9.2 Susceptible Populations

Two susceptible populations were identified by the Agency for Toxic Substances and Disease Registry (ATSDR) (2000). The first was children and the second, populations with incompletely developed conjugation mechanisms such as those with Gilbert's syndrome, a congenital liver disorder which occurs in approximately 3 to 7% of the adult population. These individuals are considered susceptible because of their diminished capacity to detoxify and excrete PCBs. Others with decreased hepatic activity like individuals with hepatitis B or liver cirrhosis may also be susceptible to PCB toxicity (ATSDR, 2000).

Children are considered susceptible to PCB toxicity because of the strong evidence that PCBs may be transferred across the placenta in pregnant women. This in combination with transfer in breast milk, and the more common routes of exposure such as consumption of contaminated foods, may potentially contribute to altered development, specifically neurobehavioral alterations (ATSDR, 2000).

9.3 Selection of Toxicity Values

Since PCBs usually occur as mixtures with varying degrees of chlorination, toxicity data must be based on the mixtures to predict potential health effects. Information on PCB exposure, however, is primarily from occupational studies and accidental exposures that may be contaminated with other chemicals.

The most documented case of human exposure to PCDFs are the Yusho (Japan, 1968) and Yucheng (Taiwan, 1979) incidents where people were accidentally exposed to PCDF and PCB contaminated food supply (IARC, 1978; IARC, 1987). From these incidences contradicting results were observed, an increase in liver cancer in Japanese men was observed while no excess of liver mortality in the affected Taiwanese population was observed (IARC, 1978; IARC, 1987).

9.3.1 Non-Cancer Oral Toxicity Reference Values

The US EPA provides toxicity reference values for PCB mixtures such as Aroclor 1254 and 1016. The US EPA (1996a) established an oral reference dose (RfD) for Aroclor 1254 of 2×10^{-5} mg/kg-day based on immunological effects in monkeys. The RfD was calculated from a lowest observable adverse effect limit (LOAEL) of 0.005 mg/kg/day. The US EPA (1996b) has also developed a RfD for Aroclor 1016 of 7×10^{-5} mg/kg-day based on a no observable adverse effect level (NOAEL) of 0.007 mg/kg-day and LOAEL of 0.028 mg/kg-day.

Aroclor 1016 is a commercial PCB mixture that is devoid of chlorinated dibenzofurans (US EPA, 1996b). The RfDs and effects are summarized below.

Table 16: PCB Congener Oral RfDs

Congener	TRV	TRV Type	Agency	Effects
Aroclor 1254	2×10^{-5} mg/kg-day	RfD	IRIS, US EPA	Ocular exudate, inflamed and prominent Meibomian glands, distorted growth of finger and toe nails; decreased IgG and IgM response to sheep erythrocytes.
Aroclor 1016	7×10^{-5} mg/kg-day	RfD	IRIS, US EPA	Reduced birth weights

The ATSDR (2000) provides oral minimal risk levels (MRLs) for intermediate and chronic exposure to PCBs. These MRLs, presented in Table 17, were derived to reflect exposure to PCB mixtures and are based on studies that involved Aroclor 1254.

Table 17: ATSDR (2000) MRLs for Oral Exposure to PCBs

Exposure	TRV	Basis	Effects
Intermediate (15-364 days)	0.03 µg/kg-day	LOAEL (0.0075 mg/kg-day)	Neurobehavioral alterations in infant monkeys that were exposed to a PCB congener mixture representing 80% of the congeners typically found in human breast milk
Chronic (365 days or more)	0.02 µg/kg-day	LOAEL (0.005 mg/kg-day)	Immunological effects in adult monkeys that were evaluated after 23 and 55 months of exposure to Aroclor 1254

The chronic MRL corresponds with the US EPA RfD for Aroclor 1254. However, Health Canada (2003) provides a TDI of 0.001 mg/kg-d, which was used in this assessment.

9.3.2 Cancer Oral Toxicity Reference Values

The US EPA (1997) established oral slope factors for PCB mixtures using a tiered approach that depends on the information available. Slope factors for high risk and persistence are considered appropriate for food chain exposure, sediment and soil ingestion, inhalation of dust or aerosol, dermal exposure (if an absorption factor has been applied) and all early life exposure. Slope factors for low risk and persistence are considered appropriate for inhalation of evaporated congeners. Central and upper bound-bound estimates are provided; central estimates describe a typical individual's risk, while upper bounds provide assurance that this risk is not likely to be underestimated. Based on the above, the upper-bound slope factor of 2.0 $(mg/kg/day)^{-1}$ for high

risk and persistence was used to assess the potential for carcinogenic effects via oral exposure pathways.

9.3.3 Non-Cancer Inhalation Toxicity Reference Values

Chronic inhalation exposure of workers to PCBs has been reported to result in respiratory tract symptoms (ATSDR, 2000). Despite these observed effects, non-cancer inhalation TRVs were not found.

