

APPENDIX F

Derivation of Method 2 Direct Contact Exposure Criteria

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Soil Method 1 Direct Exposure Criteria for 2,3,7,8 TCDD, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-BHC, alpha-chlordane, beta-BHC, delta-BHC, dibenzofuran, endosulfan II, endosulfan sulfate, endrin ketone, gamma-chlordane, heptachlor, heptachlor epoxide, hexachlorobenzene, and methoxychlor for both the residential and commercial/industrial scenario are not presented in Table 1 of the RIDEM Remediation Regulations. Therefore soil Method 2 Direct Exposure Criteria were calculated in accordance with Rule 8.02 C of the RIDEM Remediation Regulations. Method 2 Direct Exposure Criteria were calculated for both residential and commercial/industrial scenarios. The residential value for carcinogenic substances for direct contact is based on the following equation for the ingestion pathway,

$$C = \left(\frac{RISK \times AT \times CF}{CPSo \times EF} \right) \times \left(\frac{BW_a \times BW_c}{BW_a \times ED_c \times IRS_c + BW_c \times ED_a \times IRS_a} \right)$$

Where,

- C = Concentration of Contaminant in Soil
- RISK = Target Cancer Risk Level
- AT = Averaging Time
- CF = Conversion Factor
- EF = Exposure Frequency
- CPSo = Carcinogenic Potency Slope Factor (Oral)
- BWa = Body Weight (adult)
- BWc = Body Weight (child ages 1-6)
- EDa = Exposure Duration (adult)
- EDc = Exposure Duration (child ages 1-6)
- IRSa = Ingestion rate of soil (adult)
- IRSc = Ingestion rate of soil (child)

The residential default input parameters for ingestion presented in Appendix D of the RIDEM Remediation Regulations were used to calculate the Method 2 Direct Exposure Criteria.

The commercial/industrial value for carcinogenic substances for direct contact is based on the following equation for the ingestion pathway,

$$C = \left(\frac{RISK \times AT \times CF}{CPSo \times EF} \right) \times \left(\frac{BW_a}{ED \times IRS_a} \right)$$

Where,

- C = Concentration of Contaminant in Soil
- RISK = Target Cancer Risk Level
- AT = Averaging Time
- CF = Conversion Factor
- EF = Exposure Frequency
- CPSo = Carcinogenic Potency Slope Factor (Oral)
- BWa = Body Weight (adult)
- ED = Exposure Duration
- IRSa = Ingestion rate of soil (adult)

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The commercial/industrial default input parameters for ingestion presented in Appendix D of the RIDEM Remediation Regulations were used to calculate the Method 2 Direct Exposure Criteria.

The residential value for non-carcinogenic substances for direct contact is based on the following equation for the ingestion pathway,

$$C = \left(\frac{HI \times RfD_o \times CF}{EF} \right) \times \left(\frac{BW_c \times AT}{ED_c \times IRS_c} \right)$$

Where,

- C = Concentration of Contaminant in Soil
- HI = Hazard Index
- AT = Averaging Time
- CF = Conversion Factor
- EF = Exposure Frequency
- BW_c = Body Weight (child ages 1-6)
- ED_c = Exposure Duration (child ages 1-6)
- IRSc = Ingestion rate of soil (child)

The residential default input parameters for ingestion presented in Appendix D of the RIDEM Remediation Regulations were used to calculate the Method 2 Direct Exposure Criteria.

The commercial/industrial value for non-carcinogenic substances for direct contact is based on the following equation for the ingestion pathway,

$$C = \left(\frac{HI \times RfD_o \times CF}{EF} \right) \times \left(\frac{BW_a \times AT}{ED_a \times IRS_a} \right)$$

Where,

- C = Concentration of Contaminant in Soil
- HI = Hazard Index
- AT = Averaging Time
- CF = Conversion Factor
- EF = Exposure Frequency
- BW_a = Body Weight (adult)
- ED_a = Exposure Duration (adult)
- IRSa = Ingestion rate of soil (adult)

The commercial/industrial default input parameters for ingestion presented in Appendix D of the RIDEM Remediation Regulations were used to calculate the Method 2 Direct Exposure Criteria.

