APPENDIX D

Selection of Receptor Parameters

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Appendix D
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1 Introduction

Physical and physiological factors such as body weight and inhalation rate and behavioural factors such as the consumption of soil all affect the potential daily exposures experienced by each of the receptors considered in the *Human Health Risk Assessment* (HHRA). There are several sources of information on receptor parameters available for use in estimating exposure. For risk assessments conducted on sites under federal jurisdiction, the most commonly used source comes from Health Canada (Health Canada, 2004). The receptor parameters listed in this report rely on large population studies that provide average values that are considered to be representative of the Canadian population Health Canada, 1994, Health Canada, 1995, Richardson, 1997). In addition, receptor parameters, based on population studies in the United Sates are available from the US EPA (US EPA, 1997). Receptor parameters recommended by Health Canada have been used as the primary source of values for the HHRA. Where these parameters were not available from Health Canada, values from the US EPA were used. A discussion of the selection of the receptor parameters used in the HHRA is provided in below.

2 Receptor Body Weights

Estimates of average body weights for the age groups identified by Health Canada are based on statistical assessments of body weights in the Canadian population (Health Canada, 2004). The US EPA, uses age groupings that differ slightly from those used by Health Canada (USEPA, 1997). As a result, the body weight values recommended by the US EPA do not match the groupings used by Health Canada. The body weights recommended by Health Canada are typically used in risk assessments in Canada and have been selected for use in the current HHRA to ensure consistency with standard risk assessment practice in Canada.

Summary of Receptor Body Weight Values

Receptor	Receptor Body Weight (kg)
Infant	8.2
Toddler	16.5
Child	32.9
Teen	59.7
Adult	70.7

3 Incidental Soil Ingestion Rates

The incidental ingestion of soil as a result of inadvertent hand-to-mouth activity will contribute to the total daily intake of a substance from the soil. For toddlers and young children hand-to-mouth activity is part of normal behavioural development. For older children, teens and adults, incidental ingestion of soil is generally a result of soil that sticks to food or hands. The deliberate ingestion of soil, a condition known as *pica* is relatively uncommon and is not considered in this assessment.

Estimates of the daily rates of the incidental ingestion of soil are available from Health Canada and the US EPA. Data from Health Canada has been chosen in preference to data from the US EPA because this data will be more reflective of Canadian conditions. Health Canada lists two sets of daily soil ingestion rates; those suggested for use in assessing potential exposures in the Canadian populations (Health Canada, 2004) and the values used in the development of the Canadian Soil Quality Guidelines (CCME, 1996, CCME, 2000). The incidental soil ingestion rates recommended by both agencies are summarized in Table D-3. Estimates of soil ingestion for the child age group are not available from CCME. The absence of an age-specific soil ingestion rate for the child, limits the utility of CCME recommended values for assessing potential exposures for all receptor age groups to be considered in the HHRA for CFB Gagetown. Therefore, the incidental soil ingestion rates recommended by Health Canada for assessing exposures at federal contaminated sites have been selected for use in current HHRA. Health Canada also provides a recommended incidental soil ingestion rate of 100 mg/day for construction workers. This value was recommended to reflect the greater potential for construction workers to come into contact with soil on a daily basis than typical adults. This increased incidental soil ingestion rate has been used to estimate soil ingestion exposures for soldier engaged in training exercises, to reflect the greater potential that soldiers have to come into contact with the soil on the Base compared to recreational users from local communities.

Selection of Receptor Incidental Soil Ingestion Rate Values

Receptor	Incidental Soil Ingestion Rates (mg/day)		
	Health Canada, 2004	CCME, 1996	Selected Value
Infant	20	20	20
Toddler	80	80	80
Child	20	NV[1]	20
Teen	20	20	20
Adult	20	20	20
Construction Worker	100	NV	100

1: NV = No Value

4 Daily Inhalation Rates

Estimates of daily inhalation rates for receptor groups that are consistent with the age groupings recommended by Health Canada are available from Health Canada and Richardson (Health Canada, 2004, Richardson, 1997). Inhalation rates from the US EPA are set for age groups that differ slightly from those of Health Canada and are based on surveys of the US population. Data based on the Canadian population have been given preference over data from other populations. The inhalation rates recommended by Health Canada are based on the statistical assessments of inhalation rates provided by Richardson (Richardson, 1997). These values are marginally different than the daily inhalation rates previously used by Health Canada (Health Canada, 1994, Health Canada, 1995). The estimates of daily inhalation rates, developed by Richardson and currently recommended by Health Canada, represent the most recent evaluations of typical inhalation rates for the Canadian population. Therefore, these values have been used to assess potential inhalation exposures for the receptors in the current HHRA.