9.3.4 Cancer Inhalation Toxicity Reference Values

The US EPA (1997) established inhalation slope factors for PCB mixtures using a tiered approach that depends on the information available. Slope factors for high risk and persistence are considered appropriate for food chain exposure, sediment and soil ingestion, inhalation of dust or aerosol, dermal exposure (if an absorption factor has been applied) and all early life exposure. Slope factors for low risk and persistence are considered appropriate for inhalation of evaporated congeners. Central and upper bound-bound estimates are provided; central estimates describe a typical individual's risk, while upper bounds provide assurance that this risk is not likely to be underestimated. Based on the above, the upper-bound slope factor of 0.4 $(mg/kg/day)^{-1}$ was used to assess the potential for carcinogenic effects via inhalation exposure.

9.4 Bioavailability

PCBs are well absorbed after oral, inhalation, or dermal exposure and transported similarly through circulation (US EPA, 1997; ATSDR, 2000). Initially absorbed PCBs are transported to the liver and muscle, subsequently PCBs are stored in fat and skin (US EPA, 1996c).

9.4.1 Oral Bioavailability

Animal studies have shown that PCBs are readily absorbed by the gastrointestinal tract with the degree of absorption ranging from 66 to 96% (ATSDR, 2000; WHO, 2000).

Specific information concerning absorption of Aroclor 1254 is limited. Pregnant ferrets administered a single oral dose of 0.06 mg/kg Aroclor 1254 absorbed 85% of the administered dose (Bleavins *et al.*, 1984). Rats, mice, and monkeys absorb between 75 to >90% of orally administered doses of PCBs (US EPA, 1996a). Oral exposure through consumption of contaminated food (including breast milk) is the major route of exposure to PCBs for the general population.

The oral relative bioavailability for PCBs used in this assessment was 1.0

9.4.2 Inhalation Bioavailability

Inhalation is considered to be a major occupational route of exposure (ATSDR, 2000). However, quantitative data concerning inhalation exposure to PCBs is scarce (ATSDR, 2000). Following the inhalation of PCBs, absorption and distribution similar to orally administered PCBs is witnessed in rats (WHO, 2000), this evidence is supported by the US EPA (1997). Furthermore, a study reported by the International Programme on Chemical Safety (IPCS) (1993) administered a PCB mixture in an aerosol to rats that was readily absorbed, resulting in 50% of the maximum applied concentration in the liver, 2 hours following administration.

The ATSDR summarized a study by Wolff (1985) where a maximum of 80% of the PCB levels in adipose tissue of exposed capacitor workers may have been absorbed by the inhalation route. A maximum of 20% would have been derived from dermal or oral exposure (ATSDR, 2000).

The relative inhalation bioavailability factor used in this assessment was 1.0.

9.4.3 Dermal Bioavailability

Dermal absorption has been observed in animal species ranging from 20 to 60% (WHO, 2000). Given the previously mentioned study by Wolff (1985), where a maximum of 20% of PCB levels in adipose tissue may have been attributed to oral and dermal exposure. The US EPA Region III (1995) recommends a dermal bioavailability factor of 0.06 based on the dermal absorption of 3,3',4,4'-tetrachlorobiphenyl.

The US EPA (2001) recommends an absorption factor of 0.14 based on *in vitro* human and monkey testing. Based on findings in animal studies reported by the World Health Organization (WHO), a conservative 0.60 relative dermal bioavailability factor has been adopted.

9.5 Conclusion

The following tables summarize the selected TRVs and relative bioavailabilities of PCBs.

Table 18: Selected Toxicity Reference Values for PCBs

Route of Exposure	TRV	TRV Type	Source Agency
Non-Cancer Effects			
Ingestion	0.01 mg/kg-day	TDI	Health Canada, 2003
Inhalation	NA	NA	NA
Cancer Effects			
Ingestion	2.0 $(mg/kg/day)^{-1}$	Slope Factor	US EPA, 1997
Inhalation	0.4 $(mg/kg/day)^{-1}$	Slope Factor	US EPA, 1997

Notes:
NA: Not Applicable

Table 19: Selected Bioavailabilities for PCBs

Route of Exposure	Relative Bioavailability	Reference
Ingestion	1.0	Assumed
Inhalation	1.0	Assumed
Dermal	0.60	WHO (2000)

9.6 References

ATSDR (Agency for Toxic Substances and Disease Registry), 2000. Toxicological Profile for Polychlorinated Biphenyls (PCBs). November, 2000.

Bleavins MR, Breslin WJ, Aulrich RJ, *et al.*, 1984. Placental and Mammary Transfer of a Polychlorinated Biphenyl Mixture (Aroclor 1254) in the European Ferret (*musteal putoris furo*). *Environ Toxicol Chem* 3: 637-644. Cited In: ATSDR, 2000.

IARC (International Agency on Cancer Research), 1978. Environmental Monographs Volume 18: Polychlorinated Biphenyls. Available: http://193.51.164.11/htdocs/monographs/vol18/polychlorinatedbiphenyls.html.

