Appendix D

Parameter Derivation and Citations

Appendix D

Parameter Derivation and Citations

This appendix lists the chemical-specific, fate and transport, and exposure parameters used in this risk analysis. A complete list of the references for the derivation of these parameters is also included.

D.1 Chemical-Specific Parameters

Tables D-1 to D-17 contain the physical and chemical properties for the dioxin and furan congeners. Each dioxin and furan congener is considered independently in the risk assessment. Any constituent-specific values for dioxins/furans not reported in this appendix were calculated using the physical and chemical properties in the tables. The information presented in the tables includes some or all of the following:

- Vapor fraction (F_v)
- Soil adsorption coefficient (K_{oc})
- Octanol-water partition coefficient (K_{ow})
- Vapor pressure (VP)
- Water solubility (S)
- Molecular weight (MW)
- Henry's law constant (H)
- Diffusivity coefficients in water and air (D_w and D_a)
- Air-to-plant biotransfer factor (Bv)
- Root concentration factor (RCF)
- Soil-to-plant biotransfer factor (Br)
- Biotransfer factor for beef (Ba_{beef})
- Biotransfer factor for pork (Ba_{pork})
- Biotransfer factor for milk (Ba_{milk})
- Bioconcentration factor for chicken (BCF_{chick})
- Biotransfer factor for eggs (BCF_{egg})
- Fish biota to sediment accumulation factor (BSAF)
- Fraction of wet deposition that adheres to plant surface (Fw)
- Oral cancer inhalation slope factor (CSF)
- Oral reference dose (RfD)

- # Unit risk factor (URF)
- # Reference concentration (RfC).

Values for sediment and soil partition coefficients (Kd_{sw}, Kd_{bs}, and Kd_s) are calculated from equations in Appendix C for the dioxin and furan congeners. Following the tables is a list of references used to obtain the chemical and physical properties. The reference numbers cited in Tables D-1 to D-17 refer to these references.

Tables D-18 to D-35 list the physical and chemical properties for the metals considered in the risk analysis. Any constituent-specific values not reported in this appendix were calculated using the physical and chemical properties listed in these tables. The information presented in Tables D-18 to D-35 includes some or all of the following:

- # Vapor fraction (F_v)
- # Soil-water partition coefficient (Kd_s)
- # Suspended sediment-surface water partition coefficient (Kd_{sw})
- # Bed sediment-pore water partition coefficient (Kd_{bs})
- # Henry’s law constant (H)
- # Diffusivity coefficients in water and air (D_w and D_a)
- # Air-to-plant biotransfer factor (Bv)
- # Soil-to-plant biotransfer factor (Br)
- # Biotransfer factor for beef (Ba_{beef})
- # Biotransfer factor for pork (Ba_{pork})
- # Biotransfer factor for milk (Ba_{milk})
- # Fish biota concentration factor (BCF)
- # Fish biota accumulation factor (BAF)
- # Oral cancer inhalation slope factor (CSF)
- # Oral reference dose (RfD)
- # Unit risk factor (URF)
- # Reference concentration (RfC).

Tables D-36 and D-37 list the inputs used for Cl_2 + HCl. Following the tables is a list of references used to obtain the chemical and physical properties. The reference numbers cited in Tables D-18 to D-37 refer to these references.

D.2 Fate and Transport Parameters

Table D-38 contains the references and values for the fate and transport parameters used in this analysis. The parameters listed in the table are not constituent or site-specific. Constituent-specific parameters are listed in Tables D-38 to D-75. The site-specific surface water and meteorological parameters that affect fate and transport are listed in Appendix B.

D.3 Exposure Parameters

Tables D-76 and D-77 list the exposure parameters used in this analysis. Table D-76 contains exposure parameters that are not site-specific and are applicable to all 11 facilities. Table D-77 contains site-specific data on the fraction of consumption that was assumed to be contaminated. The values in this table were developed using production and processing data from counties within 50 kilometers of each site. Commercial farmers, which were also determined from the county data, are highlighted in Table D-77 for each case. A complete discussion of the references and methodology used to obtain the values listed in Tables D-76 and D-77 is contained in Section 6.0 of this report and is not repeated in this appendix.

Table D-1. Chemical-Specific Inputs for 2,3,7,8-TCDD

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	5.5E-1	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	2.7E+6	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	4.4E+6	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	9.7E-13	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	1.9E-5	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	322	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	1.6E-5	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.7E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	6.1E+4	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	3.9E+3	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	5.6E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	5.4E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	1.0E-2	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	1.11	d
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	1.27	d
BAF_{worms}	Bioconcentration factor for TCDD-TEQ in worms (unitless)	9.1	Sample et al., 1998a
$BAF_{invertebrates}$	Bioaccumulation factor for TCDD-TEQ in invertebrates (unitless)	1.3	Sample et al., 1998b
$BAF_{vertebrates}$	Bioaccumulation factor for TCDD-TEQ in vertebrates (unitless)	7.2	Sample et al., 1997
BSAF	Fish biota to sediment accumulation factor (unitless)	0.76	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
CSF	Cancer slope factor (per mg/kg/d)	156,000	U.S. EPA, 1984
RfD	Reference dose (mg/kg/d)	NA	

Table D-1. (continued)

Parameter	Definition	Value	Ref
URF	Unit risk factor (per µg/m^3)	3.3E-8	U.S. EPA, 1998
RfC	Reference concentration (mg/m^3)	NA	
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	1	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	1	Van den Berg et al., 1998

NA = Not applicable.

[a] Calculated from an equation in Travis and Arms, 1988.
[b] Pork biotransfer factor set equal to beef biotransfer factor.
[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).
[d] No BCFs for these chemical are presented due to low concentration of these isomers. Values for these chemicals are taken from the most structurally similar isomer listed in Stephens et al., 1992.

Table D-2. Chemical-Specific Inputs for 2,3,7,8-TCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	7.1E-1	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	2.1E+6	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	3.4E+6	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	1.2E-11	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	4.2E-4	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	306	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	8.6E-6	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm2/s)	4.8E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	8.1E+4	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	3.2E+3	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	6.5E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	1.6E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	3.0E-3	Lorber & Rice, 1993
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.92	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	0.46	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.23	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.1	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	1	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-3. Chemical-Specific Inputs for 1,2,3,7,8-PeCDD

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	2.6E-1	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	2.7E+6	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	4.4E+6	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	1.2E-12	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	1.2E-4	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	356.4	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	2.6E-6	U.S. EPA, 1994a, b
Da	Diffusivity in air (cm^2/s)	4.5E-2	U.S. EPA, 1994a, b
Dw	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	1.2E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	3.9E+3	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	5.6E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	5.4E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	1E-2	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	1.11	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	1.27	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.57	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	1.0	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	1.0	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-4. Chemical-Specific Inputs for 1,2,3,7,8-PeCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	4.2E-1	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	3.8E+6	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	6.2E+6	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	3.6E-12	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	2.4E-4	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	340.4	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	6.2E-6	U.S. EPA, 1994a, b
Da	Diffusivity in air (cm^2/s)	4.6E-2	U.S. EPA, 1994a, b
Dw	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	4.6E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	5.1E+3	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	4.6E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	1.1E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	2.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	1.20	d
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	2.50	d
BSAF	Fish biota to sediment accumulation factor (unitless)	0.26	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.05	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.1	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

[d] No BCFs for these chemical are presented due to low concentration of these isomers. Values for these chemicals are taken from the most structurally similar isomer listed in Stephens et al., 1992.

Table D-5. Chemical-Specific Inputs for 2,3,4,7,8-PeCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	3.0E-1	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	5.1E+6	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	8.3E+6	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	4.3E-12	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	2.4E-4	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	340.4	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	6.2E-6	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.6E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	4.6E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	6.4E+3	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	3.9E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	4.9E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	9.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	1.20	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	2.50	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.39	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.5	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	1.0	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-6. Chemical-Specific Inputs for 1,2,3,4,7,8-HxCDD

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	7E-2	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	3.8E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	6.2E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	1.3E-13	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	4.4E-6	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	390.9	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	1.2E-5	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.3E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	4.5E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	3.0E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	1.2E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	3.2E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	6.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.85	U.S. EPA, 1994a, b
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	1.46	U.S. EPA, 1994a, b
BSAF	Fish biota to sediment accumulation factor (unitless)	0.16	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.1	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.05	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.
[b] Pork biotransfer factor set equal to beef biotransfer factor.
[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-7. Chemical-Specific Inputs for 1,2,3,6,7,8-HxCDD

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	4.0E-2	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	1.2E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	2.0E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	4.7E-14	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	4.4E-6	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	390.9	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	1.2E-5	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.3E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	4.5E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	1.3E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	2.3E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	2.7E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	5.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.99	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	1.62	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.17	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.1	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.01	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-8. Chemical-Specific Inputs for 1,2,3,7,8,9-HxCDD

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	2E-2	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	1.2E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	2.0E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	6.4E-14	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	4.4E-6	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	390.9	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	1.2E-5	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.3E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	4.5E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	1.3E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	2.3E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	3E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	6E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.50	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	1.05	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.045	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.1	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.1	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-9. Chemical-Specific Inputs for 1,2,3,4,7,8-HxCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	6.0E-2	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	1.2E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	2.0E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	3.2E-13	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	8.3E-6	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	374.9	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	1.4E-5	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.4E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	1.5E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	1.3E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	2.3E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	3.8E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	7.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.86	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	1.89	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.056	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.1	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.1	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-10. Chemical-Specific Inputs for 1,2,3,6,7,8-HxCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	6.0E-2	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	1.2E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	2.0E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	2.9E-13	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	1.8E-5	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	374.9	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	6.1E-6	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.4E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	1.5E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	1.3E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	2.3E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	3.2E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	6.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.73	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	1.68	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.093	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.1	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.1	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-11. Chemical-Specific Inputs for 1,2,3,7,8,9-HxCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	1.1E-1	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	1.2E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	2.0E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	3.7E-13	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	1.3E-5	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	374.9	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	1.0E-5	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.4E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	1.5E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	1.3E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	2.3E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	3.2E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	6.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.73	d
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	1.68	d
BSAF	Fish biota to sediment accumulation factor (unitless)	0.15	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.1	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.1	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.
[b] Pork biotransfer factor set equal to beef biotransfer factor.
[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).
[d] No BCFs for these chemical are presented due to low concentration of these isomers. Values for these chemicals are taken from the most structurally similar isomer listed in Stephens et al., 1992.

Table D-12. Chemical-Specific Inputs for 2,3,4,6,7,8-HxCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	7.0E-2	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	1.2E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	2.0E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	2.6E-13	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	1.3E-5	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	374.9	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	1.0E-5	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.4E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	1.5E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	1.3E4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	2.3E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	2.7E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	5.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.39	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	0.54	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.18	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.1	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.1	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.
[b] Pork biotransfer factor set equal to beef biotransfer factor.
[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-13. Chemical-Specific Inputs for 1,2,3,4,6,7,8-HpCDD

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	2E-2	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	9.8E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	1.6E+8	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	4.2E-14	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	2.4E-6	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	425.3	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	7.5E-6	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.1E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	3.5E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	6.2E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	7.1E-4	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	5.4E-3	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	1E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.22	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	0.98	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.033	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.01	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.001	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-14. Chemical-Specific Inputs for 1,2,3,4,6,7,8-HpCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	4.0E-2	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	4.9E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	7.9E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	1.8E-13	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	1.4E-6	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	409.3	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	5.3E-5	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.2E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	4.4E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	3.7E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	1.1E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	5.4E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	1.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.18	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	0.68	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.011	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.01	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.01	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-15. Chemical-Specific Inputs for 1,2,3,4,7,8,9-HpCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	3.0E-2	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	4.9E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	7.9E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	1.4E-13	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	1.4E-6	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	409.3	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	5.3E-5	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.2E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	4.4E+5	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	3.7E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	1.1E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	1.6E-2	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	3.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.16	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	0.49	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.027	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.01	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.01	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.
[b] Pork biotransfer factor set equal to beef biotransfer factor.
[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

Table D-16. Chemical-Specific Inputs for 1,2,3,4,5,7,8,9-OCDD

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	2.0E-4	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	2.4E+7	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	3.9E+7	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	1.1E-15	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	7.4E-8	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	460.8	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	7.0E-9	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	3.9E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	8.6E+6	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	2.1E+4	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	1.6E-3	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	5.4E-3	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	1.0E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.04	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	0.47	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.034	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.0001	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.0001	d

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995).

[d] Default to mammalian value due to a lack of bird data.

Table D-17. Chemical-Specific Inputs for 1,2,3,4,6,7,8,9-OCDF

Parameter	Definition	Value	Ref
Chemical/Physical Properties			
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	2E-3	U.S. EPA, 1994a, b
K_{oc}	Soil adsorption coefficient (mL/g)	3.9E+8	U.S. EPA, 1994a, b
K_{ow}	Octanol-water partition coefficient (unitless)	6.3E+8	U.S. EPA, 1994a, b
VP	Vapor pressure (atm)	4.9E-15	U.S. EPA, 1994a, b
S	Water solubility (mL/g)	1.2E-6	U.S. EPA, 1994a, b
MW	Molecular weight (g/mol)	444.8	U.S. EPA, 1994a, b
H	Henry's law constant (atm-m^3/mol)	1.9E-6	U.S. EPA, 1994a, b
D_a	Diffusivity in air (cm^2/s)	4.0E-2	U.S. EPA, 1994a, b
D_w	Diffusivity in water (cm^2/s)	8.0E-6	U.S. EPA, 1994c
Transfer Factors			
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g air])	1.3E+6	Lorber, 1995
RCF	Root concentration factor ([µg pollutant/g plant tissue FW]/[µg pollutant/g soil water])	1.8E+5	U.S. EPA, 1994a, b
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	3.2E-4	a
Ba_{beef}/Ba_{pork}	Biotransfer factor for beef or pork (d/kg)[b]	5.4E-3	c
Ba_{milk}	Biotransfer factor for milk (d/kg)	1E-3	Lorber & Rice, 1995
BCF_{chick}	Bioconcentration factor for TCDD-TEQ in poultry (unitless)	0.07	Stephens et al., 1992
BCF_{egg}	Bioconcentration factor for TCDD-TEQ in eggs (unitless)	0.30	Stephens et al., 1992
BSAF	Fish biota to sediment accumulation factor (unitless)	0.0033	Bauer, 1992
Other Parameters			
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	6.0E-1	Lorber & Rice, 1995
Health Benchmarks			
$TEF_{H,M}$	Toxicity equivalency factor for humans and mammals	0.0001	Van den Berg et al., 1998
TEF_B	Toxicity equivalency factor for birds	0.0001	Van den Berg et al., 1998

[a] Calculated from an equation in Travis and Arms, 1988.

[b] Pork biotransfer factor set equal to beef biotransfer factor.

[c] The Ba_{beef} for dioxin congeners was calculated from the Ba_{milk} and the ratio of percent beef fat to percent milk fat. Therefore, the biotransfer factor for beef is 5.4 times higher than for milk. The Ba_{pork} was assumed to be the same as the Ba_{beef} (Lorber & Rice, 1995)

Table D-18. Chemical-Specific Inputs for Antimony

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		2	Strenge and Peterson, 1989
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		2	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		2	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0.03 0.2 0.2	Baes et al., 1984 Baes et al., 1984 Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		0.001	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		0.0001	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		0.001	d
BCF	Fish bioconcentration factor (L/kg)		0	Stephan, 1993
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.2	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		0.0004	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-19. Chemical-Specific Inputs for Arsenic

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		29	U.S. EPA, 1996
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		29	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		29	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0.008 0.036 0.06	U.S. EPA, 1992b U.S. EPA, 1992b U.S. EPA, 1992b
Ba_{beef}	Biotransfer factor for beef (d/kg)		0.002	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		6E-05	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		0.002	d
BCF	Fish bioconcentration factor (L/kg)		3.5	Stephan, 1993
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.2	c
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		1.5	U.S. EPA, 1998
RfD	Reference dose (mg/kg/d)		0.0003	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		0.0043	U.S. EPA, 1998
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-20. Chemical-Specific Inputs for Barium

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		8,265	b
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		8,265	c
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		8,265	d
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0.015 0.15 0.15	Baes et al., 1984 Baes et al., 1984 Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		1.5E-4	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		3.5E-4	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		1.5E-4	e
BCF	Fish bioconcentration factor (L/kg)		NA	
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	f
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		0.07	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		0.0005	U.S. EPA, 1997b

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] The value for K_{ds} for barium was taken from the average of the range of K_{ds} from literature (530 to 16,000 l/kg for a pH range of 5 to 9) as given in Table 43, U.S. EPA, 1996. This value differs from the predicted value given in Table 46 of that document.