Summary of Daily Inhalation Rate Values

Receptor	Daily Inhalation Rates (m^3/day)
Infant	2.1
Toddler	9.3
Child	14.5
Teen	15.8
Adult	15.8

5 Skin Surface Area

The amount of skin that is uncovered and can come into contact with soil will determine the amount of dermal exposure that is possible for receptors in each age group. Based on information provided by Base personnel, soldiers and timber harvesters on the Base would be expected to be wearing boots/shoes, long pants and shirts while on-site. For these receptors, dermal contact with soil can reasonably be expected to be limited to contact with hands and the lower and upper arms. For soldiers who shower while in bivouacs where water for showering is derived from on-site groundwater, the total body surface area would come into contact with groundwater while showering.

The hunting season on CFB Gagetown is limited to approximately 27 days in October and November. Weather conditions during the fall would generally dictate that people wear warm clothing which can be expected to include boots, long pants, shirts and, when necessary, jackets or sweaters. Therefore, the potential for dermal contact to these receptors can be expected to be limited the hands and lower arms. Although dermal contact with soil is likely to be limited to hands and lower arms, the HHRA has assumed that skin on the hands, upper and lower arms and upper and lower legs are available for contact with soil. This approach will provide conservative estimates of potential exposure for hunters by over estimating the skin surface area that could come into contact with soil on a regular or daily basis.

The fishing season on CFB Gagetown runs from mid-May through mid-September. For the purposes of the current HHRA the assessment of potential exposures for anglers has focused on potential exposures that could occur while fishing and while accessing fishing locations in Subject Areas 9 and 10. Fishing practices will govern the skin surface area that is available for contact with soil, sediment and surface water. People who wade into the water to fly fish will generally wear waders that would be expected to limit or prevent dermal contact with legs and feet. People who fish from shore would be unlikely to wear waders and thus, have a greater potential for dermal contact with soil and sediment. Information on typical fishing practices (wading or fishing from shore) for the Nerepis River and Swan Creek Lake was unavailable for input into the risk assessment. In the absence of information on typical fishing practices for people fish the Nerepis River and Swan Creek Lake, it has been assumed that, for all anglers, hands, arms and legs could come into contact with soil, sediment and surface water each day that is spent on-site engaged in fishing activities.

For recreational users of the Base it has been assumed that the area of exposed skin would include, hands, upper and lower arms and upper and lower legs and that dermal contact with soil would occur every day that a receptor is assumed to be present on-site.

Health Canada provides estimates of skin surface areas for hands, upper and lower arms and upper and lower legs (Health Canada, 2004). These recommendations are based on the statistical analysis conducted by Richardson (Richradson, 1997). These values have been used to assess dermal contact exposures for soil for the soldier, timber harvester, recreational user and hunter receptors. These values have also been used to assess dermal contact exposures with sediments and surface water for the angler receptor. Health Canada does not provide recommendations on total body surface areas (Health Canada, 2004). In order to assess potential dermal contact exposures while showering (soldier receptor), it is necessary to evaluate dermal contact over the entire body surface area. In addition to providing skin surface area estimates for hands, arms and legs, Richardson provided estimates of total body skin surface areas for various age groups for male and female receptors (Richardson, 1997). For the purposes of this assessment, the total skin surface area for adult males has been used to estimate dermal contact exposures while showering for the soldier receptor. The skin surface areas used to assess dermal contact exposures for the receptors considered in the HHRA are provided below.