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IPCS (International Programme on Chemical Safety), 1993. Environmental Health Criteria 140: Polychlorinated Biphenyls and Terphenyls (Second Edition).Available at http://www.inchem.org/documents/ehc/ehc /ehc140.htm#p5.0.

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Wolff MS. 1985. Occupational exposure to polychlorinated biphenyls (PCBs). *Environ Health Perspect* 60:133-138. Cited in ATSDR, 2000.

WHO (World Health Organization), 2000. Air Quality Guidelines for Europe: Second Edition. WHO Regional Publications, European Series, No. 91.

WHO (World Health Organization), 2003. Concise International Chemical Assessment Document 55, Polychlorinated Biphenyls: Human Health Aspects.

10. TIN

Antimony is a silvery-white metal that is found in the earth's crust. Exposure to high levels of tin can result in stomach aches, anemia as well as liver and kidney problems. It can also result in breathing problems, eye irritations as well as affect the nervous system. (ATSDR, 1992)

10.1 Assessment of Carcinogenicity

The US EPA's IRIS program has not evaluated the carcinogenicity of tin. The Agency for Toxic Substances and Disease Registry (ATSDR, 1992) state that there is no conclusive information available on the carcinogenic potential of tin.

10.2 Susceptible Populations

There are no specific populations that have been identified that are unusually susceptible to either inorganic tin or organotin compounds with respect to health effects (ATSDR, 1992).

10.3 Selection of Toxicity Values

10.3.1 Non-Cancer Oral Toxicity Reference Values

An oral reference dose (RfD) of 0.6 mg/kg/day was provided for tin in the EPA's Health Effects Summary Tables (ORNL, 2004). The RfD was derived by the U.S. EPA based on a chronic study examining ingestion by rats. The main endpoint of concern was lesions appearing on the liver. The U.S. EPA reported a no observable adverse effects level (NOAEL) of 600 mg/kg-day, and applied an uncertainty factor of 100 to derive the RfD.

10.3.2 Cancer Oral Toxicity Reference Values

The lack of suitable positive carcinogenic data precludes the derivation of an oral slope factor or unit risk for tin.

10.3.3 Non-Cancer Inhalation Toxicity Reference Values

Inhalation toxicity values for antimony have not been developed by the US EPA or Health Canada and therefore, due to insufficient data, a non-cancer inhalation TRV has not been selected for this assessment.

10.3.4 Cancer Inhalation Toxicity Reference Values

The lack of suitable positive carcinogenic data precludes the derivation of inhalation slope factors or unit risks for tin.

10.4 Bioavailability

The following section describes the bioavailabilities of tin.

10.4.1 Oral Bioavailability

The relative oral absorption factor for tin has been conservatively assumed to be 1.0.

10.4.2 Inhalation Bioavailability

The relative inhalation absorption factor for tin has been conservatively assumed to be 1.0.

10.4.3 Dermal Bioavailability

The relative dermal absorption factor for tin has been conservatively assumed to be 0.1.

10.5 Conclusion

The following tables present the TRV and bioavailability summaries for tin.

Table 20: Selected Toxicity Reference Values for Tin

Route of Exposure	TRV	TRV Type	Source Agency
Non-Cancer Effects			
Ingestion	6.0×10^{-1} mg/kg-day	RfD	ORNL, 2004
Inhalation	NA	NA	NA
Cancer Effects			
Ingestion	NA	NA	NA
Inhalation	NA	NA	NA

NA – Not Applicable

Table 21: Selected Bioavailabilities for Tin

Route of Exposure	Relative Bioavailability	Reference
Ingestion	1.0	Assumed
Inhalation	1.0	Assumed
Dermal	0.1	Assumed

10.6 References

ATSDR (Agency for Toxic Substances and Disease Registry), 1992. Toxicological Profile for Tin. September 1992.

ORNL (Oak Ridge National Laboratory). 2004. Risk Assessment Program. Risk Assessment Information System. Toxicity and Chemical-specific Factors Data Base Search.

APPENDIX B

HHRA MODELEQUATIONS, INPUTS AND OUTPUTS

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1.0 HUMAN HEALTH INTAKE EQUATIONS

1.1 Oral/Dermal Exposure

1.1.1 Soil Ingestion

$$\text{Intake}_{SING} = \frac{C_{soil} \times IR_{soil} \times RAF_{ing} \times ET_{ing} \times EF_{ing} \times ED \times CF_1}{BW \times AT}$$

Where:		**Units**
Intake_{SING} =	daily intake from ingestion of soil/dust	mg/kg-day
C_{soil} =	concentration of chemical in soil	mg/kg
IR_{soil}	ingestion rate of soil	mg/hour
RAF_{ing}	relative absorption factor - ingestion	unitless
ET_{ing}	exposure time - ingestion	hours/day
EF_{ing}	exposure frequency - ingestion	days/year
ED	exposure duration	years
CF_1	conversion factor	1E-06 kg/mg
BW	body weight of receptor	kg
AT_c	averaging time carcinogen = (365 days/year) x (75 years)	27375 days
AT_{nc}	averaging time non-carcinogen = (365 days/year) x (exposure duration)	days