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[e] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[f] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-21. Chemical-Specific Inputs for Beryllium

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		4,600	U.S. EPA, 1996
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		4,600	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		4,600	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0.0015 0.01 0.01	Baes et al., 1984 Baes et al., 1984 Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		0.001	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		9E-7	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		0.001	d
BCF	Fish bioconcentration factor (L/kg)		19	Barrows et al., 1980
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		0.002	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		0.0024	U.S. EPA, 1998
RfC	Reference concentration (mg/m^3)		2E-5	U.S. EPA, 1998

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-22. Chemical-Specific Inputs for Cadmium

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		120	U.S. EPA, 1996
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		120	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		120	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables	0.064	U.S. EPA, 1992b
		leafy vegetables	0.36	U.S. EPA, 1992b
		forage/silage	0.14	U.S. EPA, 1992b
Ba_{beef}	Biotransfer factor for beef (d/kg)		0.0004	Lorber & Rice, 1995
Ba_{milk}	Biotransfer factor for milk (d/kg)		0.0001	Lorber & Rice, 1995
Ba_{pork}	Biotransfer factor for pork (d/kg)		6E-4	Lorber & Rice, 1995
BCF	Fish bioconcentration factor (L/kg)		187	d
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		1E-3 soil 5E-4 water	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		0.0018	U.S. EPA, 1998
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] Value derived from a geomean of 15 values (Kumada et al., 1980; Kumada et al., 1972; U.S. EPA, 1992c; Williams and Geisey, 1978; Giesey et al., 1977; Canton and Slooff, 1982; Taylor 1983; Eisler, 1985).

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-23. Chemical-Specific Inputs for Chromium III

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		3.32E+6	RTI, 1994
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		3.32E+6	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		3.32E+6	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0.0045 0.0075 0.0075	Baes et al., 1984 Baes et al., 1984 Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		5.5E-3	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		0.0015	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		5.5E-3	d
BCF	Fish bioconcentration factor (L/kg)		0.6	Stephan, 1993
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		1	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-24. Chemical-Specific Inputs for Chromium VI

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		19	U.S. EPA, 1996
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		19	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		19	c
Transfer Factors				
B_r	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0.0045 0.0075 0.0075	Baes et al., 1984 Baes et al., 1984 Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		0.0055	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		0.0015	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		0.0055	d
BCF	Fish bioconcentration factor (L/kg)		0.6	Stephan, 1993
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		0.005	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		0.012	U.S. EPA, 1998
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-25. Chemical-Specific Inputs for Cobalt

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		4.5E+1	Baes et al., 1984
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		4.5E+1	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		4.5E+1	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables	7.0E-5	Baes et al., 1984
		leafy vegetables	2.0E-2	Baes et al., 1984
		forage/silage	2.0E-2	Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		2.0E-2	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		2.0E-3	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		2.0E-2	d
BCF	Fish bioconcentration factor (L/kg)		NA	
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)[1]		6.0E-2	U.S. EPA, n.d.
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		3.5E-5	ATSDR, 1992

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

[1] Dietary guideline - Risk Assessment paper by EPA's NCEA (U.S. EPA, n.d.).

Table D-26 Chemical-Specific Inputs for Copper

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		2.2E+1	RTI, 1994
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		2.2E+1	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		2.2E+1	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	2.5E-1 4.0E-1 2.4E-2	Baes et al., 1984 Baes et al., 1984 U.S. EPA, 1992b
Ba_{beef}	Biotransfer factor for beef (d/kg)		1.0E-2	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		1.5E-3	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		1.0E-2	d
BCF	Fish bioconcentration factor (L/kg)		0	Stephan, 1993
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		NA	
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-27. Chemical-Specific Inputs for Manganese

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		6.5E+1	Baes et al., 1984
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		6.5E+1	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		6.5E+1	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables	5.0E-2	Baes et al., 1984
		leafy vegetables	2.5E-1	Baes et al., 1984
		forage/silage	2.5E-1	Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		4.0E-4	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		3.5E-4	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		4.0E-4	d
BCF	Fish bioconcentration factor (L/kg)		NA	
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		1.4E-1	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		5.0E-5	U.S. EPA, 1998

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-28. Chemical-Specific Inputs for Mercury - Divalent

Parameter	**Definition**		**Value**	**Ref**
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		site-specific	
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		5.8E+4	U.S. EPA, 1997c
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		1E+5	U.S. EPA, 1997c
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		5E+4	U.S. EPA, 1997c
Ks_{red}	Reduction rate constant (day^{-1})		0.00005	U.S. EPA, 1997c
H	Henry's law constant (atm-m^3/mol)		7.1E-10	U.S. EPA, 1997c
D_a	Diffusivity in air (cm^2/s)		5.5E-2	U.S. EPA, 1997c
D_w	Diffusivity in water (cm^2/s)		8.0E-6	U.S. EPA, 1995a
Transfer Factors				
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue]/[µg pollutant/g air])	leafy vegetables forage/silage	2.1E+4 1.8E+4	U.S. EPA, 1997c
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	6.8E-2 1.3E-2 0	U.S. EPA, 1997c
Ba_{beef}	Biotransfer factor for beef (d/kg)		2.0E-2	U.S. EPA, 1997c
Ba_{milk}	Biotransfer factor for milk (d/kg)		2.0E-2	U.S. EPA, 1997c
Ba_{pork}	Biotransfer factor for pork (d/kg)		1.3E-4	U.S. EPA, 1997c
BCF	Fish bioconcentration factor (L/kg)		NA	
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	U.S. EPA, 1997c
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		3.0E-4	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

Table D-29. Chemical-Specific Inputs for Mercury - Elemental

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		1	U.S. EPA, 1997c
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		1.0E+3	U.S. EPA, 1997c
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		1.0E+3	U.S. EPA, 1997c
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		3E+3	U.S. EPA, 1997c
H	Henry’s law constant (atm-m^3/mol)		7.1E-3	U.S. EPA, 1997c
D_a	Diffusivity in air (cm^2/s)		5.5E-2	U.S. EPA, 1997c
D_w	Diffusivity in water (cm^2/s)		8.0E-6	EPA 1988
Transfer Factors				
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue]/[µg pollutant/g air])	leafy vegetables forage/silage	0	U.S. EPA, 1997c
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0	U.S. EPA, 1997c
Ba_{beef}	Biotransfer factor for beef (d/kg)		2.0E-2	U.S. EPA, 1997c
Ba_{milk}	Biotransfer factor for milk (d/kg)		2.0E-2	U.S. EPA, 1997c
Ba_{pork}	Biotransfer factor for pork (d/kg)		1.3E-4	U.S. EPA, 1997c
BCF	Fish bioconcentration factor (L/kg)		NA	
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	U.S. EPA, 1997c
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		NA	
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		3E-4	U.S. EPA, 1998

NA = Not applicable.

Table D-30. Chemical-Specific Inputs for Methylmercury

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		NA	
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		7E+3	U.S. EPA, 1997c
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		1.0E+5	U.S. EPA, 1997c
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		3E+3	U.S. EPA, 1997c
H	Henry's law constant (atm-m^3/mol)		4.7E-7	U.S. EPA, 1997c
D_a	Diffusivity in air (cm^2/s)		5.3E-2	U.S. EPA, 1997c
D_w	Diffusivity in water (cm^2/s)		8.0E-6	U.S. EPA, 1995a
Transfer Factors				
Bv	Air-to-plant biotransfer factor ([µg pollutant/g plant tissue]/[µg pollutant/g air])	leafy vegetables forage/silage	2.4E+3 5.0E+3	U.S. EPA, 1997c U.S. EPA, 1997c
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	1.5E-1 1.7E-2 0	U.S. EPA, 1997c U.S. EPA, 1997c U.S. EPA, 1997c
Ba_{beef}	Biotransfer factor for beef (d/kg)		2.0E-2	U.S. EPA, 1997c
Ba_{milk}	Biotransfer factor for milk (d/kg)		2.0E-2	U.S. EPA, 1997c
Ba_{pork}	Biotransfer factor for pork (d/kg)		1.3E-4	U.S. EPA, 1997c
BAF	Fish bioaccumulation factor - Trophic Level 3 (L/kg)		1.6E6	U.S. EPA, 1997c
BAF	Fish bioaccumulation factor - Trophic Level 4 (L/kg)		6.8E6	U.S. EPA, 1997c
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	a
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		1.0E-4	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-31. Chemical-Specific Inputs for Lead

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		2.8E+5	b
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		2.8E+5	c
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		2.8E+5	d
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([μg pollutant/g plant tissue DW]/[μg pollutant/g soil])	root vegetables	9.0E-3	Baes et al., 1984
		leafy vegetables	4.5E-2	Baes et al., 1984
		forage/silage	4.5E-2	Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		3E-4	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		2.5E-4	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		3e-4	e
BCF	Fish bioconcentration factor (L/kg)		NA	
BAF	Fish bioaccumulation factor (L/kg)		46	Stephan, 1993
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	f
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		NA	
URF	Unit risk factor (per μg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] Calculated for neutral pH conditions from an equation from U.S. EPA, 1992a:

$$\log Kd = 0.11 pH + 1.102$$

where Kd is soil-water partition coefficient (mL/g) and pH is soil pH, assumed to be 7 (neutral conditions).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

Footnotes for Table D-31 (continued)

[d] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[e] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[f] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-32. Chemical-Specific Inputs for Nickel

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		21	U.S. EPA, 1996
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		21	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		21	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0.008 0.032 0.11	U.S. EPA, 1992b U.S. EPA, 1992b U.S. EPA, 1992b
Ba_{beef}	Biotransfer factor for beef (d/kg)		0.006	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		0.001	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		0.006	d
BCF	Fish bioconcentration factor (L/kg)		0.8	Stephan, 1993
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		0.02	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		2.4E-4	U.S. EPA, 1998
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-33. Chemical-Specific Inputs for Selenium

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		5	U.S. EPA, 1996
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		5	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		5	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0.022 0.016 0.006	U.S. EPA, 1992b
Ba_{beef}	Biotransfer factor for beef (d/kg)		0.0076	Lorber & Rice, 1995
Ba_{milk}	Biotransfer factor for milk (d/kg)		0.0451	Lorber & Rice, 1995
Ba_{pork}	Biotransfer factor for pork (d/kg)		0.63	Lorber & Rice, 1995
BCF	Fish bioconcentration factor (L/kg)		NA	
BAF	Fish bioaccumulation factor (L/kg)		1258	Lemly, 1985
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.2	d
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		0.005	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-34. Chemical-Specific Inputs for Silver

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		0.4	Strenge and Peterson, 1989
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		0.4	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		0.4	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables	0.1	Baes et al., 1984
		leafy vegetables	0.4	Baes et al., 1984
		forage/silage	0.4	Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		0.003	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		0.02	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		0.003	d
BCF	Fish bioconcentration factor (L/kg)		0	Stephan, 1993
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		0.005	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-35. Chemical-Specific Inputs for Thallium (I)

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		0	a
Kd_s	Soil-water partition coefficient (mL/g or L/kg)		71	U.S. EPA, 1996
Kd_{sw}	Suspended sediment-surface water partition coefficient (L/kg)		71	b
Kd_{bs}	Bottom sediment-sediment pore water partition coefficient (L/kg)		71	c
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	0.0004 0.004 0.004	Baes et al., 1984 Baes et al., 1984 Baes et al., 1984
Ba_{beef}	Biotransfer factor for beef (d/kg)		0.04	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		0.002	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		0.04	d
BCF	Fish bioconcentration factor (L/kg)		67	U.S. EPA, 1992c
BAF	Fish bioaccumulation factor (L/kg)		NA	
Other Parameters				
F_w	Fraction of wet deposition that adheres to plant surfaces (dimensionless)		0.6	e
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		8E-5	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		NA	

NA = Not applicable.

[a] Constituent is a nonvolatile metal, therefore, it is assumed to be 100% in the particulate phase and 0% in the vapor phase.

[b] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[c] For metals, the K_d value for soil (Kd_s) was used to approximate the K_d values for suspended sediment (Kd_{sw}) and bottom sediment (Kd_{bs}).

[d] The pork biotransfer factor was assumed to equal the biotransfer factor for beef because no biotransfer factor for pork was available for this chemical.

[e] Derived from data in Hoffman et al., 1992. Hoffman et al. present experimental values of what they term "interception fraction," which corresponds in the methodology used here to the product of Rp and F_w. F_w values were estimated from the Hoffmann et al. values by dividing by an Rp of 0.47 for forage. The values used here apply to anions and correspond to moderate rainfall.

Table D-36. Chemical-Specific Inputs for Chlorine

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		1	a
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables	7E+1	Baes et al., 1984
		leafy vegetables	7E+1	
		forage/silage	7E+1	
Ba_{beef}	Biotransfer factor for beef (d/kg)		8E-2	Baes et al., 1984
Ba_{milk}	Biotransfer factor for milk (d/kg)		1.5E-2	Baes et al., 1984
Ba_{pork}	Biotransfer factor for pork (d/kg)		8E-2	b
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		1E-1	U.S. EPA, 1998
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)[a]		1E-3	c

[a] Gas presumed to exist entirely in vapor phase.
[b] Pork biotransfer factor set equal to beef.
[c] Provisional value developed by RTI.

Table D-37. Chemical-Specific Inputs for Hydrogen Chloride

Parameter	Definition		Value	Ref
Chemical/Physical Properties				
F_v	Fraction of pollutant air concentration present in the vapor phase (dimensionless)		1	
Transfer Factors				
Br	Soil-to-plant biotransfer factor ([µg pollutant/g plant tissue DW]/[µg pollutant/g soil])	root vegetables leafy vegetables forage/silage	NA	
Ba_{beef}	Biotransfer factor for beef (d/kg)		NA	
Ba_{milk}	Biotransfer factor for milk (d/kg)		NA	
Ba_{pork}	Biotransfer factor for pork (d/kg)		NA	
Health Benchmarks				
CSF	Cancer slope factor (per mg/kg/d)		NA	
RfD	Reference dose (mg/kg/d)		NA	
URF	Unit risk factor (per µg/m^3)		NA	
RfC	Reference concentration (mg/m^3)		2E-2	U.S. EPA, 1998

Table D-38. Data Sources for Fate and Transport Equations

Parameter	Definition	Value	Derivation
			Soil Concentration
Z	Soil mixing depth for soil ingestion (cm)	1	Reflects untilled soil (U.S. EPA, 1993)
BD	Soil bulk density (g/cm^3)	1.5	Based on mean for loam soil from Carsel et al. (1988). Also recommended as center of range of values in *Addendum* (U.S. EPA, 1993).
f_{oc}	Fraction of organic carbon in soil (unitless)	0.006	U.S. EPA, 1996
Vdv	Dry deposition velocity of vapors (cm/s)	0.2	The value for dioxins was taken from Koester and Hites, 1992. Dry deposition velocity was not used for the metals because they were considered to be nonvolatile.
θ_s	Soil volumetric water content (mL/cm^3)	0.2	Calculated per SEAM (U.S. EPA, 1988) $\theta_s = \theta_{sat}\left(\frac{Q}{K}\right)^{(\frac{1}{2b+3})}$ where (values from Carsel et al., 1988, for silt loam) θsat = Saturated volumetric water content of soil (0.45 mL/cm$_3$) Q = Average annual recharge rate (0.18 m/yr) K = Saturated hydraulic conductivity (0.45 m/h) b = Moisture retention exponent (5.3)
R	Universal gas constant (atm-m^3/mol-K)	8.205e-5	Standard value
μ_a	Viscosity of air (g/cm-s)	1.81e-4	*CRC Handbook* (Weast, 1979). Taken at standard conditions (temperature = 20 °C, pressure = 1 atm or 760 mm Hg).
ρ_a	Density of air (g/cm^3)	0.0012	*CRC Handbook* (Weast, 1979). Taken at standard conditions (temperature = 20 °C, pressure = 1 atm or 760 mm Hg).