Summary of Receptor Exposed Skin Surface Area Values

Parameter	Units	Recreational Users				Soldiers	Timber Harvester	Hunter	Angler	Reference
		Toddler	Child	Teen	Adult					
Total Skin Surface Area (Showering)	cm^2	NA	NA	NA	NA	18940	NA	NA	NA	Richardson, 1997
Hands	cm^2	430	590	800	890	890	890	890	890	Health Canada, 2004
Upper & Lower Arms	cm^2	890	1480	2230	2500	2500	2500	2500	2500	Health Canada, 2004
Upper & Lower Legs	cm^2	1690	3070	4970	5720	NA	NA	5720	5720	Health Canada, 2004
Totals	cm^2	3010	5140	8000	9110	3390	3390	9110	9110	Health Canada, 2004

6 Soil Adhesion to Skin

The amount of soil that sticks to the skin is a significant determinant of the potential exposure to substances absorbed through the skin. Estimates of soil adhesion to skin are available from Health Canada and the US EPA (Health Canada, 2004, US EPA, 2000). Health Canada provided two soil adhesion factors that account for the differential potential for soil to adhere to hands and other skin surface areas. These values are based on work conducted by Kissel *et al* who examined soil adhesion to skin in the US population (Kissel, 1996, Kissel, 1998). Health Canada also recommends soil adhesion factors for construction workers that are 10-fold higher than those used for the general population. These values were established to reflect the greater potential that construction workers have to come into contact with soil. The US EPA soil adhesion factors are similar to those recommended by Health Canada (2×10^{-4} g/cm^2 for the children 12 years and younger and 7×10^{-5} g/cm^2 for teens and adults and 3×10^{-4} g/cm^2 for construction workers) (US EPA, 2000, US EPA, 2001). The values recommended by Health Canada are based on a more recent evaluation of the work conducted by Kissel. Therefore, the Health Canada values have been selected for use in the current HHRA. Further, these values are consistent with the risk assessments conducted for sites under federal and/or provincial jurisdiction in Canada.

A summary of the soil adhesion factors used to assess dermal contact exposures to soil and/or sediments is provided below. The soil adhesion factors recommended for the general population have been used to assess potential dermal exposures for recreational receptors on CFB Gagetown. These soil adhesion factors have also been used to assess potential exposures for timber harvesters. Although, timber harvesters would typically be considered as industrial workers, information provided by Base personnel indicates that timber-harvesting activities are conducted largely with harvesting machinery and that the potential for these workers to come into direct contact with the soil is limited. The soil adhesion factors recommended for construction workers have been used to estimate dermal contact exposures to soil and sediment for soldiers, hunters and anglers, to reflect the greater potential that these receptors have to come into contact with soil and/or sediment than either the recreational user or the timber harvester.

Summary of Soil Adhesion Factors

Parameter	Units	Recreators				Soldiers	Timber Harvester	Hunter	Angler	Reference
		Toddler	Child	Teen	Adult					
Hands	g/cm^2	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-03	1.0E-04	1.0E-03	1.0E-03	Health Canada, 2004
Other Surfaces	g/cm2	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-04	1.0E-05	1.0E-04	1.0E-04	Health Canada, 2004
Averaged Adhesion Factor	g/cm2	2.3E-05	2.0E-05	1.9E-05	1.9E-05	3.4E-04	3.4E-05	1.9E-04	1.9E-04	Calculated

In addition to the individual soil adhesion factors for hands and arms and legs, an averaged soil-adhesion is also provided. This value is calculated as a weighted and has been used directly in the calculation of dermal contact exposures to soil and sediment. Although more sediment could be expected to adhere to skin than soil, it is the layer that is immediate contact with the skin that

contributes to the exposure. Soil or sediment that is not in direct contact with the skin will not contribute to dermal exposures. Therefore, applying the soil adhesion factors to sediments provides suitable and appropriate estimates of the amount of sediment that could be expected to contribute to dermal contact exposures.

7 Consumption of Game

Health Canada provides guidance on game consumption (Health Canada, 2004). However, estimated daily intakes of game are based on consumption rates for First Nations communities. The use of this information to estimate intakes for hunters who harvest moose and deer from CFB Gagetown will over-estimate potential exposures to the chemicals of concern in the current HHRA. Estimates of game consumption in the general population are not available from other Canadian jurisdictions.

The US EPA also provides some limited guidance on the consumption of game in the US population (US EPA, 1997). The US EPA data includes estimated daily intakes for geographic regions in the United States including the northeastern United States. A review of the information provided by the US EPA indicates that the estimates of game consumption may include the consumption of lamb and veal. Thus, these values are not truly representative of game consumption and have not been considered for inclusion in the current HHRA.