Calculations for Method 2 Direct Exposure Criteria for both residential and commercial industrial scenarios can be found in Table F1 through F4. Table F5 shows a summary of values that will be used as the Method 2 Directed Exposure Criteria. Carcinogenic Potency Slope Factors (Oral) and Reference Doses (Oral) used in the calculation can be found in Appendix G.

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Derivation of Method 2 Direct Contact Exposure Criteria

REFERENCES:

HEAST, 1997, Health Effects Assessment Summary Tables, 1997.

IRIS, 2004, USEPA Integrated Risk Information System, September, 2004.

Rhode Island Department of Environmental Management (RIDEM), 1996. Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases. August.

Table F1
Calculation of Method 2 Direct Exposure Criteria for Carcinogenic Substances for Residential Scenario
Supplemental Site Investigation
Former Gorham Manufacturing Site
333 Adelaide Avenue
Providence, Rhode Island

Parameter	Symbol	Units	Value	Reference
Concentration of Contaminant In Soil	C	mg/kg	Calculated	
Carcinogenic Potency Slope Factor (Oral)	CPS _o	(mg/kg/d) ⁻¹	Chemical Specific	IRIS, 2004 and HEAST, 1997
Target Cancer Risk Level	RISK	dimensionless	1E-06	RIDEM, 2004
Body Weight (Adult)	BW _a	kg	70	RIDEM, 2004
Body Weight (Child Ages 1-6)	BW _c	kg	15	RIDEM, 2004
Averaging Time (Carcinogens)	AT	yr	70	RIDEM, 2004
Soil Ingestion (Adult)	IRS _a	mg/d	100	RIDEM, 2004
Soil Ingestion (Child Ages 1-6)	IRS _c	mg/d	200	RIDEM, 2004
Conversion Factor	CF	mg-d/kg-yr	3.65E+08	RIDEM, 2004
Exposure Frequency	EF	d/yr	350	RIDEM, 2004
Exposure Duration (Adult)	ED _a	yr	24	RIDEM, 2004
Exposure Duration (Child Ages 1-6)	ED _c	yr	6	RIDEM, 2004

Method 2 Direct Exposure Criteria calculated using the following equation:

$$C = \left(\frac{RISK \times AT \times CF}{CPS_o \times EF} \right) \times \left(\frac{BW_a \times BW_c}{BW_a \times ED_c \times IRS_c + BW_c \times ED_a \times IRS_a} \right)$$

Chemical	CPS _o	C (mg/kg)
2,3,7,8-TCDD	1.50E+05	4.26E-06
4,4'-DDD	2.40E-01	2.66E+00
4,4'-DDE	3.40E-01	1.88E+00
4,4'-DDT	3.40E-01	1.88E+00
alpha-BHC	6.30E+00	1.01E-01
alpha-Chlordane	3.50E-01	1.83E+00
beta-BHC	1.80E+00	3.55E-01
delta-BHC ¹	1.30E+00	4.91E-01
gamma-Chlordane	3.50E-01	1.83E+00
Heptachlor	4.50E+00	1.42E-01
Heptachlor Epoxide	9.10E+00	7.02E-02

¹ CPS_o for gamma-BHC used as surrogate.

HEAST, 1997. Health Effects Assessment Summary Tables

IRIS, 2004. USEPA Integrated Risk Information System, September.

RIDEM, 2004. Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases, State of Rhode Island and Providence Plantations Department of Environmental Management Office of Waste Management, February.

Table F2
Calculation of Method 2 Direct Exposure Criteria for Carcinogenic Substances for Commercial/Industrial Scenario
Supplemental Site Investigation
Former Gorham Manufacturing Site
333 Adelaide Avenue
Providence, Rhode Island

Parameter	Symbol	Units	Value	Reference
Concentration of Contaminant In Soil	C	mg/kg	Calculated	
Carcinogenic Potency Slope Factor (Oral)	CPSo	(mg/kg/d) ⁻¹	Chemical Specific	IRIS, 2004 and HEAST, 1997
Target Cancer Risk Level	RISK	dimensionless	1E-06	RIDEM, 2004
Body Weight (Adult)	BW _a	kg	70	RIDEM, 2004
Averaging Time (Carcinogens)	AT	yr	70	RIDEM, 2004
Averaging Time (Non-carcinogens)	AT _a	yr	25	RIDEM, 2004
Soil Ingestion (Adult)	IRS _a	mg/d	50	RIDEM, 2004
Exposure Frequency	EF	d/yr	250	RIDEM, 2004
Exposure Duration (Adult)	ED	yr	25	RIDEM, 2004
Conversion Factor	CF	mg-d/kg-yr	3.65E+08	RIDEM, 2004