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Terrestrial Food Chain			
Z	Soil mixing depth (cm)	20 tilled	Reflects tilled soil (U.S. EPA, 1993). Used in calculating concentrations in root vegetables and aboveground produce consumed by humans and in silage consumed by livestock.
		1 untilled	Reflects untilled soil (U.S. EPA, 1993). Used in calculating concentrations in forage and soil which is then consumed by livestock
kp	Plant surface loss coefficient (yr^{-1})	18	Corresponds to a half-life of 14 days, and reflects physical processes only, no chemical degradation (U.S. EPA, 1993)
Tp	Length of the plant's exposure to deposition per harvest (yrs)	0.12 forage	U.S. EPA, 1990. 45 days; based on the average of average period between successive hay harvests (60 days) and average period between successive grazing (30 days) in Belcher and Travis (1989). Used in calculating concentration in forage feed to cattle.
		0.16 other	U.S. EPA, 1990. 60 days; based on average period between successive hay harvests in Belcher and Travis (1989). Used in calculating concentration in aboveground produce and root vegetables consumed by humans and silage consumed by animals.

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Yp	Yield or standing crop biomass aboveground fruits and vegetables (kg DW/m^2)	0.25 fruits 3.0 above-ground vegetables	The value for Yp was calculated from data in Rice (1994a). Yp may be estimated from dry harvest yield (Yh) and area harvested (Ah): $$Yp \approx \frac{Yh}{Ah}$$ Here, Yp was estimated for fruits, fruiting vegetables, legumes, and leafy vegetables using U.S. average Yh and Ah values for a variety of fruits and vegetables for 1993; Yh values were converted to dry weight using average conversion factors for fruits, fruiting vegetables, legumes, and leafy vegetables. The following fruits and vegetables were included in each category: Fruits: apple, apricot, berry, cherry, cranberry, grape, peach, pear, plum/prune, strawberry Fr. veg: asparagus, cucumber, eggplant, sweet pepper, tomato Legumes: snap beans Leafy: broccoli, brussels sprout, cabbage, cauliflower, celery, lettuce, and spinach The calculated Yp values for fruiting vegetables, legumes, and leafy vegetables were then weighted by relative ingestion of each group to determine the weighted average Yp given here. Unweighted Yp (kg DW/m^2) and the ingestion rates (kg DW/d) used for weighing were as follows: Yp Intake Fr. veg. 10.5 4.2 Leafy 0.34 2.0 Legume 0.075 8.8

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Terrestrial Food Chain			
Yp	Yield or standing crop biomass (kg DW/m^2)	0.24 forage	Weighted average of crop yields for pasture grass (forage) and hay. Weights were based on the fraction of a year cattle could be pastured; the weights used here were 0.75 for pasture grass and 0.25 for hay, based on 9 months/year in pasture and 3 months per year not in pasture (and fed hay). Unweighted Yp values were 0.15 kg DW/m^2 for pasture grass (U.S. EPA, 1994b) and 0.5 for hay. The Yp for hay was estimated from dry harvest yield (Yh) and area harvested (Ah) (Rice, 1994a): $Yp \approx \frac{Yh}{Ah}$ Yh = 1.22E+11 kg DW: U.S. average Yh for hay for 1993 is 1.35E+11 kg (Rice, G., 1994a); this is converted to dry weight using a conversion factor of 0.9 (Rice, 1994a). Ah = 2.45E+11 m^2: U.S. average Ah for hay for 1993 (Rice, 1994a)
		0.8 silage	Production weighted U.S. average for silage (Rice, 1994a). Crop yield for grains was not used because it was considered a protected species.

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Rp	Interception fraction (dimensionless)	1.0E-2 fruits 7.4E-02 above-ground vegetables	Calculated (Rice, 1994a): $Rp = 1 - e^{-\gamma \cdot Yp}$ γ = empirical constant; 0.0846 for leafy vegetables; 0.0324 for fruits, fruiting vegetables, and legumes. Yp = estimated as shown above for fruits, fruiting vegetables, legumes, and leafy vegetables. The following fruits and vegetables were included in each category: Fruits: apple, apricot, berry, cherry, cranberry, grape, peach, pear, plum/prune, strawberry Fr. veg: asparagus, cucumber, eggplant, sweet pepper, tomato Legumes: snap beans Leafy: broccoli, brussels sprout, cabbage, cauliflower, celery, lettuce, and spinach The calculated Rp values for fruiting vegetables, legumes, and leafy vegetables were then weighted by relative ingestion of each group to determine the weighted average Rp given here. Unweighted Rp and the ingestion rates (kg DW/d) used for weighing were as follows: Rp Intake Fr. veg. 0.26 4.2 Leafy 0.016 2.0 Legume 0.002 8.8 The ingestion rates were presented as dry weight in U.S. EPA, 1992b.

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Terrestrial Food Chain			
Rp	Interception fraction (dimensionless)	0.5 forage	Calculated (Chamberlain, 1970): $$Rp = 1 - e^{-\gamma \cdot Yp}$$ γ = empirical constant; Chamberlain (1970) gives range as 2.3-3.33; the midpoint of the range, 2.88 is used (Baes et al., 1984) Yp = 0.24 kg DW/m^2 (see above)
		0.46 silage	Calculated from Yp of 0.8 for silage Interception fractions were not used for grains because it was considered a protected species.
VG_{ag}	Empirical correction factor that reduces produce concentration because Bv was developed for azalea leaves	varies	For dioxins, the VG_{ag} was assumed to be 0.01 for fruits and fruiting vegetables. For leafy vegetables and forage, VG_{ag} was assumed to equal 1 (U.S. EPA, 1994b). The VG_{ag} was assumed to be 0.5 for silage. The VG_{ag} was not used for grains because it was considered a protected species.
VG_{bg}	Empirical correction factor that reduces produce concentration	0.01 dioxins	For dioxins, the VG_{bg} was assumed to be 0.01 for root vegetables (U.S. EPA, 1994b).
		1.0 metals	For metals, the VG_{bg} was assumed to be 1.0 (U.S. EPA, 1993a).

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
	Terrestrial Food Chain		
Qp	Quantity of plant matter eaten by cattle (kg plant tissue DW/d		
	Subsistence Beef Farmer	8.8 forage 0.47 grain 2.5 silage	Forage intake = 75% of total dry matter intake (DMI) for beef cattle on subsistence farms (i.e., unsupplemented) (Rice, 1994b) Grain intake = 3.9% of total dry matter intake (DMI) for beef cattle on subsistence farms (i.e., unsupplemented) Silage intake = 21% of total dry matter intake (DMI) for beef cattle on subsistence farms (i.e., unsupplemented) DMI = 2% of body weight for beef cattle (Rice, 1994b) Average body weight for beef cattle = 590 kg (Rice, 1994b)
	Commercial Beef Farmer	3.8 forage 3.1 grain 1.0 silage	(Rice, 1994b). Values here include grain supplement during growing phase for beef cattle.
	Subsistence Dairy Farmer	13.2 forage 3.0 grain 4.1 silage	Forage intake = 65% of total dry matter intake (DMI) for dairy cattle on subsistence farms (Rice, 1994b) Grain intake = 15% of total dry matter intake (DMI) for dairy cattle on subsistence farms Silage intake = 20% of total dry matter intake (DMI) for dairy cattle on subsistence farms DMI = 3.2% of body weight for dairy cattle (Rice, 1994b) Average body weight for dairy cattle = 630 kg (Rice, 1994b)
	Commercial Dairy Farmer	6.2 forage 12.2 grain 1.9 silage	Taken from Rice (1994b)

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Terrestrial Food Chain			
Qs	Quantity of soil eaten by cattle (kg soil/d)		
	Subsistence Beef Farmer	0.5	Soil intake = 4% of DMI for beef cattle on subsistence farms (Rice, 1994b) DMI = 2% of body weight (Rice, 1994b) Average body weight for beef cattle = 590 kg (Rice, 1994b)
	Commercial Beef Farmer	0.25	(Rice, 1994b)
	Subsistence Dairy Farmer	0.4	Soil intake = 2% of DMI for dairy cattle on subsistence farms (Rice, 1994b) DMI = 3.2% of body weight (Rice, 1994b) Average body weight for dairy cattle = 630 kg (Rice, 1994b)
	Commercial Dairy Farmer	0.2	(Rice, 1994b)
Terrestrial Food Chain			
Qp	Quantity of plant matter eaten by hog (kg plant tissue DW/d)	3.0 grain 1.3 silage	Grain intake = 70% of average daily intake (U.S. EPA, 1990). Silage intake = 30% of average daily intake (U.S. EPA, 1990). Hogs are not grazing animals and are not assumed to eat forage.
Qs	Quantity of soil eaten by hogs (kg soil /d)	0.37	Soil intake = 8% of DMI for hogs (U.S. EPA, 1993)
F_d	Fraction of chicken diet that is soil (unitless)	0.1	Biotransfer factors for poultry were calculated for chickens consuming 10% of their diet as contaminated soil. (Stephens et al., 1992). Only chickens raised by subsistence poultry farmers were assumed to eat soil. These chickens consumed no contaminated grain. No consumption rate of soil is used in the calculation of dioxin concentration in poultry because the bioconcentration factor for poultry is unitless.

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Aquatic Food Chain			
Z	Soil mixing depth for watershed (cm)	1	Reflects untilled soil (U.S. EPA, 1993).
ER	Soil enrichment ratio (unitless)	3	(U.S. EPA, 1993).
T_w (also T_k)	Waterbody temperature (K)	298	Assumption; equals 25 °C.
K	USLE erodibility factor (ton/acre)[a]	0.34	National value for silt loam obtained for consistency with the national parameterization of other soil properties required for the model. STATSGO national soils data was used to estimate central tendency statistics for the more than 1,400 STATSGO map units across the country with silt loam soils and nonzero K values. All central tendency statistics (mean, median, mode, area-weighted mean) were 0.34.
K	USLE erodibility factor (ton/acre) *for farm ponds*	0.29	Average of default values provided in U.S. EPA, 1997c (western = 0.28; eastern = 0.30).
LS	USLE length-slope factor (unitless) *for farm ponds*	1.5	Average of default values provided in U.S. EPA, 1997c (2.5 for eastern location and 0.4 for western location)
C	USLE cover management factor (unitless) *for farm ponds*	0.8	The value for "cropland and pasture" and "other agricultural land" categories in a table on page 407 of *Stormwater Management* (Wanielista and Yousef, 1993).
P	USLE supporting practice factor (unitless) *for farm ponds*	1	Represents no erosion/runoff control measures (U.S. EPA, 1993).
b	Empirical slope coefficient for sediment delivery ratio calculation	0.125	U.S. EPA, 1993.

[a] Modeled waterbodies have site-specific values for all USLE parameters except K; a national default value was used for K. To maintain consistency with default values selected for farm ponds, a different default value was applied.

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Aquatic Food Chain			
a	Empirical intercept coefficient for sediment delivery ratio calculation	0.6-2.1	Depends on watershed area; values are as follows (U.S. EPA, 1993): (Note 1 sq. mile = 2.59x10^6 m^2) Watershed Area (sq. miles) — a $\leq$ 0.1 — 2.1 1 — 1.9 10 — 1.4 100 — 1.2 1,000 — 0.6
d_b	Depth of the upper benthic layer (m)	0.03	Based on center of range given in U.S. EPA, 1993
BS	Bed sediment concentration (g/cm^3)	1	U.S. EPA, 1993
θ_{bs}	Bed sediment porosity (L_{water}/L)	0.6	Calculated from bed sediment concentration (BS = 1, see above) and solids density (ρ_s = 2.65 g/cm^3) as follows U.S. EPA, 1993: $\theta_{bs} = 1 - \frac{BS}{P_s}$
θ	Temperature correction factor (unitless)	1.026	U.S. EPA, 1993
C_d	Drag coefficient (unitless)	0.0011	U.S. EPA, 1993

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Aquatic Food Chain			
ρ_w	Density of water (g/cm^3)	1	*CRC Handbook* (Weast, 1979).
k	von Karman's constant	0.4	U.S. EPA, 1993.
μ_w	Viscosity of water (g/cm-sec)[b]	1.69E-2	U.S. EPA, 1993.
λ_2	Dimensionless viscous sublayer thickness (unitless)	4	U.S. EPA, 1993.
f_{lipid}	Fish lipid content (fraction)	0.03	Great Lakes Water Quality Initiative apportioned by 36/64 percent TL 3 and TL 4 ingestion rates using 1997 EFH table 10-66 "Total Consumption of Freshwater Fish Caught by all Survey Respondents During the 1990 Season" (U.S. EPA, 1997a)
OC_{ss}	Fraction of organic carbon in suspended solids (unitless)	0.045	Corresponds roughly to a surface soil fraction organic carbon of 0.006.
OC_{sed}	Fraction organic carbon in bottom sediment (unitless)	0.014 0.024	Mean value, Suedel and Rodgers, 1991 Used to calculate Kd_{bs} for dioxins as Kd_{bs} = Koc * OC_{sed}. Value of OC_{sed} is 4*foc (U.S. EPA, 1993)

[b] Temperature-based viscosity of water calculated per U.S. EPA 1993; the equation as presented in U.S. EPA 1993 contains a typographical error that does not significantly impact risk results.

1997 EFH refers to U.S. EPA, 1997a.

(continued)

Table D-38. (continued)

Parameter	Definition	Value	Derivation
Breast Milk Exposure for Dioxins			
h	Half-life of dioxin in adults (days)	2555	U.S. EPA, 1994a
f_1	Proportion of ingested dioxin that is stored in fat (unitless)	0.9	U.S. EPA, 1994a
f_2	Proportion of mother's weight that is fat (unitless)	0.3	U.S. EPA, 1994a
f_3	Fraction of fat in breastmilk (unitless)	0.04	U.S. EPA, 1994a
f_4	Fraction ingested contaminant which is adsorbed (unitless)	0.9	U.S. EPA, 1994a

Table D-39. Intake Rates and Other Exposure Factors Applicable for All Cases

Parameter	Exposure Factor		Reference
Body Weight			
Body weight (kg)	Adult (>19 years)	71.8	Body Weights of Adults (kg) (1997 EFH Table 7-2)
	Adult female (>19 years)	65.4	Same
	Child (12-19 years)	58.3	Body Weights of Children (kg) (1997 EFH Table 7-3)
	Child (6-11 years)	30.7	Same
	Child (0-5 years)	14.3	Same
Inhalation of Air			
Intake rate of air (m^3/d)	Adult (>19 years)	13.3	EFH-recommended value
	Child (12-19 years)	14.0	Daily Inhalation Rates Calculated from Food-Energy Intakes (1997 EFH Table 5-11)
	Child (6-11 years)	11.8	Same
	Child (0-5 years)	6.5	Same
Ingestion of Drinking Water			
Intake of drinking water (L/d)	Adult (>19 years)	1.38	Total Tapwater Intake (mL/d) for Both Sexes Combined (1997 EFH Table 3-6)
	Child (12-19 years)	0.96	Same
	Child (6-11 years)	0.79	Same
	Child (0-5 years)	0.65	Same
Ingestion of Soil			
Intake of soil (g/d)	Adult (>19 years)	50	EFH Chapter 4 Recommendation
	Child (12-19 years)	100	Same
	Child (6-11 years)	100	Same
	Child (0-5 years)	179	Distribution of Average (Mean) Daily Soil Ingestion Estimates Per Child for 64 Children (mg/d) (1997 EFH Table 4-9)
Exposure Duration			
Exposure duration (yr)	Adult Farmer and Adult Subsistence Fisher (>19 years)	17.3	Values and Their Standard Errors for Average Total Residence Time, T, for Each Group in Survey (1997 EFH Table 15-163)
	Adult Non-farmer/ Non-Subsistence Scenario (>19 years)	13.5	Descriptive Statistics for Both Genders by Current Age (1997 EFH Table 15-168)
	Child (12-19 years)	9.1	Same
	Child (6-11 years)	8.9	Same
	Child (0-5 years)	6.5	Same
	Infant	1	U.S. EPA, 1994b

(continued)

Table D-39. (continued)