In the absence of information on game consumption patterns in the general Canadian population, the game consumption rates recommended by Health Canada have been used to assess potential exposures to the chemicals of concern, through the consumption of moose and deer from CFB Gagetown. The game consumption rates recommended by Health Canada are summarized below.

Summary of Game Consumption Rates (Health Canada, 2004)

Group	Infant	Toddler	Child	Teen	Adult
Combined	0	85 g/day	125 g/day	175 g/day	270 g/day

8 Consumption of Fish

Health Canada provides guidance on fish consumption (Health Canada, 2004). However, this is based on a statistical analysis of fish consumption patterns in First Nations populations (Richardson, 1997). However, the consumption recommended fish consumption rates represent the arithmetic mean values for First Nations people who report eating fish. Those who did not report consuming fish were excluded from the analysis. Thus, these fish consumption rates will over estimate typical fish consumption rates in the general population. Arithmetic mean consumption rates calculated for the entire data set (both fish eaters and non-fish eaters) were significantly lower than the consumption rates for the fish eater group alone (Richardson, 1997). A comparison of fish consumption rates for the combined group and fish eaters only is provided

below. The values presented represent the averaged fish consumption rates for both sexes combined.

Summary of Fish Consumption Rates for Fish Eater and Combined Eaters & Non Eaters[1]

Group	Infant	Toddler	Child	Teen	Adult
Eaters Only	0	95 g/day	170 g/day	200 g/day	220[2] g/day
Combined	0	14 g/day	24 g/day	32 g/day	48[2] g/day

1: Source; Richardson, 1997

2: the adult consumption rate represents the averaged fish consumption rate for adults >19 years old

Estimates of sport fish consumption are available from the US EPA and from a study conducted by Kearny *et al*. who studied fish consumption rates among people who regularly eat sport fish caught from the Great Lakes (Kearny, 1995). In their 1992 to 1993 study, Kearney et al. (1995) estimated the yearly averaged daily sport fish consumption rate for adults of 21.3 g/day. It should be noted that this consumption rate is based on anglers who regularly consume fish caught from the Great Lakes Basin, and may over estimate typical consumption rates in the general population. However, this value compares favorably with the data from the US EPA 1997 exposure factors handbook (table 10-82 which recommends a 95th percentile fresh water fish consumption rate of 13 g/day for residents of Maine (USEPA, 1997).

While Health Canada provides guidance on daily fish consumption rates, the data upon which these recommendations are based were not intended to represent yearly-averaged daily consumption rates. Further, the data will over-estimate fish consumption rates in the general population. For the purposes of this assessment, fish consumption rates reported by Kearney have been used to estimate potential exposures to the chemicals of concern through the consumption of sport fish. Although the daily fish consumption rate recommended by the US EPA would also be reasonable, the daily consumption rate recommended by Kearney will provide more conservative estimates of exposure.

It is reasonable to assume that consumption is proportional to body weight and that smaller adults and children will eat proportionally less fish than larger adults. For the purposes of this assessment the yearly averaged daily consumption rates are calculated as shown below. A summary of the estimated yearly-averaged daily fish consumption rates is also provided below. These value have been used to estimate potential exposures to the chemicals of concern for the relevant receptors in the current HHRA.

$$SP_{ya} = CR_{std} \times \left(\frac{BW_r}{BW_{std}} \right)$$

Where:

SP_{ya}	= Yearly averaged daily sport fish consumption	g/day
CR_{std}	= Standard consumption rate	g/day
BW_r	= Receptor-specific body weight	kg
BW_{std}	= Standard body weight	kg

Summary of Yearly-Averaged Daily Fish Consumption Rates

Receptor	CR_{std}	BW_r	BW_{std}	Yearly Averaged Daily Consumption
	g/day	kg	kg	grams/day
Infant	0	8.2	70.7	0
Toddler	21.3	16.5	70.7	4.9
Child	21.3	32.9	70.7	9.9
Teen	21.3	59.7	70.7	17.9
Adult	21.3	70.7	70.7	21.3

The use of the linear scaling factor provides estimated daily intakes of fish for the toddler and child that are similar to the daily intakes rates listed in Richardson, 1997. A summary of the ratios between the adult and toddler, child and teen receptor consumptions rates calculated using the scaling factor and the ratio between the adult and toddler, child and teen consumption rates recommended for the combined eater and non-eaters (Richardson, 1997) is provided below.