Method 2 Direct Exposure Criteria calculated using the following equation:

$$C = \left(\frac{RISK \times AT \times CF}{CPSo \times EF} \right) \times \left(\frac{BW_a}{ED \times IRS_a} \right)$$

Chemical	CPSo	C
2,3,7,8-TCDD	1.50E+05	3.82E-05
4,4'-DDD	2.40E-01	2.38E+01
4,4'-DDE	3.40E-01	1.68E+01
4,4'-DDT	3.40E-01	1.68E+01
alpha-BHC	6.30E+00	9.08E-01
alpha-Chlordane	3.50E-01	1.64E+01
beta-BHC	1.80E+00	3.18E+00
delta-BHC ¹	1.30E+00	4.40E+00
gamma-Chlordane	3.50E-01	1.64E+01
Heptachlor	4.50E+00	1.27E+00
Heptachlor Epoxide	9.10E+00	6.29E-01

¹ CPSo for gamma-BHC used as surrogate.

HEAST, 1997. Health Effects Assessment Summary Tables

IRIS, 2004. USEPA Integrated Risk Information System, September.

RIDEM, 2004. Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases, State of Rhode Island and Providence Plantations Department of Environmental Management Office of Waste Management, February.

Table F3
Calculation of Method 2 Direct Exposure Criteria for Non-Carcinogenic Substances for Residential Scenario
Supplemental Site Investigation
Former Gorham Manufacturing Site
333 Adelaide Avenue
Providence, Rhode Island

Parameter	Symbol	Units	Value	Reference
Concentration of Contaminant In Soil	C	mg/kg	Calculated	
Reference Dose (Oral)	RfDo	mg/kg/d	Chemical Specific	IRIS, 2004
Hazard Index	HI	dimensionless	1	RIDEM, 2004
Body Weight (Child Ages 1-6)	BW _c	kg	15	RIDEM, 2004
Averaging Time (Child Ages 1-6)	AT _c	yr	6	RIDEM, 2004
Soil Ingestion (Child Ages 1-6)	IRS _c	mg/d	200	RIDEM, 2004
Conversion Factor	CF	mg-d/kg-yr	3.65E+08	RIDEM, 2004
Exposure Frequency	EF	d/yr	350	RIDEM, 2004
Exposure Duration (Child Ages 1-6)	ED _c	yr	6	RIDEM, 2004

$$C = \left(\frac{HI \times RfD_o \times CF}{EF} \right) \times \left(\frac{BW_c \times AT_c}{ED_c \times IRS_c} \right)$$

Chemical	RfD _o	C (mg/kg)
4,4'-DDD ¹	5.00E-04	3.91E+01
4,4'-DDE ¹	5.00E-04	3.91E+01
4,4'-DDT	5.00E-04	3.91E+01
alpha-Chlordane	5.00E-04	3.91E+01
delta-BHC ²	3.00E-04	2.35E+01
Dibenzofuran	2.00E-03	1.56E+02
Endosulfan II ³	6.00E-03	4.69E+02
Endosulfan Sulfate ³	6.00E-03	4.69E+02
Endrin ketone ⁴	3.00E-04	2.35E+01
gamma-Chlordane	5.00E-04	3.91E+01
Heptachlor	5.00E-04	3.91E+01
Heptachlor Epoxide	1.30E-05	1.02E+00
Methoxychlor	5.00E-03	3.91E+02

¹ RfD_o for 4,4'-DDT is used as surrogate for 4,4'-DDD and 4,4'-DDE.

² RfD_o for gamma-BHC used as surrogate.

³ RfD_o for Endosulfan used as surrogate.

⁴ RfD_o for Endrin used as surrogate.

IRIS, 2004. USEPA Integrated Risk Information System, September.

RIDEM, 2004. Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases, State of Rhode Island and Providence Plantations Department of Environmental Management Office of Waste Management, February.