Parameter	Exposure Factor		Reference
Miscellaneous			
Lifetime/averaging time for carcinogens (yr)	70		Standard Value
Exposure frequency (d/yr)	350		Fields & Diamond, 1991
Loss-Adjusted Ingestion of Produce			
Intake of root vegetables (g whole weight/d)	Adult (>19 years) Child (12-19 years) Child (6-11 years) Child (0-5 years)	16.5 11.7 8.90 5.86	Consumer-Only Intake of Homegrown Exposed Root Vegetables (g/kg-day) (1997 EFH Table 13-65)
Intake aboveground produce (fruits and vegetables) (g DW/d)	Adult (>19 years) Child (12-19 years) Child (6-11 years) Child (0-5 years)	15.4 11.9 10.8 6.15	Consumer-Only Intake of Homegrown Exposed Fruit (g/kg-day) (1997 EFH Table 13-61), and Consumer-Only Intake of Homegrown Exposed Vegetables (g/kg-day) (1997 EFH Table 13-63)
Loss-Adjusted Ingestion of Animal Products			
Intake of beef (g FW/d)[a]	Adult (>19 years) Child (12-19 years) Child (6-11 years) Child (0-5 years)	79 55.4 65.7 25.7	Consumer-Only Intake of Home-Produced Beef (1997 EFH Table 13-36)
Intake of milk (g FW/d)[a]	Adult (>19 years) Child (12-19 years) Child (6-11 years) Child (0-5 years)	510 945 1083 1001	Consumer-Only Intake of Home-Produced Dairy (g/kg-day) (1997 EFH Table 13-28)
Intake of pork (g FW/d)[a]	Adult (>19 years) Child (12-19 years) Child (6-11 years) Child (0-5 years)	36.6 34.4 27.9 21.5	Consumer-Only Intake of Home-Produced Pork (1997 EFH Table 13-54)
Intake of chicken (g FW/d)	Adult (>19 years) Child (12-19 years) Child (6-11 years) Child (0-5 years)	45.2 37.3 39.9 24.3	Consumer-Only Intake of Home-Produced Poultry (1997 EFH Table 13-55)

(continued)

Table D-39. (continued)

Parameter	Exposure Factor		Reference
Intake of eggs (g FW/d)	Adult (>19 years) Child (12-19 years) Child (6-11 years) Child (0-5 years)	43.8 38.5 33.8 24.2	Consumer-Only Intake of Home-Produced Eggs (g/kg-day) (1997 EFH Table 13-43)
Ingestion of Fish			
Intake of fish (g/d)	Subsistence Fisher Adult (>19 years) Child (12-19 years) Child (6-11 years) Child (0-5 years)	 69.6 59.6 42.1 19.6	EFH-Recommended Values (Chapter 12), U.S. EPA, 1997a
	Recreational Fisher and Subsistence Farmer Adult (>19 years) Child (12-19 years) Child (6-11 years) Child (0-5 years)	 11.5 8.7 8.6 5.3	Mean Fish Intake Among Individuals Who Eat Fish and Reside in Households with Recreational Fish Consumption (1997 EFH Table 10-61)
Ingestion of Breastmilk by the Infant			
Ingestion rate of breastmilk (kg/d)	0.8		U.S. EPA, 1994a

[a] For cadmium and selenium, these consumption rates have to be multiplied by dry weight conversion factors before being used to calculate individual hazard quotients. The conversion factors are 0.4 and 0.1 for beef and milk, respectively (Lorber & Rice, 1995). The conversion factor for pork is assumed to equal that for beef.

1997 EFH refers to U.S. EPA, 1997a.

References

ATSDR (Agency for Toxic Substances and Disease Registry). 1992. *Toxicological Profile for Cobalt*. TP-91/10. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Baes, C.F., III, R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture*. Publication No. ORNL-5786. Prepared for U.S. Department of Energy. Oak Ridge National Laboratory, Oak Ridge, TN. pp. 10, 11, 50, and 51.

Barrows, M.E., S.R. Petrocelli, K.J. Macek, and J.J. Carroll. 1980. Chapter 24: Bioconcentration and elimination of selected water pollutants by bluegill sunfish (*Lepomis macrochirus*). In: *Dynamics, Exposure and Hazard Assessment of Toxic Chemicals,* R. Haque (ed.), Ann Arbor Science Publishers Inc., Ann Arbor, MI. pp. 379 to 392.

Bauer, K.M. 1992. *Multivariate Statistical Analyses of Dioxin and Furan Levels in Fish, Sediment, and Soil Samples Collected Near Resource Recovery Facilities*. *Final Report.* Prepared for Connecticut Department of Environmental Protection. Midwest Research Institute, Kansas City, MO.

Belcher, G.D., and C.C. Travis. 1989. *Modeling Support for the Rura and Municipal Waste Combustion Projects: Final Report on Sensitivity and Uncertainty Analysis for the Terrestrial Food Chain Model*. Interagency Agreement No. 1824-A020-A1. Prepared for U.S. Environmental Protection Agency. Oak Ridge National Laboratory, Office of Risk Analysis, Health and Safety Research Division, Oak Ridge, TN. pp. 18 to 20.

Canton, J.H., and W. Slooff. 1982. Toxicity and accumulation studies of cadmium (Cd^{2+}) with freshwater organisms of different trophic levels. *Ecotoxicology and Environmental Safety* 6:113-128.

Carsel, R.F., R.S. Parrish, R.L. Jones, J.L. Hansen, and R.L. Lamb. 1988. Characterizing the uncertainty of pesticide leaching in agricultural soils. *Journal of Contaminant Hydrology* 2:111-124.

Chamberlain, A.C. 1970. Interception and retention of radioactive aerosols by vegetation. *Atmospheric Environment* 4:57-78.

Eisler, R. 1985. Cadmium hazards to fish, wildlife, and invertebrates: a synoptic review. In: *Contaminant Hazard Reviews, Report No. 2*. U.S. Fish and Wildlife Service, U.S. Department of the Interior, Laurel, MD.

Fields, T., Jr., and B. Diamond. 1991. Human health evaluation manual, supplemental guidance: "standard default exposure factors". OSWER Directive 9285.6-03. Memorandum. U.S. Environmental Protection Agency, Washington, DC. March 25.

Geisey, J.P., Jr., G.J. Leversee, and D.R. Williams. 1977. Effects of naturally occurring aquatic organic fractions on cadmium toxicity to *Simocephalus serrulatus* (Daphnidae) and *Gambusia affinis* (Poeciliidae). *Water Research* 11:1013-1020.

Hoffman, F.O., K.M. Thiessen, M.L. Frank, and B.G. Blaylock. 1992. Quantification of the interception and initial retention of radioactive contaminants deposited on pasture grass by simulated rain. *Atmospheric Environment* 26A(18):3313-3321.

Koester, C.J., and R.A. Hites. 1992. Wet and dry deposition of chlorinated dioxins and furans. *Environmental Science and Technology* 26:1375-1382.

Kumada, H., S. Kimura, and M. Yokote. 1980. Accumulation and biological effects of cadmium in rainbow trout. *Bulletin of the Japanese Society of Scientific Fisheries* 46(1):97-103.

Kumada, H., S. Kimura, M. Yokote, and Y. Matida. 1972. Acute and chronic toxicity, uptake, and retention of cadmium in freshwater organisms. *Bulletin of Freshwater Fisheries Research Laboratory* 22(2):157-165.

Lemly, A.D. 1985. Toxicology of selenium in a freshwater reservoir: implications for environmental hazard evaluation and safety. *Ecotoxicology and Environmental Safety* 10:314-338.

Lorber, M. 1995. Development of an air-to-leaf vapor phase transfer factor for dioxins and furans. In: *Organohalogen Compounds: Proceedings of the 15th International Symposium on Chlorinated Dioxins and Related Compounds*, Volume 24, pp. 179-186. August 21-25, 1995, Edmonton, Canada.

Lorber, M., and G. Rice. 1995. Further issues for modeling the indirect exposure impacts from combuster emissions. Memorandum to Anna M. Burke, Marian Olsen, Deborah Forman, Elmer Akin, Carol T. Braverman, Mario Mangino, Gerald Carney, Jon Rauscher, Mary Rouse, Bob Fields, Suzanne Wuerthele, Arnold Den, Pat Cirone, Bob Ambrose, Joanne Griffith, and Alec McBride. U.S. Environmental Protection Agency, Washington, DC. January 20.

Rice, G. 1994a. Interception Fraction and Associated Parameters. Draft Working Papers (Unpublished). Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC.

Rice, G. 1994b. Quantity of Plants and Soil Consumed by Animal. Draft Working Papers (Unpublished). Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC.

RTI (Research Triangle Institute). 1994. *Chemical properties for soil screening levels* (Draft). 5629-240-03D. Research Triangle Park, NC.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter, II, and C.J.E. Welsh. 1997. *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants*. ORNL/TM-13391. Prepared for Office of Environmental Policy and Assistance, U.S. Department of Energy. Prepared by Oak Ridge National Laboratory, Oak Ridge, TN.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998a. *Development and Validation of Bioaccumulation Models for Small Mammals*. ES/ER/TM-219. Prepared for Office of Environmental Management, U.S. Department of Energy. Oak Ridge National Laboratory, Oak Ridge, TN.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II, and T.L. Ashwood. 1998b. *Development and Validation of Bioaccumulation Models for Earthworms*. ES/ER/TM-220. Prepared for Office of Environmental Management, U.S. Department of Energy. Oak Ridge National Laboratory, Oak Ridge, TN.

Stephan, C.E. 1993. *Derivation of Proposed Human Health and Wildlife Bioaccumulation Factors for the Great Lakes Initiative*. Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Duluth, MN.

Stephens, R.D., M.X. Petreas, and D.G. Hayward. 1992. Biotransfer and bioaccumulation of dioxins and dibenzofurans from soil. In: *Organohalogen Compounds: Proceedings of the 12th International Symposium on Dioxins and Related Compounds*, Volume 8, pp. 377-380.

Strenge, D.L., and S.R. Peterson. 1989. *Chemical Databases for the Multimedia Environmental Pollutant Assessment System (MEPAS): Version 1*. PNL-7415. Prepared for U.S. Department of Energy. Battelle Memorial Institute, Richland, WA. pp. 4.1 to 4.7.

Suedel, B.C., and J.H. Rodgers, Jr. 1991. Variability of bottom sediment characteristics of the continental United States. *Water Resources Bulletin* 27(1):101-109.

Taylor, D. 1983. The significance of the accumulation of cadmium by aquatic organisms. *Ecotoxicology and Environmental Safety* 7:33-42.

Travis, C.C., and A.D. Arms. 1988. Bioconcentration of organics in beef, milk, and vegetation. *Environmental Science and Technology* 22(3):271-274.

U.S. EPA (Environmental Protection Agency). n.d. *Risk Assessment Issue Paper for: Oral Reference Dose for Cobalt*. National Center for Environmental Assessment, Cincinnati, OH.

U.S. EPA (Environmental Protection Agency). 1984. *Health Effects Assessment for 2,3,7,8-Tetrachlorodibenzo-p-dioxin*. EPA/540/1-86-044. Office of Emergency and Remedial Response, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1988. *Superfund Exposure Assessment Manual*. EPA/540/1-88/001. Office of Remedial Response, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1990. *Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions* (Interim Final). EPA/600/6-90/003. Office of Health and Environmental Assessment, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1992a. *Background Document for Finite Source Methodology for Wastes Containing Metals*. HWEP-S0040. Office of Solid Waste, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1992b. *Technical Support Document for Land Application of Sewage Sludge. Volume I* . EPA 822/R-93-001a. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1992c. *TSC1292 Criteria Chart. 304(a) Criteria and Related Information for Toxic Pollutants*. Region IV - Water Management Division, Atlanta, GA.

U.S. EPA (Environmental Protection Agency). 1993. *Addendum to Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions* (External Review Draft). EPA/600/AP-93/003. Exposure Assessment Group, Office of Health and Environmental Assessment, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1994a. *Estimating Exposure to Dioxin-Like Compounds. Volume II: Properties, Sources, Occurrence and Background Exposures* (External Review Draft). EPA/600/6-88/005Cb. Office of Research and Development, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1994b. *Estimating Exposure to Dioxin-Like Compounds. Volume III: Site-specific Assessment Procedures*. EPA/600/6-88/005Cc. Office of Research and Development, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1994c. *User's Guide for Wastewater Treatment Compound Property Processor and Air Emissions Estimator (WATER8)*. EPA-453/C-94-080C. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

U.S. EPA (Environmental Protection Agency). 1995. WATER8. Version 4.0. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

U.S. EPA (Environmental Protection Agency). 1996. *Soil Screening Guidance Technical Background Document*. EPA/540/R/95/128. Office of Solid Waste and Emergency Response, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1997a. *Exposure Factors Handbook*. EPA/600/P-95/002Fa. Office of Research and Development, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1997b. *Health Effects Assessment Summary Tables. FY 1997 Update*. Prepared by International Consultants, Inc., for National Center for Environmental Protection, Cincinnati, OH.

U.S. EPA (Environmental Protection Agency). 1997. *Mercury Study Report to Congress. Volume III - Fate and Transport of Mercury in the Environment*. EPA 452/R-97/005. Office of Air Quality Planning and Standards and Office of Research and Development, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1998. Integrated Risk Information System (IRIS) Database. Cincinnati, OH. August.

Van den Berg, M., L.S. Birnbaum, A.T.C. Bosveld, B. Brunström, P.M. Cook, M. Feeley, J.P. Giesy, Jr., A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X.R. van Leeuwen, A.K.D. Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Wærn, and T. Zacharewski. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. *Environmental Health Perspectives* 106(12):775-792.

Wanielista, M.P., and Y.A. Yousef. 1993. *Stormwater Management*. John Wiley & Sons, Inc., New York, NY. pp. 399 to 410.

Weast, R.C. (ed). 1979. *CRC Handbook of Chemistry and Physics*. 60th Edition. CRC Press, Boca Raton, FL. pp. F-11 to F-58

Williams, D.R., and J.P. Geisey, Jr. 1978. Relative importance of food and water sources to cadmium uptake by *Gambusia affinis* (Poeciliidae). *Environmental Research* 16:326-332.

Appendix E

Particulate Matter (PM) Risk Assessment for the Proposed Combustor Emissions MACT Standard

Abt Associates Inc.
Hampden Square-Suite 600 ■ 4800 Montgomery Lane ■ Bethesda, MD 20814-5341 ■ (301) 913-0500

MEMORANDUM

TO: Tony Marimpietri and Zach Pekar, Research Triangle Institute

FROM: Amy Benson and Nathan Brodeur, Abt Associates Inc.

DATE: May 14, 1999

SUBJECT: Particulate Matter (PM) Risk Assessment for the Proposed Combustor Emissions MACT Standard

1.0 INTRODUCTION

This memorandum describes the method used to estimate changes in incidence of health effects resulting from the attainment of technical standards for PM emissions from hazardous waste combustion units. The changes in incidence are estimated using the Criteria Air Pollutant Modeling System (CAPMS), which has been used as the primary analytical tool for evaluating benefits attributable to the Clean Air Act and for evaluating proposed alternatives to the current PM and ozone national ambient air quality standards (NAAQS).

The method used in this analysis is described below. Specifically, this memorandum addresses: (1) the use of modeled PM concentrations in the analysis, (2) application of health effect concentration-response functions to the PM concentrations, (3) the method used to estimate the exposed population and baseline incidences for use with the concentration-response functions to estimate total reductions in incidence of health endpoints, and (4) the method used to sum results to present estimates aggregated over a year. Results of applying the method are aggregated for all facilities and presented separately by individual class of combustion unit. In addition, the results are presented for all health endpoints modeled in the analysis. However, because there is some overlap among health endpoints and populations modeled, suggestions are also made for how to avoid double counting of the presented effects.

2.0 USE OF PM CONCENTRATION DATA

The Research Triangle Institute (RTI) estimated ambient PM concentrations from five years of emissions data, for 1216 sectors associated with 76 sites containing hazardous waste combustion units. A "baseline" scenario was developed by RTI. The baseline reflects ambient PM conditions for the case in which no additional emissions controls (beyond those currently in place) are implemented. A "MACT control" scenario, with PM concentrations corresponding to the MACT control levels, was also developed.

Several types of modeled ambient PM concentrations were used in this analysis. Mean and median concentrations estimated using five years of data, and 24-hour average concentrations of both PM-2.5 and PM-10 measures were used[1]. The type of measure used in this analysis depends on the PM measure used in the epidemiology studies which from which the concentration-response functions were derived. The five-year mean and median concentrations were used with the concentration-response functions based on long-term PM concentrations (averaged over one or more years). The 24-hour average concentrations, in the custom distribution form described below, were used to evaluate concentration-response functions based on short-term PM concentrations averaged over one to several days.

2.1 CAPMS AIR QUALITY DATA FORMAT

For each air quality scenario, CAPMS requires that the temporal distribution of concentrations be described for each location and pollutant being examined for the entire period modeled. For efficiency, CAPMS uses a reduced form of the temporal distribution of concentrations rather than every modeled concentration in chronological order. The reduced form distribution, or concentration profile, is outlined below.