Comparison of Scaled and Reported Daily Fish Consumption Rates

Receptor	Ratio based on Scaling	Ratio based on Richardson 1997
Toddler	0.23	0.29
Child	0.46	0.50
Teen	0.84	0.66

The data presented above shows that for the toddler and child receptors, the difference in the adult/receptor consumption ratios between the scaled values and the recommended values are small and the selection of one approach over the other would not alter the conclusions of the risk assessment. However, for the teen the scaling factor approach provides a significantly more conservative estimate of daily fish consumption than would be derived using the values reported in Richardson, 1997. Thus, the approach used in the current assessment will provide conservative estimates of exposure to PCDD/PCDF through the consumption of fish.

For the purposes of this assessment it has been assumed that all fish consumed by anglers comes from the rivers and lakes on CFB Gagetown. Because it is unlikely that all fish caught and consumed by anglers over the course of a year would come exclusively from CFB Gagetown, this approach will be likely to over estimate exposures to PCDD/PCDF through the consumption of fish.

9 Consumption of Blueberries

Estimates of blueberry consumption in the Canadian population are available from Health Canada (Health Canada, 1994). Yearly-averaged daily consumption rates are provided for all five receptor age groups. These estimates are based on a Nutrition Canada Survey that used a 24-hour recall dietary survey of 13,000 Canadians to establish food consumption rates in the general population. Although the survey was conducted between 1970 and 1972, the errors that may be introduced into the assessment as a result of changes in food consumption patterns between the

time the survey was conducted and present are expected to be small for food items such as blueberries. A summary of the yearly-averaged daily consumption rates for blueberries, recommended by Health Canada (Health Canada, 1994) is provided below.

Summary of Yearly-Averaged Daily Blueberry Consumption Rates (g/day)

Infant	Toddler	Child	Teen	Adult
0.67 g/day	0.67 g/day	1.0 g/day	1.51 g/day	1.99 g/day

10 Inadvertent Ingestion of Water During Swimming or Wading

Information on the amounts of water typically ingested while swimming or wading is not available from Canadian agencies. The US EPA 1989 *Risk Assessment Guidance for Superfund Sites* (RAGS), lists a value of 50 ml/day (or per event) for the inadvertent ingestion of water while swimming. (US EPA, 1989, Exhibit 6-12). The value of 50 ml/day (or per event) was selected based on the assumption made by USEPA in the early 1990s (USEPA, 1991) that a swimmer would accidentally ingest water at that rate while swimming. That value has been established by precedent in the US for use as a value for various means of accidental or incidental ingestion of surface water. For exposure scenarios other than swimming, such as wading, playing or falling into the water, this value is highly conservative. This value has been used to estimate exposures through the inadvertent ingestion of water while swimming or wading.

11 Duration of Showering Events and Wading Events While Fishing

Based on information provided by Base personnel, contact with groundwater would only occur for soldiers while showering. For the purposes of this assessment it has been assumed that a showering event would last for 10 minutes/day (0.167 hours/day).

For the purposes of this assessment exposure to surface water has been evaluated for the angler receptor because this group is expected to have the greatest level of exposure to surface water on CFB Gagetown. In addition this group of receptors is assumed to spend the greatest length of time in the vicinity of the Nerepis River and Swan Creek Lake (SA 9 and SA 10 respectively). Guidance on the amount of time typically spent wading while fishing or accessing fishing locations is not available from regulator agencies in Canada or the United States. While fly-fishing typically requires that anglers wade into the river, the anglers typical wear waders that limit or prevent direct contact with the water while wading. For the purposes of this assessment, it has been assumed that anglers who fly-fish would wear waders that would prevent dermal contact while fishing. Assumptions regarding potential exposures to surface waters while fishing are intended to address the potential exposures that people who fish from the shore could experience. It is also intended to address accidental exposures that could be experienced by fly-fishers. For the purposes of assess potential exposures to the chemicals of concern in surface water, it has been assumed that wading activities would last for two (2) hours every day that an angler is fishing in either of the SAs considered in the risk assessment.

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