1.2 Soil Dermal

$$\text{Intake}_{SDERM} = \frac{C_{soil} \times \left(\left(SA_{body} \times SAF_{body}\right) + \left(SA_{hand} \times SAF_{hand}\right)\right) \times RAF_{derm} \times ET_{derm} \times EF_{derm} \times ED \times CF_1 \times CF_2}{BW \times AT}$$

Where:		**Units**
Intake_{SDERM} =	daily intake from dermal contact with soil	mg/kg-day
C_{soil} =	concentration of chemical in soil	mg/kg
SA_{body} =	exposed surface area - body	cm^2
SAF_{body} =	soil adherence factor - body	mg/cm^2-day
SA_{hand} =	exposed surface area - hand	cm^2
SAF_{hand} =	soil adherence factor - hand	mg/cm^2-day
RAF_{derm} =	relative absorption factor - dermal	unitless
ET_{derm} =	exposure time	hours/day
EF_{derm} =	exposure frequency	days/year
ED =	exposure duration	years
CF_1 =	conversion factor	1E-06 kg/mg

CF_2	=	conversion factor	0.042 days/hour
BW	=	body weight of receptor	kg
AT_c	=	averaging time carcinogen = (365 days/year) x (75 years)	27375 days
AT_{nc}	=	averaging time non-carcinogen = (365 days/year) x (exposure duration)	days

1.2.1 Soil/Dust Inhalation

$$Intake_{SDINHAL} = \frac{C_{soil} \times P_{air} \times IR_{air} \times RAF_{inh} \times ET_{inh} \times EF_{inh} \times ED \times CF_2}{BW \times AT}$$

Where:			**Units**
$Intake_{SDINHAL}$	=	daily intake from inhalation of soil/dust	mg/kg-day
C_{soil}	=	concentration of chemical in soil	mg/kg
P_{air}	=	particulate concentration in air	kg/m^3
RAF_{inh}	=	relative absorption factor - inhalation	unitless
IR_{air}	=	inhalation rate of air	m^3/hour
ET_{inh}	=	exposure time - inhalation	hours/day
EF_{inh}	=	exposure frequency - inhalation	days/year
ED	=	exposure duration	years
CF_2	=	conversion factor	0.042 days/hour
BW	=	body weight of receptor	kg
AT_c	=	averaging time carcinogen = (365 days/year) x (75 years)	27375 days
AT_{nc}	=	averaging time non-carcinogen = (365 days/year) x (exposure duration)	days

1.3 Food Ingestion

1.3.1 Caribou Ingestion

$$Intake_{caribou} = \frac{C_{caribou} \times IR_{game} \times F_{caribou} \times F_{site} \times RAF_{ing} \times EF_{game} \times ED}{BW \times AT}$$

Where:			**Units**
$Intake_{caribou}$	=	daily intake from the ingestion of caribou	mg/kg-day
$C_{caribou}$	=	concentration in caribou	mg/kg
IR_{game}	=	ingestion rate of wild game	kg/day
F_{site}	=	fraction of wild game consumed from site	unitless
$F_{caribou}$	=	fraction of wild game that is caribou	unitless
RAF_{ing}	=	relative absorption factor - oral	unitless
EF_{game}	=	exposure frequency – wild game ingestion	days/year
ED	=	exposure duration	years
BW	=	body weight of receptor	kg

AT_c	=	averaging time carcinogen = (365 days/year) x (75 years)	27375 days
AT_{nc}	=	averaging time non-carcinogen = (365 days/year) x (exposure duration)	days

1.3.2 Arctic Hare Ingestion

$$Intake_{hare} = \frac{C_{hare} \times IR_{game} \times F_{hare} \times F_{site} \times RAF_{ing} \times EF_{game} \times ED}{BW \times AT}$$

Where:			**Units**
$Intake_{hare}$	=	daily intake from the ingestion of arctic hare	mg/kg-day
C_{hare}		concentration in arctic hare	mg/kg
IR_{game}		ingestion rate of wild game	kg/day
F_{game}		fraction of wild game consumed from site	unitless
F_{hare}		fraction of wild game that is arctic hare	unitless
RAF_{ing}		relative absorption factor - oral	unitless
EF_{game}		exposure frequency – wild game ingestion	days/year
ED		exposure duration	years
BW		body weight of receptor	kg
AT_c		averaging time carcinogen = (365 days/year) x (75 years)	27375 days
AT_{nc}		averaging time non-carcinogen = (365 days/year) x (exposure duration)	days

1.3.3 Fish Ingestion

$$Intake_{fish} = \frac{C_{fish} \times IR_{fish} \times F_{fish} \times F_{cf} \times RAF_{ing} \times EF_{fish} \times ED}{BW \times AT}$$