Concentration profiles can be developed for any averaging time (ranging from hourly and daily averages to annual means or medians). Averaging times are selected to match those reported by published epidemiological and/or clinical studies used to derive concentration-response relationships. Characterizing a year’s worth of air quality concentrations using an annual statistic, such as the mean or median, is straightforward; a single value describes ambient conditions in a given location across the entire year. For this analysis, RTI provided Abt Associates with five-year mean and five-year median PM concentrations which were used to evaluate the concentration-response functions based on long-term PM concentrations. Developing concentration profiles of pollutant concentrations for shorter averaging times, however, requires some data processing.

A custom distribution was created for shorter averaging times. In the custom distribution, the number of values describing pollutant concentrations across the modeled time period were reduced to 20. For example, the 365 24-hour averages across a year were reduced to 20 points by ranking the concentrations chronologically, apportioning them to 20 equally-sized bins, and taking the average value for each bin. The value in each bin is a central estimate of the daily average concentration for 1/20th of the year. A 20-point distribution must be provided for each location-pollutant-averaging time combination for both air quality scenarios (Baseline and MACT). CAPMS then uses the concentrations reported for each scenario to calculate the change in air quality (ΔQ) at each of the 20 points (MACT scenario concentrations are subtracted from corresponding Baseline concentrations).

For this analysis, RTI modeled five years of air quality data. Therefore, RTI predicted 1825 24-hour average PM concentrations across a five-year period. These 1825 24-hour average

---

[1] PM10 includes all air particles that are 10 µm in diameter and smaller; PM2.5 includes all particles that are 2.5 µm in diameter and smaller.

PM concentrations were then reduced to a 20-point distribution. For the purpose of benefits modeling, this 20-point distribution was then assumed to be representative of the distribution of 24-hour average PM concentrations across a single year. This 20-point custom distribution was then used to evaluate concentration-response functions which rely on short-term PM concentrations averaged over one to several days, as described below.

2.2 TRANSLATING AIR QUALITY IMPROVEMENTS INTO ANNUAL HEALTH BENEFITS USING THE CAPMS CUSTOM DISTRIBUTION

The concentrations from the custom distribution are used together with concentration-response functions to translate air quality improvements into estimates of avoided adverse health effects. For example, the number of avoided mortality cases attributable to short-term PM reductions can be estimated using the concentration-response function from Schwartz et al. (1996a). In this case, the function is evaluated using each of the 20 “daily” ΔQ values estimated as described in Section 2.1. Each of the resulting 20 estimates represents the number of mortality cases avoided each day during the period of the year associated with a given ΔQ value.

Each estimate of daily mortality cases avoided is multiplied by the number of days in the period (365 days per year/20 periods per year = 18.25 days per period) to derive a total number of cases for that period. An estimate of the annual number of avoided mortality cases is the sum of the estimates for the 20 periods. Estimates of the number of cases avoided are calculated in this manner for each modeled location. The general approach outlined for this PM mortality example applies to the evaluation of all concentration-response functions based on short-term average PM concentrations.

3.0 USE OF CONCENTRATION-RESPONSE FUNCTIONS

Epidemiological studies have estimated the relationship between PM and health endpoints in different geographic locations. The concentration-response functions estimated by these studies differ from each other in several ways. They may have different functional forms; they may have measured PM concentrations in different ways; they may have characterized the health endpoint, y, in slightly different ways; or they may have considered different types of populations. For example, some studies of the relationship between ambient PM concentrations and mortality have excluded accidental deaths from their mortality counts; others have included all deaths. One study may have measured daily (24-hour) average PM concentrations while another study may have used two-day averages. Some studies have assumed that the relationship between y and PM is best described by a linear form (i.e., the relationship between y and PM is estimated by a linear regression in which y is the dependent variable and PM is one of several independent variables). Other studies have assumed that the relationship is best described by a log-linear form (i.e., the relationship between the natural logarithm of y and PM is estimated by a linear regression).[2] Finally, some studies have considered changes in the health endpoint only

---

[2] The log-linear form used in the epidemiological literature on PM-related health effects is often referred to as “Poisson regression” because the error term in the regression is assumed to have a Poisson distribution rather than the usual normal distribution. The form of the regression, however, is still log-linear.

among members of a particular subgroup of the population (e.g., individuals 65 and older), while other studies have considered the entire population in the study location. Furthermore, some of the epidemiological studies measuring the relationship between PM air pollution and adverse effects quantify the relationship in terms of PM-10, while others focus exclusively on the fine fraction, PM-2.5. (Because modeled predictions of the change in ambient PM-10 and PM-2.5 concentrations are both available, this analysis evaluated each concentration-response function using the appropriate PM indicator.)

To estimate changes in health effects in this analysis, CAPMS applies the concentration-response functions available in epidemiological studies to changes in PM concentrations between the baseline and the control air quality scenarios investigated. Several issues related to the use of the concentration-response functions are described in the following sections. Section 3.1 describes the health effects modeled in this analysis and issues related to the overlap in these effects; Section 3.2 describes the type functional forms of the majority of concentration-response functions used in this analysis; and Section 3.3 describes how concentration-response functions are “pooled” before being used to estimate changes in health effects. Exhibit 3.1 summarizes the concentration-response functions used to quantify changes in health effects in this analysis. Much of the discussion in the following sections is taken from the Retrospective Analysis of the Clean Air Act (U.S. EPA, 1997a) and documents supporting the Regulatory Impact Analysis of the Particulate Matter and Ozone NAAQS (U.S. EPA, 1997b). Additional information is included where necessary.

3.1 Description and Overlap of Health Effects Modeled

Epidemiological studies that have estimated relationships between ambient PM concentrations and health effects are available for several health effects and several different population groups. The broad categories of health endpoints for which concentration-response functions have been estimated based on measures of PM are:

(1) mortality,
(2) hospital admissions, and
(3) respiratory symptoms and restricted activity days (not requiring hospitalization).

The health endpoints included in each of these categories and the possible overlap among health effects and populations studied are described below. Descriptions of the populations investigated in the relevant studies are important because, in most cases, the concentration-response functions from these studies are applied only to the subpopulation (e.g., asthmatic children) investigated in the epidemiological study.

Exhibit 3.1 Concentration-Response Functions Used to Estimate Health Effects Associated with Exposure to Particulate Matter

	Concentration-Response Function		PM Averaging Time				
Endpoint	**Source**	**Functional Form**	**Studied**	**Applied**	**Population[a]**	**Annual Baseline Incidence (per 100,000 population)[b]**	**Pollutant Coefficient[c]**
Mortality							
Mortality (Long-Term exposure), using PM2.5 indicator	Pope et al., 1995	log-linear	median of four years of data	annual median[d]	ages 30+	759 (number of nonaccidental deaths in the population ages 30 + divided by 100,000 individuals of all ages .)	0.006408
Mortality (Short-Term exposure), using PM2.5 indicator	Schwartz et al., 1996a (Boston, Knoxville, St. Louis, Steubenville, Portage & Topeka)	log-linear	2-day average	1-day average[e]	all	803 (nonaccidental deaths in general pop.)	0.001433
Mortality (Short-Term exposure), using PM10 indicator[e]	Ito & Thurston, 1996 (Chicago)	log-linear	2-day average	1-day average[f]	all	803 (nonaccidental deaths in general pop.)	0.000782
	Kinney et al., 1995 (Los Angeles)	log-linear	1-day average		all		
	Pope et al., 1992 (Utah)	log-linear	5-day average		all		
	Schwartz, 1993a (Birmingham)	log-linear	3-day average		all		
	Schwartz et al., 1996a (Boston)	log-linear	2-day average		all		
	Schwartz et al., 1996a (Knoxville)	log-linear	2-day average		all		
	Schwartz et al., 1996a (St. Louis)	log-linear	2-day average		all		
	Schwartz et al., 1996a (Steubenville)	log-linear	2-day average		all		
	Schwartz et al., 1996a (Portage)	log-linear	2-day average		all		
	Schwartz et al., 1996a (Topeka)	log-linear	2-day average		all		

(continued)

Exhibit 3.1 (continued)

Endpoint	Concentration-Response Function		PM Averaging Time		Population[a]	Annual Baseline Incidence (per 100,000 population)[b]	Pollutant Coefficient[c]
	Source	Functional Form	Studied	Applied			
Hospital Admissions							
All respiratory illnesses, using PM2.5 indicator	Thurston et al., 1994 (Toronto)	linear	1-day average	1-day average	all	n/a	3.45 X 10^{-8} [f]
All respiratory illnesses, using PM10 indicator	Schwartz, 1995 (Tacoma)	log-linear	1-day average	1-day average	age 65+	504 (general pop.)	0.00170
	Schwartz, 1995 (New Haven)	log-linear	1-day average		age 65+		
	Schwartz, 1996 (Spokane)	log-linear	1-day average		age 65+		
COPD, using PM10 indicator	Schwartz, 1994a (Birmingham)	log-linear	1-day average	1-day average	age 65+	103 (general pop.)	0.002533
	Schwartz, 1994b (Detroit)	log-linear	1-day average		age 65+		
	Schwartz, 1996 (Spokane)	log-linear	1-day average		age 65+		
Pneumonia, using PM10 indicator	Schwartz, 1994a (Birmingham)	log-linear	1-day average	1-day average	age 65+	229 (general pop.)	0.0013345
	Schwartz, 1994b (Detroit)	log-linear	1-day average		age 65+		
	Schwartz, 1994c (Minneapolis)	log-linear	1-day average		age 65+		
	Schwartz, 1996 (Spokane)	log-linear	1-day average		age 65+		
Congestive heart failure, using PM10 indicator	Schwartz and Morris, 1995 (Detroit)	log-linear	2-day average	1-day average	age 65+	231 (general pop.)	0.00098
Ischemic heart disease, using PM10 indicator	Schwartz & Morris, 1995 (Detroit)	log-linear	1-day average	1-day average	age 65+	450 (general pop.)	0.00056

(continued)

Exhibit 3.1 (continued)

Endpoint	Concentration-Response Function		PM Averaging Time		Population[a]	Annual Baseline Incidence (per 100,000 population)[b]	Pollutant Coefficient[c]
	Source	Functional Form	Studied	Applied			
Respiratory Symptoms/Illnesses not requiring hospitalization							
Chronic bronchitis, using PM10 indicator	Schwartz, 1993b		annual mean	annual mean	all	n/a	0.012
Acute bronchitis, using PM2.5 indicator	Dockery et al., 1989	logistic	annual mean	annual mean[d]	ages 10-12	n/a	0.0298
Upper respiratory symptoms (URS), using PM10 indicator	Pope et al., 1991	log-linear	1-day average	1-day average	asthmatics, ages 9-11	38,187 (applied pop.)	0.0036
Lower respiratory symptoms (LRS), using PM2.5 indicator	Schwartz et al., 1994	logistic	1-day average	1-day average	ages 8-12	n/a	0.01823
MRADs, using PM2.5 indicator	Ostro and Rothschild, 1989	log-linear	2-week average	1-day average	ages 18-65	780,000 days/year (applied pop.)	0.00741
RADs, using PM2.5 indicator	Ostro, 1987	log-linear	2-week average	1-day average	ages 18-65	400,531 days/year (applied pop.)	0.00475
Acute respiratory symptoms (any of 19), using PM10 indicator	Krupnick et al., 1990	logistic	1-day average COH	1-day average	ages 18-65 (study examined “adults”)	n/a	0.00046
Shortness of breath (days), using PM10 indicator	Ostro et al., 1995	logistic	1-day average	1-day average[d]	African-American asthmatics, ages 7-12	n/a	0.00841

(continued)

Exhibit 3.1 (continued)

Endpoint	Concentration-Response Function		PM Averaging Time		Population[a]	Annual Baseline Incidence (per 100,000 population)[b]	Pollutant Coefficient[c]
	Source	Functional Form	Studied	Applied			
Work loss days (WLDs), using PM2.5 indicator	Ostro, 1987	log-linear	2-week average	1-day average	ages 18-65	150,750 days/year (applied pop.)	0.0046

NOTES:

[a] The population examined in the study and to which this analysis applies the reported concentration-response relationship. In general, epidemiological studies analyzed the concentration-response relationship for a specific age group (e.g., ages 65+) in a specific geographical area. This analysis applies the reported pollutant coefficient to all individuals in the age group nationwide.

[b] annual baseline incidence in the applied population per 100,000 individuals in the indicated population. For hospital admissions and mortality, the national baseline incidence rates are meant to provide the reader with a general perspective of the potential magnitude of the baseline incidence; for other endpoints, the annual baseline incidence estimates were taken directly from the epidemiological literature and were applied to all sectors in the analysis.

[c] a single pollutant coefficient reported for several studies indicates a pooled analysis; see text for discussion of pooling concentration-response relationships across studies.

[d] The following studies report a lowest observed pollution level:

Pope et al., 1995	Mortality (long-term exposure)	$9\ \mu\text{g/m}^3\ \text{PM}_{2.5}$
Dockery et al., 1995	Acute Bronchitis	$11.8\ \mu\text{g/m}^3\ \text{PM}_{2.5}$ ($20.1\ \mu\text{g/m}^3\ \text{PM}_{10}$)
Ostro et al., 1995	Shortness of Breath, days	$19.63\ \mu\text{g/m}^3\ \text{PM}_{10}$

The remaining studies did not report lowest observed concentrations.

[e] Pooling of the ten studies used for this endpoint is described in EPA (1996).

[f] All 1-day averages are 24-hour averages, 2-day averages are 48-hour averages, etc.

* See U.S. EPA 1997 for citations

Mortality Studies

The studies that associate PM exposures with premature mortality presented in this analysis differ primarily in the type of PM exposure which is used as input to the concentration response functions (i.e., whether PM2.5 or PM10 is used and whether short-term or long-term exposure is used). The mortality studies also differ slightly in the populations studied. Brief descriptions of the mortality studies used in this analysis and the issues related to the overlap in the incidence predicted from these studies are discussed here.

One long-term exposure study is presented here. Pope et al. (1995) is a prospective cohort study which investigated the association between long-term exposure to ambient PM2.5 concentrations (measured in the study as the median of all daily concentrations measured over a four-year period) and mortality in a cohort of adults thirty years and older.[3]

Two estimates of the relationship between mortality and short-term exposure to PM are presented. One estimate is from a pooled analysis of 10 individual studies, in which PM-10 concentrations are averaged over a period of 1 to 5 days. The second estimate is taken from Schwartz et al. (1996), and uses a 2-day average PM-2.5 measure. In both cases, short-term exposure is related to daily mortality for the full population.

Long-term studies may be preferable to “short-term” (daily average) studies for estimating health effects for a couple of reasons. First, by their basic design, daily studies detect acute effects but cannot detect the effects of long-term exposures. A chronic exposure study design (a prospective cohort study) is best able to identify the long-term exposure effects, and will likely detect some of the short-term exposure effects as well.

The second reason that long-term studies may be preferable to short-term studies is that long-term study results may be less likely to be affected by deaths that are premature by only a very short amount of time. Critics of the use of short-term studies for policy analysis purposes correctly point out that an added risk factor that results in terminally ill individuals dying a few days or weeks earlier than they otherwise would have (a phenomenon referred to as “harvesting”) is potentially included in the measured PM mortality “signal” detected in such a study. Because the short-term study design does not examine individual people (but instead uses daily mortality rates in large, typically city, populations), it is impossible to know anything about the overall health status of the people who die on any given day. While some of the excess deaths associated with peak PM exposures may have resulted in a substantial loss of life (measuring loss of life in terms of lost years of remaining life), others may have resulted in a relatively short amount of lifespan lost. While it is not clear that the results of prospective cohort (long-term) studies are completely unaffected by “harvesting,” because they follow individuals such studies are better able to examine the health status of individuals who die during the course of the study.

---

[3] Dockery et al., 1993, is another study relating long-term exposures to PM to premature mortality. However, the study by Pope et al. considered a much larger population and included many more locations (52 cities versus six in the Dockery study). The Pope study is therefore considered to be preferable.

Although long-term exposure studies may be preferable, only one is presented in this analysis. Therefore, results of studies which use short-term PM exposures are also presented in this analysis for comparison. However, because a long-term exposure study may detect some of the same short-term exposure effects detected by short-term studies, including both types of study in a benefit analysis would likely result in some degree of double counting of benefits.