Table F4
Calculation of Method 2 Direct Exposure Criteria for Non-Carcinogenic Substances for Commercial/Industrial Scenario
Supplemental Site Investigation
Former Gorham Manufacturing Site
333 Adelaide Avenue
Providence, Rhode Island

Parameter	Symbol	Units	Value	Reference
Concentration of Contaminant In Soil	C	mg/kg	Calculated	
Reference Dose (Oral)	RfDo	mg/kg/d	Chemical Specific	IRIS, 2004
Hazard Index	HI	dimensionless	1	RIDEM, 2004
Body Weight (Adult)	BW _a	kg	70	RIDEM, 2004
Averaging Time (Non-carcinogens)	AT _a	yr	25	RIDEM, 2004
Soil Ingestion (Adult)	IRS _a	mg/d	50	RIDEM, 2004
Exposure Frequency	EF	d/yr	250	RIDEM, 2004
Exposure Duration (Adult)	ED	yr	25	RIDEM, 2004
Conversion Factor	CF	mg-d/kg-yr	3.65E+08	RIDEM, 2004

$$C = \left(\frac{HI \times RfD_o \times CF}{EF} \right) \times \left(\frac{BW_a \times AT_a}{ED \times IRS_a} \right)$$

Chemical	RfD _o	C (mg/kg)
4,4'-DDD ¹	5.00E-04	1.02E+03
4,4'-DDE ¹	5.00E-04	1.02E+03
4,4'-DDT	5.00E-04	1.02E+03
alpha-Chlordane	5.00E-04	1.02E+03
delta-BHC ²	3.00E-04	6.13E+02
Dibenzofuran	2.00E-03	4.09E+03
Endosulfan II ³	6.00E-03	1.23E+04
Endosulfan Sulfate ³	6.00E-03	1.23E+04
Endrin ketone ⁴	3.00E-04	6.13E+02
gamma-Chlordane	5.00E-04	1.02E+03
Heptachlor	5.00E-04	1.02E+03
Heptachlor Epoxide	1.30E-05	2.66E+01
Methoxychlor	5.00E-03	1.02E+04

¹ RfD_o for 4,4'-DDT is used as surrogate for 4,4'-DDD and 4,4'-DDE.

² RfD_o for gamma-BHC used as surrogate.

³ RfD_o for Endosulfan used as surrogate.

⁴ RfD_o for Endrin used as surrogate.

IRIS, 2004. USEPA Integrated Risk Information System, September.

RIDEM, 2004. Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases, State of Rhode Island and Providence Plantations Department of Environmental Management Office of Waste Management, February.

Table F5
**Summary of Calculated Method 2 Direct Exposure Criteria for
 Carcinogenic and Non-Carcinogenic Substances for
 Supplemental Site Investigation
 Former Gorham Manufacturing Site
 333 Adelaide Avenue
 Providence, Rhode Island**

	Residential		Commercial/Industrial	
	C	NC	C	NC
2,3,7,8-TCDD	4.26E-06	--	3.82E-05	--
4,4'-DDD	2.66E+00	3.91E+01	2.38E+01	1.02E+03
4,4'-DDE	1.88E+00	3.91E+01	1.68E+01	1.02E+03
4,4'-DDT	1.88E+00	3.91E+01	1.68E+01	1.02E+03
alpha-BHC	1.01E-01	--	9.08E-01	--
alpha-Chlordane	1.83E+00	3.91E+01	1.64E+01	1.02E+03
beta-BHC	3.55E-01	--	3.18E+00	--
delta-BHC	4.91E-01	2.35E+01	4.40E+00	6.13E+02
Dibenzofuran	NC	1.56E+02	NC	4.09E+03
Dieldrin	3.99E-02	3.91E+00	3.58E-01	1.02E+02
Endosulfan II	NC	4.69E+02	NC	1.23E+04
Endosulfan Sulfate	NC	4.69E+02	NC	1.23E+04
Endrin ketone	NC	2.35E+01	NC	6.13E+02
gamma-Chlordane	1.83E+00	3.91E+01	1.64E+01	1.02E+03
Heptachlor	1.42E-01	3.91E+01	1.27E+00	1.02E+03
Heptachlor Epoxide	7.02E-02	1.02E+00	6.29E-01	2.66E+01
Methoxychlor	NC	3.91E+02	NC	1.02E+04

C - carcinogenic

NC - non-carcinogenic

-- - no reference dose (RfD) value available

Bold value indicates selected Method 2 Direct Exposure Criteria

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