Where:			**Units**
$Intake_{fish}$	=	daily intake from the ingestion of fish	mg/kg-day
C_{fish}		concentration in fish	mg/kg
IR_{fish}		ingestion rate of fish	kg/day
F_{fish}		fraction of fish caught from site	unitless
F_{cf}	=	fraction fish that are contaminated	unitless
RAF_{ing}	=	relative absorption factor - oral	unitless
EF_{fish}	=	exposure frequency – fish ingestion	days/year
ED		exposure duration	years
BW		body weight of receptor	kg
AT_c		averaging time carcinogen = (365 days/year) x (75 years)	27375 days
AT_{nc}		averaging time non-carcinogen = (365 days/year) x (exposure duration)	days

1.3.4 Water Ingestion

$$\text{Intake}_{\text{WATER}} = \frac{C_{\text{water}} \times IR_{\text{water}} \times F_{\text{water}} \times RAF_{\text{ing}} \times EF_{\text{water}} \times ED}{BW \times AT}$$

Where:		**Units**
$\text{Intake}_{\text{WATER}}$ =	daily intake from the ingestion of water	mg/kg-day
C_{water} =	concentration in water	mg/L
IR_{water} =	ingestion rate of water	L/day
F_{water} =	fraction of water consumed from site	unitless
RAF_{ing} =	relative absorption factor - oral	unitless
EF_{water} =	exposure frequency – drinking water	days/year
ED =	exposure duration	years
BW =	body weight of receptor	kg
AT_c =	averaging time carcinogen = (365 days/year) x (75 years)	27375 days
AT_{nc} =	averaging time non-carcinogen = (365 days/year) x (exposure duration)	days

1.4 Water Exposure

1.4.1 Dermal Exposure

$$\text{Intake}_{\text{dermwater}} = \frac{DA_{\text{event}} \times SA_{\text{water}} \times ET_{\text{dwater}} \times EF_{\text{dwater}} \times ED}{BW \times AT}$$

Where:		**Units**
$\text{Intake}_{\text{dermwater}}$ =	daily intake from the dermal contact with surface water	mg/kg-day
DA_{event} =	absorbed dose per event	mg/cm2-event
SA_{water} =	exposed surface area – dermal water	cm^2
ET_{dwater} =	exposure time – dermal water	hours/day
EF_{dwater} =	exposure frequency – dermal water	days/year
ED =	exposure duration	years
BW =	body weight of receptor	kg
AT_c =	averaging time carcinogen = (365 days/year) x (75 years)	27375 days
AT_{nc} =	averaging time non-carcinogen = (365 days/year) x (exposure duration)	days

$$DA_{event} = K_p \times C_{water} \times t_{event}$$

Where:		Units
DA_{event} =	absorbed dose per event	mg/cm^2-event
K_p =	dermal permeability coefficient of compound in water	cm/hr
C_{water} =	concentration of chemical in water	mg/cm^3
t_{event} =	event duration	hour/event

1.5 Risk Characterization

After the various intakes are derived, the final step is the calculation of the incremental excess lifetime cancer risks (IELCR) and non-carcinogenic hazard quotient (HQ) values for each of the pathways and receptors identified. IELCRs and HQs are then summed for individual receptors, across all applicable exposure pathways to obtain an estimate of the total individual IELCRs and HQs for specific receptors.

1.5.1 Carcinogenic Chemicals

For carcinogenic chemicals, risk estimates represent the incremental probability that an individual will develop cancer over a lifetime as a result of a specific exposure to that chemical (US EPA OW, 1998). Since carcinogenic risk estimates are over a lifetime of exposure, a composite receptor comprising five separate lifestages (infant, toddler, child, teen, adult) was used to evaluate carcinogenic intakes. An intake value was derived for each exposure and each pathway. These values were then summed to get a pathway specific cancer intake.

$$IELCR_x = Intake_x \times CSF_x$$

Where:		Units
$IELCR_x$ =	incremental lifetime cancer risk for pathway x	unitless
$Intake_x$ =	chemical specific intake for pathway x	mg/kg-day
CSF_x =	chemical specific cancer slope factor for pathway x	$(mg/kg\text{-}day)^{-1}$

$$IELCR_{O/D} = Intake_{O/D} \times CSF_{O/D}$$

Where:		Units
$IELCR_{O/D}$	incremental lifetime cancer risk for oral/dermal exposure	unitless
$Intake_{O/D}$	chemical specific intake for oral/dermal pathway	mg/kg-day
$CSF_{O/D}$	chemical specific oral cancer slope factor	$(mg/kg\text{-}day)^{-1}$

$$IELCR_{FOOD} = Intake_{FOOD} \times CSF_{O/D}$$

Where:			**Units**
$IELCR_{FOOD}$	=	incremental lifetime cancer risk for food ingestion exposure	unitless
$Intake_{FOOD}$	=	chemical specific intake for food intake pathway	mg/kg-day
$CSF_{O/D}$	=	chemical specific oral cancer slope factor	$(mg/kg\text{-}day)^{-1}$