Hospital Admissions Studies

Several studies have investigated the association between ambient PM concentrations and increased hospital admissions for a variety of ailments and among different population groups. These studies and the issues of overlap among the endpoints and populations investigated are described below. All of these studies compare PM concentrations averaged over one to two days with daily hospital admissions.

Hospital Admissions for Respiratory Illnesses

Several studies have investigated hospital admissions specifically for respiratory ailments. Two estimates are available for hospital admissions for "all respiratory illnesses". The first study, Thurston et al. (1994), investigated respiratory admissions for individuals of all ages. The pooled analysis using information from Schwartz (1995 and 1996) estimates all respiratory hospital admissions for individuals aged 65 years and older. Studies of hospital admissions for chronic obstructive pulmonary disease (COPD) and pneumonia, which are both subsets of hospital admissions for all respiratory diseases are also presented.

Because Thurston et al. (1994) includes hospital admissions for a large group of respiratory illnesses and all age groups, this study is the most comprehensive and is therefore considered to be the most appropriate study for predicting changes in hospital admissions for respiratory illnesses related to PM exposure. Because Schwartz (1994a,b,c; 1996) estimates incidence for a subset of hospital admissions counted by Thurston et al. (1994), the incidence predicted by the Schwartz studies should not be added to the incidence predicted by Thurston et al. (1994).

Hospital Admissions for Cardiac Disease

Hospital admissions for ischemic heart disease and congestive heart failure related to PM exposure have been investigated by Schwartz and Morris (1995). These admissions are not included in the group of respiratory illness hospital admissions. In addition, there is no overlap between hospital admissions for ischemic heart disease and admissions for congestive heart failure. Therefore, they can both be counted as benefits associated with reducing exposure to PM.

Respiratory Symptoms and Restricted Activity Days

Several studies have investigated changes in a variety of respiratory symptoms not requiring admission to the hospital. These studies have investigated illnesses in both the general population and in asthmatic individuals; many of the studies have used children as the study population. The types of symptoms investigated and issues related to potential overlap among the symptoms examined in these studies are described here. Because some of these symptoms may vary only slightly among the studies, there is considerable overlap among the health effects investigated in these studies. Exhibit 3.2 defines the symptoms and the populations investigated for each of the studies presented in this analysis.

Exhibit 3.2 Descriptions of Studies of Respiratory Symptoms not Requiring Hospitalization

Health Endpoint, PM Indicator	Definition of Health Endpoint	Population Studied	Reference
Chronic bronchitis, using PM10 indicator	Chronic bronchitis was defined as positive responses to the following questions: (1) whether a doctor had ever told the subject that he or she had chronic bronchitis, and (2) whether he or she still had bronchitis at the time of the study.	all	Schwartz, 1993
Acute bronchitis, using PM2.5 indicator	Bronchitis was defined as a doctor's diagnosis of bronchitis reported within the year prior to the study. Occurrence of bronchitis diagnosed during the year was compared with the annual mean PM concentration reported during the year.	ages 10-12	Dockery et al., 1989
Upper respiratory symptoms (URS), using PM10 indicator	URS includes runny or stuffy nose; wet cough; and burning, aching, or red eyes. Presence of symptoms on a given day were compared with the PM concentration on the same day.	asthmatics, ages 9-11	Pope et al., 1991
Lower respiratory symptoms (LRS), using PM2.5 indicator	LRS is the presence of at least two of the following symptoms: cough, chest pain, phlegm, or wheeze. Presence of symptoms on a given day was compared with PM concentrations measured on the previous day; symptoms were counted only if they were not present on the previous day.	ages 8-12	Schwartz et al., 1994

(continued)

Exhibit 3.2 (continued)

Health Endpoint, PM Indicator	Definition of Health Endpoint	Population Studied	Reference
Minor Restricted Activity Days (MRADs), using PM2.5 indicator	An MRAD is a day in which an individual restricts his or her activity due to either respiratory or nonrespiratory symptoms; an MRAD does not result in either work loss or bed disability Occurrence of MRADs was compared with PM concentrations averaged over a 2 week period.	ages 18-65	Ostro and Rothschild, 1989
Restricted Activity Days (RADs), using PM2.5 indicator	A RAD is a day in which an individual restricts his activity; RADs include both days of work loss or bed disability as well as minor restrictions. Occurrence of RADs was compared with 2-week average PM concentrations.	ages 18-65	Ostro, 1987
Acute respiratory symptoms (any of 19), using PM10 indicator	The study measured daily presence of any of 19 symptoms, including chest discomfort, coughing, wheezing, sore throat, cold, doctor-diagnosed flu, asthma, hay fever [all symptoms considered were not reported in the study]	adults	Krupnick et al., 1990
Shortness of breath, using PM10 indicator	The study measured daily presence of shortness of breath.	African-American asthmatics, ages 7-12	Ostro et al., 1995
Work loss days (WLDs), using PM2.5 indicator	Days of work loss were compared with 2-week average PM concentrations.	ages 18-65	Ostro, 1987

Respiratory Illnesses Measured in the General Population

There may be some overlap between bronchitis studied by Dockery et al. (1989) and chronic bronchitis defined by Schwartz (1993). In particular, Dockery et al. (1989) considered the effects of PM exposure on bronchitis which was diagnosed by a doctor within the previous year, which may include some of the same types of cases investigated by Schwartz (1993). Although the bronchitis measured in Dockery et al. (1989) is likely to include more cases of acute bronchitis than the bronchitis cases measured by Schwartz (1993), the measure in Dockery et al. (1989) may also include some cases of chronic bronchitis, if the cases diagnosed in the year prior to the study continue into future years. For this reason, and because the populations studied overlap each other, the estimates of avoided incidence based on these studies are not necessarily mutually exclusive. However, both studies give valuable information regarding the incidence of bronchitis avoided in two different population groups.

Lower respiratory symptoms (LRS) as described in Schwartz et al. (1994) are distinct from doctor-diagnosed bronchitis, and therefore do not overlap with the avoided cases of bronchitis.

There are several aggregation issues related to the set of endpoints that are studied in adults. Acute respiratory symptoms (any of 19 symptoms) studied by Krupnick et al. (1990) may overlap with minor restricted activity days (MRADs) studied by Ostro and Rothschild (1989), because the age ranges of the populations studied are the same, and it is possible that an acute respiratory symptom could result in a minor respiratory restricted activity day. The degree of overlap, however, is not known, and it is possible that some of the benefit associated with each endpoint is not included within the benefit associated with the other endpoint.

MRADs and Work Loss Days (WLDs) are defined specifically as mutually exclusive endpoints (Ostro and Rothschild, 1989). Both of these estimates (MRADs and WLDs) are subsets of Restricted Activity Days (RADs). However, because the concentration-response functions for RADs and MRADs were estimated by different studies, there is no guarantee that the predicted incidence of MRADs will be less than the predicted incidence of RADs.

Respiratory Illnesses Measured in the Asthmatic Population

Three studies in Exhibit 3.2 measured respiratory illnesses exclusively in asthmatic individuals. Pope et al. (1991) studied upper respiratory symptoms (URS) in children aged 9-11. Ostro et al. (1995) measured shortness of breath among African-American asthmatics aged 7-12.[4] Estimates using Pope et al. (1991) do not appear to overlap with estimates predicted using Ostro et al. (1995).

3.2 Functional Forms of the Concentration Response Functions Used in the Health Effects Studies

The concentration-response functions presented in the available health effects studies estimate a change in health effects associated with a change in PM. The estimated relationship between PM and a health endpoint in a study location is specific to the type of population studied, the measure of PM used, and the characterization of the health endpoint considered. When using a concentration-response function estimated in an epidemiological study to estimate changes in the incidence of a health endpoint corresponding to a particular change in PM, it is

---

[4] Another study, Ostro et al. (1991), measured days of moderate or worse asthma status in adults. Although this study investigated health effects in a population (asthmatics) which is important to consider, the concentration-response function from the study was not used in the current analysis because the incidence estimated using the study is very sensitive to the actual baseline and control scenario air quality data. Because this analysis uses only at the air quality contributed only by hazardous waste combustors without adding other ambient anthropogenic and natural air concentrations, the actual incidence could not be estimated.

important that the inputs be appropriate for the concentration-response function being used. For example, it is important that the measure of PM, the type of population, and the characterization of the health endpoint be the same as (or as close as possible to) those used in the study that estimated the concentration-response function.

Estimating the relationship between PM and a health endpoint, y, consists of (1) choosing a functional form of the relationship and (2) estimating the values of the parameters in the function assumed. The two most common functional forms in the epidemiological literature on PM and health effects are the log-linear and the linear relationship. The log-linear relationship is of the form

$$y = Be^{\beta PM} \quad , \tag{1}$$

or, equivalently,

$$\ln(y) = \alpha + \beta PM \quad , \tag{2}$$

where the parameter B is the incidence of y when the concentration of PM is zero, the parameter β is the coefficient of PM, ln(y) is the natural logarithm of y, and $\alpha = \ln(B)$. If the functional form of the concentration-response relationship is log-linear, the relationship between ΔPM and Δy is

$$\Delta y = y[e^{\beta * \Delta PM} - 1] \quad , \tag{3}$$

where y is the baseline incidence of the health effect (i.e., the incidence before the change in PM). For a log-linear concentration-response function, the relative risk (RR) associated with the change (ΔPM) is

$$RR_{\Delta PM} = e^{\beta * \Delta PM} \quad . \tag{4}$$

Epidemiological studies often report a relative risk for a given ΔPM, rather than the coefficient, β, in the concentration-response function. The coefficient can be derived from the reported relative risk and ΔPM by solving for β in equation (4):

$$\beta = \ln(RR)/\Delta PM \quad . \tag{5}$$

The linear relationship is of the form

$$y = \alpha + \beta PM \quad , \tag{6}$$

where α incorporates all the other independent variables in the regression (evaluated at their mean values, for example) multiplied by the respective coefficients. If the functional form of the concentration-response relationship is linear, the relationship between ΔPM and Δy is simply

$$\Delta y = \beta * \Delta PM \quad . \tag{7}$$

A few epidemiological studies have used functional forms other than linear or log-linear forms. Of these, logistic regressions were the most common. The details of the models used in these studies are given in the papers reporting the methods and results of the studies.

The input components (including PM averaging time, the applied population, and the baseline incidence) necessary to estimate incidence changes using concentration-response functions from individual studies are shown in Exhibit 3.1. In the case of PM averaging time, both the averaging time used in the epidemiological study (indicated as “Studied” in Exhibit 3.1), and the averaging time used to estimate sector-specific incidence changes in this analysis (indicated as “Applied” in Exhibit 3.1) are presented.

3.3 Pooling Several Concentration-Response Functions to Estimate one Concentration-Response Function

When there are several estimates of the relationship between PM and a given health endpoint (perhaps using estimates from different studies or different geographic locations), the results of the studies can be pooled to derive a single estimate. In this analysis, several studies were pooled to obtain a “central tendency” concentration response function if the functional forms, pollutant averaging times, and study populations were judged to be similar enough among the studies or locations.

The method in which the estimates of PM coefficients from different studies are used in a pooled analysis depends on the underlying assumption about how the different estimates are related to each other. It is reasonable that a “pooled estimate” which combines the estimates from different studies should give more weight to estimates from studies with little reported uncertainty than to estimates with a great deal of uncertainty.

The analysis presented here assumes that there is a distribution of PM coefficients (β’s), rather than one estimate of the relationship between PM and a given health effect. Specifically, the coefficients reported in different studies or different geographic locations may be estimates of *different* underlying PM coefficients, rather than just different estimates of the same PM coefficient. Therefore, this analysis uses the random-effects model to pool results from different studies, because the random effects model does not assume that all studies are estimating the same parameter.[5]

Five separate pooled analyses using the random-effects model were carried out in this analysis:

(1) An analysis of PM-10 mortality, using the ten short-term exposure PM-10 studies,

---

[5] In studies of the effects of PM-10 on mortality, for example, if the composition of PM-10 varies among study locations, the underlying relationship between mortality and PM-10 may be different from one study location to another. For example, fine particles make up a greater fraction of PM-10 in Philadelphia County than in Southeast Los Angeles County. If fine particles are disproportionately responsible for mortality relative to coarse particles, then one would expect the true value of β for PM-10 in Philadelphia County to be greater than the true value of β for PM-10 in Southeast Los Angeles County.

(2) An analysis of PM-2.5 mortality, using six different locations at which concentration-response functions for mortality and short-term exposure to PM2.5 were estimated by Schwartz et al. (1996),

(3) An analysis of respiratory illness hospital admissions, using three "all respiratory illness" hospital admissions studies,

(4) An analysis of COPD hospital admissions, using three studies, and

(5) An analysis of pneumonia hospital admissions, using four pneumonia hospital admissions studies.

For those health-effects studies which used PM concentrations averaged over one to several days (e.g., mortality studies), PM concentrations averaged over one day were used in this analysis, because daily averages are the only short-term air quality measurements available as described in Section 2.0. The health effects studies which use multi-day averages are in effect using a smoothed data set, comparing each day's mortality to recent average exposure rather than to exposure on the same day that the health effect was observed. The more nearly linear the concentration-response function, however, the less difference it makes whether multi-day averaging functions are used with single-day PM data.[6] The concentration-response functions considered here are nearly linear.

4.0 ESTIMATES OF BASELINE INCIDENCES USED WITH LOG-LINEAR FUNCTIONS AND EXPOSED POPULATIONS

Some types of concentration-response functions used in this analysis estimate health effects in given subpopulations. To use these functions, the analysis requires an estimate of the size of such subpopulations.[7] For example, the Schwartz (1995, 1996) study of hospital admissions for all respiratory symptoms examined respiratory hospital admissions for people ages 65 and over. Therefore, in order to estimate the change in incidence of respiratory hospital admissions predicted by the Schwartz (1995, 1996) study for a given change in air quality, it is necessary to have an estimate of the number of persons aged 65 and older that are exposed to that air quality change. The general method of using available data to make baseline and sub-population estimates is described below.

Other concentration-response functions require baseline incidences because these functions estimate changes in risk as a percent change in incidence between the baseline and the control scenarios. To use these functions, the analysis requires an estimate of the baseline

---

[6] If the functions were perfectly linear, using one day averages rather than multi-day averages would make no difference at all.

[7] Although the concentration-response functions might be applicable to a wider segment of the population than was included in the epidemiological study of interest, this was not done in the current analysis.

incidence of the health effect being studied. "Baseline" incidences are those expected to occur under conditions where the MACT standard has not been implemented.

4.1 EXPOSED POPULATIONS

This analysis focuses on sectors (which are geographic areas generally smaller than counties) that are associated with particular hazardous waste combustion units. Each hazardous waste facility has 16 sectors associated with it, which form concentric circles radiating out from the combustion stack. These sectors are situated at varying distances from the stack and have varying pollutant concentrations, as well as varying exposed populations. As noted above, in order to evaluate concentration-response functions which examine a specific sub-population (ages 65 and over, for example), it is necessary to have estimates of the number of people in a particular population subgroup that are exposed to given change in air quality. Therefore, for this analysis, ideally it would be possible to have sector-level population estimates for the variety of population subgroups that are examined in the concentration-response functions. However, population estimates at the sector level were available for some but not all of the pertinent sub-populations.

Sector-level population estimates were available for two age categories which were commonly examined in the concentration-response functions used in this analysis: ages 18-65, and ages 65 and over. In those cases where it was not possible to obtain sector-specific sub-population data, the percentage of persons in the subpopulation at the county level was applied to the sector level. For example, Census data is available which estimates that in Autauga County, Alabama, 5% of the population is between the ages of 8 and 12 (the examined population in Schwartz et al.'s (1994) study of Lower Respiratory Symptoms). This percentage was then multiplied by the total sector population to estimate the total number of children aged 8-12 in a sector which lies completely within Autauga County.

While the method described in the preceding paragraph works in those cases where a sector lies completely within one county, many sectors lie in multiple counties. In those cases where a sector lies in more than one county, the sector was assigned a spatially-weighted average of the county-level sub-population percentage breakdowns. This spatially-weighted average was determined by multiplying the proportion of each sector (in terms of area) located in a given county by that county's sub-population percentage. The resulting proportion-adjusted county-specific data is then summed for all the counties in which a sector lies, giving an estimate of sector-level sub-population percentages. This spatially-weighted average method assumes that county populations are uniformly distributed throughout the county.

