organic Form of Selenium." *Journal of Wildlife Management*. Volume 53. Pages 418-428.

Sample, B.E., D.M. Opresko, G.W. Suter II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* Risk Assessment Program Health Sciences Research Division, Oak Ridge, Tennessee. Prepared for U.S. Department of Energy.

Silver

U.S. EPA. 1997. Aquatic Toxicity Information Retrieval Database (AQUIRE). Office of Research and Development, National Health and Environmental Effects Research Laboratory, Mid-Continent Ecology Division. January.

Thallium

Schafer, E.W. 1972. "The Acute Oral Toxicity of 369 Pesticidal, Pharmaceutical and Other Chemicals to Wild Birds." ***Toxicological and Applied Pharmacology.*** **Volume 21. Pages 315-330.**

Zinc

Stahl, J.L., J.L. Greger, and M.E. Cook. 1990. "Breeding-Hen and Progeny Performance When Hens Are Fed Excessive Dietary Zinc." ***Poultry Science.*** **Volume 69. Pages 259-263.**

APPENDIX H

SITE-SPECIFIC SOIL SCREENING LEVELS

SITE-SPECIFIC SOIL SCREENING LEVELS[23]

This is an OPTIONAL step that may be appropriate for large facilities which are screening a number of sites with similar habitats for common COPECs. It provides a method for calculating levels of COPECs in abiotic media that should not represent an excessive risk to the ecosystem as a whole because of the conservative assumptions in this method. The media specific screening levels are only protective of the food web exposure pathways for which they were derived; their appropriateness needs to be verified on a site-specific basis.

Establish ecologically based screening levels (EBSLs)

Site specific ecologically based screening levels (EBSLs) are calculated using the dietary exposure model and TRVs developed during the ecoscreen. EBSLs are determined by assembling a reliable set of TRVs from the available toxicity data. These TRVs are used to represent the maximum safe daily ingested dose for class-specific guild measurement receptors or media concentrations for community measurement receptors. In calculating these media concentrations it is assumed that there is no possibility for the transport of contamination between media. EBSLs cannot be calculated for sites where contamination may be transported from one media to another since this transport would alter the media concentration or dose ingested to differ from that calculated using the equations. The dose or media concentration is then put into the equations for each community and feeding guild measurement receptor, which are then solved for the allowable concentration in the media. For community receptors the media would be the one for the community, and for the guild measurement receptors all contaminated media would be included as a route of exposure. For each receptor, acceptable media levels would need to be calculated for all complete pathways. Once the calculations were completed for all receptors, the lowest calculated screening level for each media would be the EBSL for that media.

Calculate screening level hazard quotients (SLHQ) for individual COPECs

A screening level hazard quotient (SLHQ) can be calculated for each COPEC in each media found at each of the sites by dividing the maximum COPEC concentration found at the site by the EBSL developed above for that COPEC. These SLHQ can be used both to screen out sites that do not represent excessive ecological risk and to prioritize the different media at a single site for corrective action.

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[23]See Section 6.0 for limitations of ecologically-based media screening levels.

APPENDIX I

NM WQCC Standards for Surface Water

STATE OF NEW MEXICO

STANDARDS FOR INTERSTATE AND INTRASTATE SURFACE WATERS

Filed with State Records Center
January 24, 2000
As NMAC 6.1
Effective February 23, 2000

New Mexico Water Quality Control Commission
Harold Runnels Building
1190 St. Francis Drive P.O. Box 26110
Santa Fe, New Mexico 87502

Constituent Agencies:

Environment Department
State Engineer Office
Game and Fish Department
Oil Conservation Division
Department of Agriculture
State Parks Division
Soil and Water Conservation Commission
Bureau of Mines and Mineral Resources
Members-at-Large

for these uses is ensured by the general standards and numeric standards for bacterial quality, pH, and temperature which are established for all classified waters of the State listed in Subpart II of this Part (Sections 2000 through 2999).

J. The following schedule of numeric standards and equations for the substances listed shall apply to the subcategories of fisheries identified in Section 3100 of this Part:

1. Acute Standards

Dissolved aluminum	750	µg/L
Dissolved arsenic	340	µg/L
Dissolved beryllium	130	µg/L
Total mercury	2.4	µg/L
Total recoverable selenium	20.0	µg/L
Dissolved silver	$e^{(1.72[\ln(hardness)]-6.6825)}$	µg/L
Cyanide, weak acid dissociable	22.0	µg/L
Total chlordane	2.4	µg/L
Dissolved cadmium	$(e^{(1.128[\ln(hardness)]-3.6867)})cf$	µg/L

The hardness-dependent formulae for cadmium must be multiplied by a conversion factor (cf) to be expressed as dissolved values. The acute factor for cadmium is cf = 1.136672 - [(ln hardness)(0.041838)].