1.5.2 Non-carcinogenic Chemicals

The potential for non-carcinogenic health effects resulting from exposure to a chemical is generally assessed by comparing an exposure estimate to a reference dose (RfD). A RfD is a daily oral intake rate that is estimated to pose no appreciable risk of adverse health effects, even to sensitive populations (US EPA OW, 1998).

$$HQ_x = \frac{Intake_x}{RfD_x}$$

Where:			**Units**
HQ_x	=	hazard quotient for pathway x	unitless
$Intake_x$	=	chemical specific intake for pathway x	mg/kg-day
RfD_x	=	chemical specific reference dose for pathway	mg/kg-day

The total non-carcinogenic hazard attributable to exposure to all chemicals through a single exposure pathway is known as a hazard index (HI) (US EPA OW, 1998). The HI is calculated as follows:

$$HI = \sum_i HQ_x$$

Where:			**Units**
HI	=	hazard index for a specific exposure pathway	unitless
HQ_x	=	hazard quotient for chemical x	unitless

A receptor's total hazard is considered to be the sum of all the HI values for each of the specific exposure pathways.

Table 1 Parameter Definitions and Receptor Exposure Assumptions

Parameter Definitions		Exposure Assumptions	
		Lower Site	Upper Site
TDI =	reference dose (mg/kg bw-day)	chemical specific	chemical specific
EDI =	estimated daily intake (multimedia exposure assessment) (mg/kg bw-day)	chemical specific	chemical specific
SAF =	soil allocation factor (unitless)	chemical specific	chemical specific
BW =	body weight (kg)	16.5	16.5
BSC =	background soil concentration (mg/kg)	chemical specific	chemical specific
RAF_{ing} =	relative absorption factor for gut (unitless)	chemical specific	chemical specific
RAF_{derm} =	relative absorption factor skin (unitless)	chemical specific	chemical specific
C_{soil} =	concentration of chemical in soil (mg/kg)	site specific	site specific
$C_{caribou}$ =	concentration of chemical in caribou (mg/kg)	site specific	site specific
C_{hare} =	concentration of chemical in hare (mg/kg)	site specific	site specific
C_{fish} =	concentration of chemical in fish (mg/kg)	site specific	site specific
C_{water} =	concentration of chemical in water (mg/L)	site specific	site specific
DA_{event}=	absorbed dose per event (mg/cm^2-event)	chemical specific	chemical specific
IR_{soil} =	soil ingestion rate (mg/hr)	3.33	3.33
IR_{air} =	air inhalation rate (m^3/hr)	0.39	0.3875
IR_{game} =	wild game ingestion rate (mg/day)	85000.00	85000
IR_{fish} =	fish ingestion rate (mg/day)	95000.00	95000
IR_{water} =	water ingestion rate (L/day)	0.60	0.6
P_{air}=	particulate concentration in air (kg/m^3)	7.60E-10	7.6E-10
SA_{body}=	exposed receptor surface area - body (cm^2)	2580	2580
SA_{hand}=	exposed receptor surface area - hand (cm^2)	430	430
SA_{water}=	exposed receptor surface area - dermal water (cm^2)	430	430
SAF_{body}=	soil adherance factor - body (mg/cm^2-day)	0.01	0.01
SAF_{hand}=	soil adherance factor - hand (mg/cm^2-day)	0.10	0.1
$ETerm_{ing}$ =	exposure term for soil ingestion pathway (unitless - event driven)	0.247	0.0384
$ETerm_{derm}$ =	exposure term for soil dermal contact pathway (unitless - event driven)	0.247	0.0384
$ETerm_{inh}$ =	exposure term for soil dust inhalation pathway (unitless - event driven)	0.247	0.0384
ET_{ing} =	exposure time for soil ingestion pathway (hour/day)	24	24
ET_{derm} =	exposure time for soil dermal contact pathway (hour/day)	24	24
ET_{inh} =	exposure time for soil dust inhalation pathway (hour/day)	24	24
ET_{dwater} =	exposure frequency for surface water dermal contact pathway (event/day)	3	3
EF_{ing}=	exposure frequency for soil ingestion pathway (days/year)	90	14
EF_{derm}=	exposure frequency for soil dermal contact pathway (days/year)	90	14
EF_{inh}=	exposure frequency for soil dust inhalation pathway (days/year)	90	14
EF_{game}=	exposure frequency for wild game ingestion pathway (days/year)	90	14
EF_{fish}=	exposure frequency for fish ingestion pathway (days/year)	90	14
EF_{water}=	exposure frequency for water ingestion pathway (days/year)	90	14
EF_{dwater}=	exposure frequency for water dermal contact pathway (days/year)	90	14
ED=	exposure duration (years)	4.5	4.5
F_{site}=	fraction of wild game caught from the site (unitless)	1.00	1
$F_{caribou}$=	fraction of wild game that is caribou (unitless)	0.90	0.9
F_{hare}=	fraction of wild game that is hare (unitless)	0.10	0.1
F_{fish}=	fraction of fish caught from site (unitless)	1.00	1
F_{cf}=	fraction of fish contaminated (unitless)	1.00	1
F_{water}=	fraction of drinking water from site (unitless)	1.00	1
CF_1=	conversion factor (kg/mg)	1.00E-06	0.000001
CF_2=	conversion factor (days/hour)	4.20E-02	0.042
AT=	averaging time (non-cancer/cancer days)	1642.5/27375	1642.5/27375