4.2 BASELINE INCIDENCE

As mentioned above, some concentration-response functions require estimates of baseline incidence. It was necessary to estimate sector-level baseline incidence in order to evaluate those concentration-response functions at the sector-level. Sector-specific baseline incidence estimates were not available for any endpoints, so the spatially-weighted averages of county-specific data were also applied in determining sector-specific baseline incidence estimates. Unlike estimates of the exposed population, for which all of the pertinent county-level sub-population breakdowns were available from the U.S. Census, county-level baseline incidence estimates were obtained from a variety of sources, as documented below.

County-specific mortality rates (across all ages) were obtained for each county in the United States from the National Center for Health Statistics (NCHS). Because most PM studies that estimated concentration-response functions for mortality considered only non-accidental mortality, county-specific baseline mortality rates used in the estimation of PM-related mortality were adjusted to reflect an estimate of county-specific non-accidental mortality. This estimate was determined by multiplying each county-specific mortality rate by the ratio of national non-accidental mortality to national total mortality (0.93).

Although total mortality incidences (over all ages) were available for counties, age-specific mortality incidences were not available at the county level. County-specific baseline mortality incidences among individuals aged 30 and over (necessary for PM2.5-related long-term exposure mortality, estimated by Pope et al., 1995) were therefore estimated by applying national age-specific death rates to county-specific age distributions, and adjusting the resulting estimated age-specific incidences so that the estimated total incidences (including all ages) equaled the actual county-specific total incidences. For example, if the total of the estimated age-specific incidences obtained in this way was 5% higher than the actual total incidence for a county, then each of the estimated age-specific incidences was multiplied by (1/1.05). These county-specific, age-specific mortality incidence estimates were then applied at the sector level using the spatially-weighted average method described in Section 4.1.

Each county-specific hospital admissions baseline incidence rate was obtained by multiplying the national hospital admissions rate for the relevant International Classification of Diseases (ICD) code(s) per 100,000 exposed population by the county-specific population, and then adjusting this incidence by the ratio of the county-specific proportion of the population that was aged 65 or older to the national proportion of the population aged 65 or older[8]. These county-specific hospital admissions baseline incidence rates were then used to determine spatially-weighted average baseline incidence rates at the sector level using the spatially-weighted average method described in Section 4.1.

While county-level baseline incidence estimates could be obtained for the mortality and hospital admissions endpoints, they were not available for all endpoints. Baseline incidence rates for all respiratory symptoms and illnesses included in the benefit analysis and for restricted activity days were obtained from the studies reporting concentration-response functions for those

---

[8] Except for Thurston et al., 1994, all hospital admissions studies used in the national benefit analysis apply only to individuals 65 and older. The Thurston study used a linear concentration-response function, which does not require a baseline incidence rate for calculation of PM-related incidence.

health endpoints. No baseline incidence rates were available from other sources for these endpoints. In these cases, the same baseline incidence was applied to all sectors in the analysis[9].

5.0 AGGREGATING INCIDENCE OVER A YEAR

This analysis presents total changes in health effects expected to occur over a one-year time period for the population exposed to PM emissions from combustors. However, several of the epidemiological studies measure changes in health effects for time periods other than one year. For example, some studies of respiratory symptoms estimate changes in the occurrence of symptoms during a single day. To present changes in health effects avoided during a given year, this analysis uses appropriate multipliers to adjust the changes in health effects predicted by studies which estimate these changes for time periods shorter than one year, as described in greater detail in Section 2.

There is one exception to presenting results as the number of cases avoided per year. Schwartz (1993) defines chronic bronchitis as positive responses to the following questions: (1) whether a doctor had ever told the subject that he or she had chronic bronchitis, and (2) whether he or she still had bronchitis at the time of the study. Therefore, the duration of an individual case of chronic bronchitis is not defined, and the results using information from this study cannot be reported as the number of cases avoided per year. Instead, the results are reported as the number of cases avoided for some time period greater than one year, but which cannot be specified given the available information.

It should be noted that this analysis estimates the avoidance of recurring health effects for a given individual. For example, if an individual avoids ten incidents of shortness of breath during a given year as a result of implementing the MACT standard, all ten incidents will be counted in the results.

6.0 BENEFITS ESTIMATES: NO-THRESHOLD ASSUMPTIONS

The current analysis assumes that health effects may occur at any PM concentration level down to zero. Even if the modeled PM concentrations in the baseline and MACT control scenarios are below the lowest observed PM concentrations seen in the available epidemiological studies or below National Ambient Air Quality Standards (NAAQS) for PM-10 or PM-2.5, health effects are assumed to result from the changes in PM concentrations between the two scenarios.

Consideration of thresholds may, however, be important. Systemic toxicants (chemicals and other substances that cause noncarcinogenic and nonmutagenic health effects) have often been treated as having concentration levels below which there are no observable adverse effects,

---

[9] For hospital admissions and mortality, the national baseline incidence rates provided in Exhibit 3.1 are meant to provide the reader with a general perspective of the potential magnitude of the baseline incidence; for other endpoints, the annual baseline incidence estimates in Exhibit 3.1 were taken directly from the epidemiological literature and were applied to all sectors in the analysis.

based on our understanding of the adaptive and homeostatic mechanisms of these types of toxicants (U.S. EPA, 1988). The lowest observed levels seen in some of the epidemiological studies in this analysis or the PM NAAQS may represent plausible estimates of such thresholds.

This project did not estimate total ambient PM concentrations; only the contribution to total PM from hazardous waste combustors was estimated. Without estimates of total PM concentrations, it is not possible to conduct any threshold analyses. Given the opportunity and additional resources, it would be appropriate to determine estimates of site-specific ambient PM concentrations, which, coupled with the change in modeled combustor emissions evaluated in this analysis, would allow for an alternate estimate of benefits using the lowest observed effect levels reported in the above three studies or the NAAQS as threshold levels below which health effects do not occur. However, given the current scope of this analysis and the available information, it was not feasible to address threshold issues at this time.

7.0 UNCERTAINTY

There are several sources of uncertainty in the health effects estimates associated with using the available concentration-response functions in this analysis. There is uncertainty about how well the studies estimated the concentration-response relationships in the study locations; there is uncertainty about how applicable these concentration-response functions are to other locations (the “assessment locations”); and there is uncertainty about extrapolating the estimated concentration-response functions beyond the range of PM concentrations that were used to estimate these functions. Finally, there are uncertainties associated with other aspects of applying concentration-response functions to estimate changes in incidence associated with changes in PM concentrations.

An obvious uncertainty in an estimated concentration-response function is the statistical uncertainty surrounding estimates of parameters in the function. The standard errors reported along with parameter estimates describe this statistical uncertainty. A less obvious uncertainty, however, is whether the functional form of the relationship being estimated is correct. The form of the relationship between PM and the health effect studied in a given epidemiological study is based on the available data, and evaluated to determine how well the data fit the relationship. It is possible that a functional form not examined in a particular study may fit the data better than the form chosen by the authors. In addition, if data are sparse, the functional form used may not be as good as a form that might be chosen if more data were available. For example, many concentration-response relationships are estimated by “Poisson regression,” and assume a log-linear relationship between the expected value of the health endpoint and PM. This is a no-threshold model, which assumes that at any level of PM there will be some effect. Although good research investigates which model is most consistent with the data, there is always some degree of uncertainty about whether the model estimated is the functional form that best describes the relationship under investigation. Finally, confounding effects and modifying effects not sufficiently accounted for in the studies may contribute to error in the estimation of concentration-response functions and therefore in the estimation of incidence, based on these functions.

Uncertainties associated with other aspects of model specification contribute additional uncertainty to the estimates of PM-related incidence. One source of uncertainty is the measure of particulate matter used in concentration-response functions. Some studies use TSP (total suspended particulates) as the measure of particulate matter; others use PM10; because of a lack of monitoring data, only a few studies have used PM2.5. If only a component of particulate matter (e.g., PM2.5) is causally related to a health endpoint, other measures of particulate matter could be poor proxies for the correct measure, potentially leading to biased estimates of the concentration-response function and therefore misestimation of PM-related incidence.

Even if an estimated concentration-response function provides a good description of the relationship between a health endpoint and PM for the location in which it was estimated, it is not necessarily a good description of this relationship in a different location. The concentration-response relationship may differ from one location to another as, for example, the composition of the PM and/or the composition of the exposed populations differ.

In applying estimated concentration-response functions to estimate changes in incidence associated with changes in PM concentrations, the PM concentrations considered in the analysis may extend beyond the range of those used to estimate the concentration-response function. Extrapolation of the concentration-response function to PM concentrations that are lower than or higher than those used to estimate the function could bias the results of the analysis. For example, if there is a PM concentration threshold below which there is no association between PM and the studied health effect, extrapolation down to zero of a concentration-response function based on higher levels of PM could result in an overestimate of incidence.

There are several additional sources of uncertainty in applying estimated concentration-response functions in this analysis. In most cases, concentration-response functions are applied to the population group investigated in the study which estimated the function. Using concentration-response functions in this manner may potentially result in an underestimate of the incidence of health effects because the incidence in that portion of the population not covered in the study is implicitly zero. Health effects for which this underestimation of incidence may be most pronounced are those that were studied only in the elderly or in certain subsets of children but occur in wider age ranges in the population. For example, studies of hospital admissions were often limited to observation of effects in the population 65 years and older. The incidence of hospital admissions was then estimated for the same population of individuals. To the extent that younger individuals are also affected by PM 2.5, the number of PM-related hospital admissions may be underestimated in the current analysis. Also, several functions investigated respiratory effects in children in a limited age group (e.g., ages 10-12 years); to the extent that these respiratory symptoms may be observed in younger or older children, this analysis may underestimate the number of effects seen in the population surrounding hazardous waste combustors.

Many concentration-response functions are based on a relative risk model. In this case, the number of new cases of an effect (or the number of cases avoided, if PM levels decline) is calculated as a percent change from the baseline incidence. When such concentration-response functions are used, a measure of baseline incidence is therefore required. Ideally, location-specific baseline incidence rates would be used. However, for some health effects, the only available information on baseline incidence is from the study that estimated the concentration-response function. Applying the incidence rate specific to the study location to other areas examined in this analysis may underestimate or overestimate the number of cases associated with a change in PM concentrations in a given area. The extent of over- or underestimation on the current analysis is not known.

8.0 RESULTS

The results generated from this analysis are contained in the attached tables. Results are presented as avoided incidence per year for each health endpoint presented. The results are aggregated by facility type (as provided by RTI). Each table contains one facility type. For example, one sheet presents the aggregated results of all LWAK sites. Each health end-point presented in the table has been modeled using the modeled PM concentrations as inputs. It should be noted, however, that although the model runs both the PM2.5 and PM10 concentration-functions for estimating changes in incidence of acute bronchitis (predicted using Dockery et al., 1989) and changes in incidence of lower respiratory functions (predicted using Schwartz et al., 1994), results are presented only for the model which uses PM2.5 as the input. A table presenting results aggregated across all incinerator categories is also provided.

8.1 Aggregation of the Health Effects

Results are presented for the health endpoints investigated in the concentration-response studies described in Section 3. However, because there are several issues related to the overlap of some of these health endpoints, the reader should refer to Section 3.1 for suggestions about how to interpret these results. For all health endpoints except mortality, total changes in incidence which cover the largest number of PM-related health effects for the largest portion of the population and which avoid double counting of effects are indicated in bold in the results file.

Special note should be given to one study (Krupnick et al., 1990) which estimates fairly large changes in incidence, but which is not included in the aggregated (i.e. bolded) set of results. The estimates of avoiding incidence of any of 19 acute symptoms predicted using Krupnick et al. (1990) may overlap with the estimates of avoided MRADs predicted using Ostro and Rothschild (1989). Therefore, it is possible that many of the avoided health effects which would be predicted using the Krupnick et al. (1990) study are included in the suggested aggregation of results.

In the case of mortality, Pope et al. (1995) is bolded because it investigates long-term exposure, which may be preferable to studies that use short-term estimates (as discussed in Section 3). However, because Pope et al. (1995) is the only long-term study used in this analysis and is applied only to the population of individuals 30 years and older, the results of using the short-term studies are also presented. The short-term studies are applied to the full population.

8.2 Magnitude of Benefits Estimates

The avoided incidence estimates are relatively small in magnitude for the majority of endpoints, even when estimates are aggregated across all of the facilities of a particular combustion unit type. This is consistent with the small changes in 24-hour average PM concentrations between the baseline and MACT air quality scenarios.

Because Pope et al. (1995) is a long-term study, it may be expected that the results of applying the Pope et al. (1995) mortality study to the full population would result in higher estimates of incidence than applying the results of Schwartz et al. (1996a). However, it is possible that the change in air quality is greater using the data required by the Schwartz function than the data required by the Pope function because the studies use different measures of air quality data. Specifically, estimates of annual avoided mortality incidence are calculated by the CAPMS computer model for the Pope study based on the change in the annual median PM 2.5 air quality concentration. In contrast, CAPMS calculates mortality incidence estimates for the Schwartz study based on the change in 20 separate daily average PM 2.5 concentrations which are representative of the distribution of daily average PM 2.5 concentrations across a year. Each of these 20 daily average concentrations represents 1/20th of a year, or 18.25 days. CAPMS then sums the incidence estimates for each of these 20 daily average concentrations to calculate an annual avoided mortality incidence for the Schwartz study.

Point Estimate Benefits - Avoided Incidence

Air Quality Scenario- PMMactJuly Incremental to PMBaseJuly
Facility Type-CINC
Modeled Population= 5355230.65

Endpoint	Reference	Avoided Incidence for No-Threshold Analysis (cases/year)
Mortality (long-term exp. - ages 30+)	**Pope et al., 1995**	**0.01**
Mortality (short-term exp.) - PM10	pooled analysis (10 functions)	0.05
Mortality (short-term exp.) - PM2.5	Schwartz et al., 1996a	0.07
Chronic Bronchitis	**Schwartz, 1993b**	**0.51**
Hosp. Admissions - All Respiratory (all ages)	**Thurston et al., 1994**	**0.07**
All Respiratory (ages 65+)	Schwartz, 1995, 1996 (pooled analysis)	0.06
Pneumonia (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.02
COPD (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.02
Hosp. Admissions - Congestive Heart Failure	**Schwartz and Morris, 1995**	**0.02**
Hosp. Admissions - Ischemic Heart Disease	**Schwartz and Morris, 1995**	**0.02**
Acute Bronchitis	**Dockery et al., 1989**	**0.46**
Lower Respiratory Symptoms	**Schwartz et al., 1994**	**4.09**
Upper Respiratory Symptoms	**Pope et al., 1991**	**0.47**
Any of 19 Acute Symptoms	Krupnick et al., 1990	116.20
Shortness of breath	Ostro et al., 1995	1.97
Work Loss Days	**Ostro, 1987**	**37.33**
MRAD	**Ostro and Rothschild, 1989**	**311.08**
RAD	Ostro, 1987	102.41

*The method of measuring chronic bronchitis in Schwartz (1993) does not necessarily result in the number of cases avoided/year. Instead, this value may represent number of cases avoided over a period of years.

Point Estimate Benefits - Avoided Incidence

Air Quality Scenario- PMMactJuly Incremental to PMBaseJuly
Facility Type-CK
Modeled Population= 1088193.9

Endpoint	Reference	Avoided Incidence for No-Threshold Analysis (cases/year)
Mortality (long-term exp. - ages 30+)	Pope et al., 1995	0.00
Mortality (short-term exp.) - PM10	pooled analysis (10 functions)	0.02
Mortality (short-term exp.) - PM2.5	Schwartz et al., 1996a	0.02
Chronic Bronchitis	**Schwartz, 1993b**	**0.15**
Hosp. Admissions - All Respiratory (all ages)	**Thurston et al., 1994**	**0.02**
All Respiratory (ages 65+)	Schwartz, 1995, 1996 (pooled analysis)	0.02
Pneumonia (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.01
COPD (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.01
Hosp. Admissions - Congestive Heart Failure	**Schwartz and Morris, 1995**	**0.01**
Hosp. Admissions - Ischemic Heart Disease	**Schwartz and Morris, 1995**	**0.01**
Acute Bronchitis	**Dockery et al., 1989**	**0.13**
Lower Respiratory Symptoms	**Schwartz et al., 1994**	**1.18**
Upper Respiratory Symptoms	**Pope et al., 1991**	**0.14**
Any of 19 Acute Symptoms	Krupnick et al., 1990	31.36
Shortness of breath	Ostro et al., 1995	0.22
Work Loss Days	**Ostro, 1987**	**7.62**
MRAD	**Ostro and Rothschild, 1989**	**63.50**
RAD	Ostro, 1987	20.90

*The method of measuring chronic bronchitis in Schwartz (1993) does not necessarily result in the number of cases avoided/year. Instead, this value may represent number of cases avoided over a period of years.