Dissolved chromium	$e^{(0.819[\ln(hardness)]+2.5736)}$	µg/L
Dissolved copper	$e^{(0.9422[\ln(hardness)]-1.7408)}$	µg/L
Dissolved lead	$(e^{(1.273[\ln(hardness)]-1.46)})cf$	µg/L

The hardness-dependent formulae for lead must be multiplied by a conversion factor (cf) to be expressed as dissolved values. The acute and chronic factor for lead is cf = 1.46203 - [(ln hardness)(0.145712)].

Dissolved nickel	$e^{(0.8460[\ln(hardness)]+2.253)}$	µg/L
Dissolved zinc	$e^{(0.8473[\ln(hardness)]+0.8618)}$	µg/L
Total chlorine residual	19	µg/L

2. Chronic Standards

Dissolved aluminum	87.0	µg/L
Dissolved arsenic	150	µg/L
Dissolved beryllium	5.3	µg/L
Total mercury	0.012	µg/L
Total recoverable selenium	5.0	µg/L
Cyanide, weak acid dissociable	5.2	µg/L
Total chlordane	0.0043	µg/L
Dissolved cadmium	$(e^{(0.7852[\ln(hardness)]-[2.715])})cf$	µg/L

The hardness-dependent formulae for cadmium must be multiplied by a conversion factor (cf) to be expressed as dissolved values. The chronic factor for cadmium is cf = 1.101672 - [(ln hardness)(0.041838)].

Dissolved chromium	$e^{(0.819[\ln(hardness)]+0.534)}$	µg/L

Dissolved copper	$e^{(0.8545[\ln(hardness)]-1.7428)}$	µg/L
Dissolved lead	$(e^{(1.273[\ln(hardness)]-4.705)})cf$	µg/L

The hardness-dependent formulae for lead must be multiplied by a conversion factor (cf) to be expressed as dissolved values. The acute and chronic factor for lead is cf = 1.46203 - [(ln hardness)(0.145712)].

Dissolved nickel	$e^{(0.846[\ln(hardness)]+0.0554)}$	µg/L
Dissolved zinc	$e^{(0.8473[\ln(hardness)]+0.8699)}$	µg/L
Total chlorine residual	11	µg/L

K. Livestock Watering: The following numeric standards shall not be exceeded:

Dissolved aluminum	5.0	mg/L
Dissolved arsenic	0.2	mg/L
Dissolved boron	5.0	mg/L
Dissolved cadmium	0.05	mg/L
Dissolved chromium	1.0	mg/L
Dissolved cobalt	1.0	mg/L
Dissolved copper	0.5	mg/L
Dissolved lead	0.1	mg/L
Total mercury	0.01	mg/L
Dissolved selenium	0.05	mg/L
Dissolved vanadium	0.1	mg/L
Dissolved zinc	25.0	mg/L
Radium-226 + radium-228	30.0	pCi/L
Tritium	20,000	pCi/L
Total gross alpha (including radium-226, but excluding radon and uranium)	15	pCi/L

L. Wildlife Habitat: Wildlife habitat should be free from any substances at concentrations that are toxic to or will adversely affect plants and animals that use these environments for feeding, drinking, habitat or propagation, or can bioaccumulate and impair the community of animals in a watershed or the ecological integrity of surface waters of the State. In the absence of site-specific information, and subject to the following paragraph, the following chronic numeric standards shall not be exceeded:

Total mercury	0.77	µg/L
Total recoverable selenium	5.0	µg/L
Cyanide, weak acid dissociable	5.2	µg/L
Total chlorine residual	11	µg/L
Total DDT and metabolites	0.001	µg/L
Total PCBs	0.014	µg/L

The discharge of substances which bioaccumulate, in excess of levels specified above is allowed if, and only to the extent that, the substances are present in the intake waters which are diverted and utilized prior to discharge, and then only if the discharger utilizes best available treatment technology to reduce the amount of bioaccumulating substances which are discharged.