Table 2 Summary Toxicological Reference Values and Relative Absorption Factors

Compound	Non-carcinogenic		Carcinogenic		SAF	RAF_{ing}	RAF_{inh}	RAF_{derm}
	TDI (oral) mg/kg-d	TDI (inhal.) mg/kg-d	SFo (oral) $(mg/kg\text{-}d)^{-1}$	SFi (inhal) $(mg/kg\text{-}d)^{-1}$				
Inorganics								
Antimony	4.0E-04	--	--	--	0.2	1	1	0.1
Barium	1.6E-02	--	--	--	0.2	1	1	0.1
Beryllium	2.0E-03	4.75E-6	--	1.01E+01	0.2	1	1	0.03
Cadmium	8.0E-04	--	--	4.29E+01	0.2	1	1	0.14
Copper	1.0E-02	--	--	--	0.2	1	1	0.1
Lead	3.57E-03	--	--	--	0.2	1	1	0.006
Tin	6.0E-01	--	--	--	0.2	1	1	0.02
TPH - CCME CWS								
Aliph>C06-C08 - F1	5.0E+00	--	--	--	0.2	1	1	0.2
Aliph>C08-C10 -F1	1.0E-01	--	--	--	0.2	1	1	0.2
Arom>C08-C10 -F1	4.0E-02	--	--	--	0.2	1	1	0.2
F1 - Total								
Aliph>C10-C12 -F2	1.0E-01	2.23E-01	--	--	0.2	1	1	0.2
Aliph>C12-C16 -F2	1.0E-01	2.23E-01	--	--	0.2	1	1	0.2
Arom>C10-C12 -F2	4.0E-02	4.0E-02	--	--	0.2	1	1	0.2
Arom>C12-C16 -F2	4.0E-02	4.0E-02	--	--	0.2	1	1	0.2
F2 - Total								
Aliph>C16-C21-F3	2.0E+00	--	--	--	0.2	1	1	0.2
Aliph>C21-C34 -F3	2.0E+00	--	--	--	0.2	1	1	0.2
Arom>C16-C21 -F3	3.0E-02	--	--	--	0.2	1	1	0.2
Arom>C21-C34 -F3	3.0E-02	--	--	--	0.2	1	1	0.2
F3 - Total								
Aliph>C34-C50 -F4	2.0E+01	--	--	--	0.2	1	1	0.2
Arom>C34-C50 -F4	3.0E-02	--	--	--	0.2	1	1	0.2
F4 - Total								
Organics								
Total PCBs	1.0E-03	--	2.0	4.2E-01	0.2	1	1	0.1

-- not available: where separate inhalation TRVs are not available, the inhalation dose is summed with the dermal/ingestion dose and then compared to the oral TRV.

Table 3 CoPC Concentrations Used in HHRA

Compound	C_{soil} (mg/kg)	$C_{caribou}$ (mg/kg)	C_{hare} (mg/kg)	C_{fish} (mg/kg)	C_{water} (mgL)
Inorganics					
Antimony	19.5	6.52E-04	1.86E-02	--	3.00E-04
Barium	735	1.26E-02	1.22E+00	0.1	1.00E-02
Beryllium	0.55	1.0E-04	5.53E-04	--	--
Cadmium	19.2	8.7E-04	6.14E-02	--	--
Copper	940	4.4E-01	3.59E+00	0.53	2.00E-03
Lead	800	3.3E-03	7.80E-01	--	--
Tin	53	7.7E-02	4.99E-01	2.4	--
TPH - CCME CWS					
Aliph>C10-C12 -F2	4788	1.54E-02	1.54E-02	--	--
Aliph>C12-C16 -F2	5852	1.88E-02	1.88E-02	--	--
Arom>C10-C12 -F2	1197	3.85E-03	3.85E-03	--	--
Arom>C12-C16 -F2	1463	4.71E-03	4.71E-03	--	--
F2 - Total	13300	4.28E-02	4.28E-02	--	--
Aliph>C16-C21-F3	10248	1.94E-01	1.94E-01	--	--
Aliph>C21-C34 -F3	4392	8.33E-02	8.33E-02	--	--
Arom>C16-C21 -F3	2562	4.86E-02	4.86E-02	--	--
Arom>C21-C34 -F3	1098	2.08E-02	2.08E-02	--	--
F3 - Total	18300	3.47E-01	3.47E-01	--	--
Aliph>C34-C50 -F4	54400	5.14E-02	5.14E-02	--	--
Arom>C34-C50 -F4	13600	1.29E-02	1.29E-02	--	--
F4 - Total	68000	6.43E-02	6.43E-02	--	--
Organics					
Total PCBs	25.2	1.18E-03	1.15E-03	2.20E-02	--