Point Estimate Benefits - Avoided Incidence
Air Quality Scenario- PMMactJuly Incremental to PMBaseJuly
Facility Type-LWAK
Modeled Population= 944791.62

Endpoint	Reference	Avoided Incidence for No-Threshold Analysis (cases/year)
Mortality (long-term exp. - ages 30+)	**Pope et al., 1995**	**0.00**
Mortality (short-term exp.) - PM10	pooled analysis (10 functions)	0.01
Mortality (short-term exp.) - PM2.5	Schwartz et al., 1996a	0.01
Chronic Bronchitis	**Schwartz, 1993b**	**0.07**
Hosp. Admissions - All Respiratory (all ages)	**Thurston et al., 1994**	**0.01**
All Respiratory (ages 65+)	Schwartz, 1995, 1996 (pooled analysis)	0.01
Pneumonia (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.00
COPD (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.00
Hosp. Admissions - Congestive Heart Failure	**Schwartz and Morris, 1995**	**0.00**
Hosp. Admissions - Ischemic Heart Disease	**Schwartz and Morris, 1995**	**0.00**
Acute Bronchitis	**Dockery et al., 1989**	**0.05**
Lower Respiratory Symptoms	**Schwartz et al., 1994**	**0.44**
Upper Respiratory Symptoms	**Pope et al., 1991**	**0.05**
Any of 19 Acute Symptoms	Krupnick et al., 1990	16.09
Shortness of breath	Ostro et al., 1995	0.06
Work Loss Days	**Ostro, 1987**	**3.91**
MRAD	**Ostro and Rothschild, 1989**	**32.58**
RAD	Ostro, 1987	10.73

*The method of measuring chronic bronchitis in Schwartz (1993) does not necessarily result in the number of cases avoided/year. Instead, this value may represent number of cases avoided over a period of years.

Point Estimate Benefits - Avoided Incidence
Air Quality Scenario- PMMactJuly Incremental to PMBaseJuly
Facility Type-OINC-Large
Modeled Population= 18848701.57

Endpoint	Reference	Avoided Incidence for No-Threshold Analysis (cases/year)
Mortality (long-term exp. - ages 30+)	**Pope et al., 1995**	**1.42**
Mortality (short-term exp.) - PM10	pooled analysis (10 functions)	2.19
Mortality (short-term exp.) - PM2.5	Schwartz et al., 1996a	3.61
Chronic Bronchitis	**Schwartz, 1993b**	**22.05**
Hosp. Admissions - All Respiratory (all ages)	**Thurston et al., 1994**	**3.48**
All Respiratory (ages 65+)	Schwartz, 1995, 1996 (pooled analysis)	2.97
Pneumonia (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	1.07
COPD (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.91
Hosp. Admissions - Congestive Heart Failure	**Schwartz and Morris, 1995**	**0.79**
Hosp. Admissions - Ischemic Heart Disease	**Schwartz and Morris, 1995**	**0.88**
Acute Bronchitis	**Dockery et al., 1989**	**17.86**
Lower Respiratory Symptoms	**Schwartz et al., 1994**	**158.42**
Upper Respiratory Symptoms	**Pope et al., 1991**	**18.38**
Any of 19 Acute Symptoms	Krupnick et al., 1990	4,990.20
Shortness of breath	Ostro et al., 1995	70.66
Work Loss Days	**Ostro, 1987**	**1,841.54**
MRAD	**Ostro and Rothschild, 1989**	**15,340.16**
RAD	Ostro, 1987	5,052.23

*The method of measuring chronic bronchitis in Schwartz (1993) does not necessarily result in the number of cases avoided/year. Instead, this value may represent number of cases avoided over a period of years.

Point Estimate Benefits - Avoided Incidence
Air Quality Scenario- PMMactJuly Incremental to PMBaseJuly
Facility Type-OINC-Small
Modeled Population= 53033181.14

Endpoint	Reference	Avoided Incidence for No-Threshold Analysis (cases/year)
Mortality (long-term exp. - ages 30+)	**Pope et al., 1995**	**0.06**
Mortality (short-term exp.) - PM10	pooled analysis (10 functions)	0.24
Mortality (short-term exp.) - PM2.5	Schwartz et al., 1996a	0.41
Chronic Bronchitis	**Schwartz, 1993b**	**2.59**
Hosp. Admissions - All Respiratory (all ages)	**Thurston et al., 1994**	**0.42**
All Respiratory (ages 65+)	Schwartz, 1995, 1996 (pooled analysis)	0.31
Pneumonia (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.11
COPD (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.10
Hosp. Admissions - Congestive Heart Failure	**Schwartz and Morris, 1995**	**0.08**
Hosp. Admissions - Ischemic Heart Disease	**Schwartz and Morris, 1995**	**0.09**
Acute Bronchitis	**Dockery et al., 1989**	**2.08**
Lower Respiratory Symptoms	**Schwartz et al., 1994**	**18.49**
Upper Respiratory Symptoms	**Pope et al., 1991**	**2.13**
Any of 19 Acute Symptoms	Krupnick et al., 1990	604.52
Shortness of breath	Ostro et al., 1995	6.85
Work Loss Days	**Ostro, 1987**	**228.06**
MRAD	**Ostro and Rothschild, 1989**	**1,900.72**
RAD	Ostro, 1987	625.68

*The method of measuring chronic bronchitis in Schwartz (1993) does not necessarily result in the number of cases avoided/year. Instead, this value may represent number of cases avoided over a period of years.

Point Estimate Benefits - Avoided Incidence
Air Quality Scenario- PMMactJuly Incremental to PMBaseJuly
Facility Type-Area Source CK
Modeled Population= 41626

Endpoint	Reference	Avoided Incidence for No-Threshold Analysis (cases/year)
Mortality (long-term exp. - ages 30+)	**Pope et al., 1995**	**0.00**
Mortality (short-term exp.) - PM10	pooled analysis (10 functions)	0.00
Mortality (short-term exp.) - PM2.5	Schwartz et al., 1996a	0.00
Chronic Bronchitis	**Schwartz, 1993b**	**0.00**
Hosp. Admissions - All Respiratory (all ages)	**Thurston et al., 1994**	**0.00**
All Respiratory (ages 65+)	Schwartz, 1995, 1996 (pooled analysis)	0.00
Pneumonia (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.00
COPD (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.00
Hosp. Admissions - Congestive Heart Failure	**Schwartz and Morris, 1995**	**0.00**
Hosp. Admissions - Ischemic Heart Disease	**Schwartz and Morris, 1995**	**0.00**
Acute Bronchitis	**Dockery et al., 1989**	**0.00**
Lower Respiratory Symptoms	**Schwartz et al., 1994**	**0.00**
Upper Respiratory Symptoms	**Pope et al., 1991**	**0.00**
Any of 19 Acute Symptoms	Krupnick et al., 1990	0.00
Shortness of breath	Ostro et al., 1995	0.00
Work Loss Days	**Ostro, 1987**	**0.00**
MRAD	**Ostro and Rothschild, 1989**	**0.00**
RAD	Ostro, 1987	0.00

*The method of measuring chronic bronchitis in Schwartz (1993) does not necessarily result in the number of cases avoided/year. Instead, this value may represent number of cases avoided over a period of years.

Point Estimate Benefits - Avoided Incidence

Air Quality Scenario- PMMactJuly Incremental to PMBaseJuly
Facility Type-Area Source INC
Modeled Population= 3951983

Endpoint	Reference	Avoided Incidence for No-Threshold Analysis (cases/year)
Mortality (long-term exp. - ages 30+)	**Pope et al., 1995**	**0.01**
Mortality (short-term exp.) - PM10	pooled analysis (10 functions)	0.04
Mortality (short-term exp.) - PM2.5	Schwartz et al., 1996a	0.06
Chronic Bronchitis	**Schwartz, 1993b**	**0.45**
Hosp. Admissions - All Respiratory (all ages)	**Thurston et al., 1994**	**0.06**
All Respiratory (ages 65+)	Schwartz, 1995, 1996 (pooled analysis)	0.05
Pneumonia (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.02
COPD (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	0.01
Hosp. Admissions - Congestive Heart Failure	**Schwartz and Morris, 1995**	**0.01**
Hosp. Admissions - Ischemic Heart Disease	**Schwartz and Morris, 1995**	**0.01**
Acute Bronchitis	**Dockery et al., 1989**	**0.40**
Lower Respiratory Symptoms	**Schwartz et al., 1994**	**3.61**
Upper Respiratory Symptoms	**Pope et al., 1991**	**0.42**
Any of 19 Acute Symptoms	Krupnick et al., 1990	103.70
Shortness of breath	Ostro et al., 1995	1.59
Work Loss Days	**Ostro, 1987**	**33.31**
MRAD	**Ostro and Rothschild, 1989**	**277.61**
RAD	Ostro, 1987	91.39

*The method of measuring chronic bronchitis in Schwartz (1993) does not necessarily result in the number of cases avoided/year. Instead, this value may represent number of cases avoided over a period of years.

Point Estimate Benefits - Avoided Incidence

Air Quality Scenario- PMMactJuly Incremental to PMBaseJuly
Facility Type-All Incinerators
Modeled Population= 77237114

Endpoint	**Reference**	**Avoided Incidence for No-Threshold Analysis (cases/year)**
Mortality (long-term exp. - ages 30+)	**Pope et al., 1995**	**1.49**
Mortality (short-term exp.) - PM10	pooled analysis (10 functions)	2.48
Mortality (short-term exp.) - PM2.5	Schwartz et al., 1996a	4.09
Chronic Bronchitis	**Schwartz, 1993b**	**25.15**
Hosp. Admissions - All Respiratory (all ages)	**Thurston et al., 1994**	**3.96**
All Respiratory (ages 65+)	Schwartz, 1995, 1996 (pooled analysis)	3.34
Pneumonia (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	1.20
COPD (ages 65+)	Schwartz, 1994a,b,c, 1996 (pooled analysis)	1.02
Hosp. Admissions - Congestive Heart Failure	**Schwartz and Morris, 1995**	**0.89**
Hosp. Admissions - Ischemic Heart Disease	**Schwartz and Morris, 1995**	**0.98**
Acute Bronchitis	**Dockery et al., 1989**	**20.40**
Lower Respiratory Symptoms	**Schwartz et al., 1994**	**181.00**
Upper Respiratory Symptoms	**Pope et al., 1991**	**20.99**
Any of 19 Acute Symptoms	Krupnick et al., 1990	5,710.92
Shortness of breath	Ostro et al., 1995	79.48
Work Loss Days	**Ostro, 1987**	**2,106.92**
MRAD	**Ostro and Rothschild, 1989**	**17,551.95**
RAD	Ostro, 1987	5,780.31

*The method of measuring chronic bronchitis in Schwartz (1993) does not necessarily result in the number of cases avoided/year. Instead, this value may represent number of cases avoided over a period of years.

9.0 REFERENCES

Abt Associates Inc., July 3, 1996 (Revised November 1996). "A Particulate Matter Risk Assessment for Philadelphia and Los Angeles," prepared for the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Contract No. 68-W4-0029, Work Assignments 9, 9-1, and 15-1.

Dockery, D.W., F.E. Speizer, D.O. Stram, J.H. Ware, J.D. Spengler, and B.G. Ferris, Jr. 1989. Effects of Inhalable Particles on Respiratory Health of Children. *Am. Rev. Respir. Dis.* 139: 587-594.

Ito, K. and Thurston, G.D. 1996. Daily PM10/Mortality Associations: An Investigation of At-Risk Subpopulations. *Journal of Exposure Analysis and Environmental Epidemiology* 6(1): 79-225.

Kinney et al. 1995. A Sensitivity Analysis of Mortality/PM10 Associations in Los Angeles. *Inhalation Toxicology* 7: 59-69.

Krupnick A.J., Harrington W., Ostro B. 1990. Ambient Ozone and Acute Health Effects: Evidence from Daily Data. *Journal of Environmental Economics and Management* 18:1-18.

Ostro, B.D. 1987. Air Pollution and Morbidity Revisited: a Specification Test. *J. Environ. Econ. Manage.* 14: 87-98.

Ostro B.D. and S. Rothschild. 1989. Air Pollution and Acute Respiratory Morbidity: An Observational Study of Multiple Pollutants. *Environmental Research* 50:238-247.

Ostro, B.D., M.J. Lipsett, M.B. Wiener, and J.C. Selner. 1991. Asthmatic Responses to Airborne Acid Aerosols. *American Journal of Public Health* 81: 694-702.

Ostro, B.D., M.J. Lipsett, J.K. Mann, H. Braxton-Owens, and M.C. White. 1995. Air Pollution and Asthma Exacerbations Among African American Children in Los Angeles. *Inhalation Toxicology.*

Pope, C.A., III, D.W. Dockery, J.D. Spengler, and M.E. Raizenne. 1991. Respiratory Health and PM_{10} Pollution: a Daily Time Series Analysis. *Am. Rev. Respir. Dis.* 144: 668-674.

Pope, C.A., III, Schwartz, J., and M.R. Ransom. 1992. Daily mortality and PM_{10} in Utah valley. *Arch. Environ. Health* 47: 211-217.

Pope, C.A., III, M.J. Thun, M.M. Namboodiri, D.W. Dockery, J.S. Evans, F.E. Speizer, and C.W. Heath, Jr. 1995. Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults. *Am. J. Respir. Crit. Care Med.* 151: 669-674.

Schwartz, J. 1993a. Air pollution and daily mortality in Birmingham, Alabama. *Am. J. Epidemiol.* 137: 1136-1147.

Schwartz, J. 1993b. Particulate Air Pollution and Chronic Respiratory Disease. *Environmental Research* 62: 7-13.

Schwartz, J. 1994a. Air Pollution and Hospital Admissions in Elderly Patients in Birmingham, Alabama. *American Journal of Epidemiology* 139:589-98.

Schwartz, J. 1994b. Air Pollution and Hospital Admissions for the Elderly in Detroit, Michigan. *American Journal of Respiratory Care Med* 150:648-55.

Schwartz, J. 1994c. PM_{10}, Ozone and Hospital Admissions for the Elderly in Minneapolis-St. Paul, Minnesota. *Archives of Environmental Health* 49(5): 366-374.

Schwartz, J. 1995. Short Term Fluctuations in Air Pollution and Hospital Admissions of the Elderly for Respiratory Disease. *Thorax* 50:531-538.

Schwartz, J. 1996. Air Pollution and Hospital Admissions for Respiratory Disease. *Epidemiology* 7(1): 20-28.

Schwartz, J. and R. Morris. 1995. Air Pollution and Hospital Admissions for Cardiovascular Disease in Detroit, Michigan. *Am. J. Epidemiol.* 142: 23-35.

Schwartz, J. D. W. Dockery, L.M. Neas, D. Wypij, J.H. Ware, J.D. Spengler, P. Koutrakis, F.E.Speizer, and B.G. Ferris, Jr. 1994. Acute Effects of Summer Air Pollution on Respiratory Symptom Reporting in Children. *Am. J. Respir. Crit. Care Med.* 150: 1234-1242.

Schwartz, J., Dockery, D., and L. Neas. 1996a. Is Daily Mortality Specifically Associated With Fine Particles? *J. Air & Waste Man. Assoc.* 46: 927-939.

Thurston, G. K. Ito, C. Hayes, D. Bates, and M. Lippmann. 1994. Respiratory Hospital Admission and Summertime Haze Air Pollution in Toronto, Ontario: Consideration of the Role of Acid Aerosols. *Environmental Research* 65: 271-290.

U.S. Environmental Protection Agency (EPA). 1988. Background Document 1; Reference Dose (RfD): Description and Use in Health Risk Assessments. February 10.

U.S. Environmental Protection Agency (EPA)/ Office of Air Quality Planning and Standards, 1996. *Review of National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information (Staff Paper).* EPA-452\R-96-013.

U.S. Environmental Protection Agency(EPA)/ Office of Air Quality Planning and Standards, 1997a. *The Benefits and Costs of the Clean Air Act: 1970 to 1990.* October. Appendix D.

U.S. Environmental Protection Agency (EPA)/Office of Air Quality Planning and Standards, 1997b. *Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed Regional Haze Rule*. Appendix I.