-- = Parameter not evaluated for this pathway

Table 4 Exposure Pathway Specific Hazard Quotients

Compound	HQ Soil Ingestion	HQ Soil Dermal	HQ Soil Dust Inhalation	HQ Site Soil	HQ Caribou Ingestion	HQ Hare Ingestion	HQ Fish Ingestion	HQ Water Ingestion	HQ Food Intake	HQ Water Dermal
Inorganics										
Antimony	5.83E-02	5.05E-03	5.15E-06	6.33E-02	1.86E-03	5.91E-03	--	6.72E-03	1.45E-02	7.23E-04
Barium	5.49E-02	4.76E-03	4.85E-06	5.97E-02	9.00E-04	9.69E-03	8.87E-03	5.60E-03	2.51E-02	6.02E-04
Beryllium	3.29E-04	8.55E-06	1.22E-05	3.50E-04	5.94E-05	3.51E-05	--	--	9.46E-05	--
Cadmium	2.87E-02	3.48E-03	2.53E-06	3.22E-02	1.24E-03	9.75E-03	--	--	1.10E-02	--
Copper	1.12E-01	9.74E-03	9.93E-06	1.22E-01	5.06E-02	4.56E-02	7.52E-02	1.79E-03	1.73E-01	1.93E-04
Lead	2.68E-01	1.39E-03	2.37E-05	2.69E-01	1.06E-03	2.78E-02	--	--	2.88E-02	--
Tin	1.06E-04	9.15E-06	9.33E-09	1.15E-04	1.47E-04	1.06E-04	5.68E-03	--	5.93E-03	--
TPH - CCME CWS										
Aliph>C10-C12 -F2	5.72E-02	9.92E-03	2.27E-06	6.72E-02	1.76E-04	1.96E-05	--	--	1.96E-04	--
Aliph>C12-C16 -F2	7.00E-02	1.21E-02	2.77E-06	8.21E-02	2.15E-04	2.39E-05	--	--	2.39E-04	--
Arom>C10-C12 -F2	3.58E-02	6.20E-03	3.16E-06	4.20E-02	1.10E-04	1.22E-05	--	--	1.22E-04	--
Arom>C12-C16 -F2	4.37E-02	7.58E-03	3.86E-06	5.13E-02	1.35E-04	1.50E-05	--	--	1.50E-04	--
F2 - Total	2.07E-01	3.58E-02	1.21E-05	2.43E-01	6.36E-04	7.07E-05	--	--	7.07E-04	--
Aliph>C16-C21-F3	6.13E-03	1.06E-03	5.41E-07	7.19E-03	1.11E-04	1.23E-05	--	--	1.23E-04	--
Aliph>C21-C34 -F3	2.63E-03	4.55E-04	2.32E-07	3.08E-03	4.76E-05	5.29E-06	--	--	5.29E-05	--
Arom>C16-C21 -F3	1.02E-01	1.77E-02	9.02E-06	1.20E-01	1.85E-03	2.06E-04	--	--	2.06E-03	--
Arom>C21-C34 -F3	4.38E-02	7.59E-03	3.87E-06	5.13E-02	7.93E-04	8.82E-05	--	--	8.82E-04	--
F3 - Total	1.55E-01	2.68E-02	1.37E-05	1.81E-01	2.80E-03	3.11E-04	--	--	3.11E-03	--
Aliph>C34-C50 -F4	3.25E-03	5.64E-04	2.87E-07	3.82E-03	2.94E-06	3.27E-07	--	--	3.27E-06	--
Arom>C34-C50 -F4	5.42E-01	9.40E-02	4.79E-05	6.36E-01	4.90E-04	5.45E-05	--	--	5.45E-04	--
F4 - Total	5.45E-01	9.45E-02	4.82E-05	6.40E-01	4.93E-04	5.48E-05	--	--	5.48E-04	--
Organics										
Total PCBs	3.01E-02	2.61E-03	2.66E-06	3.27E-02	1.35E-03	1.46E-04	3.12E-02	--	3.27E-02	--

-- = Parameter not evaluated for this pathway

Table 5 Exposure Pathway Incremental Excess Lifetime Cancer Risks

Compound	IELCR Soil Ingestion	IELCR Soil Dermal	IELCR Soil Dust Inhalation	IELCR Site Soil	IELCR Caribou Ingestion	IELCR Hare Ingestion	IELCR Fish Ingestion	IELCR Water Ingestion	IELCR Food Intake	IELCR Water Dermal
Inorganics										
Cadmium	--	--	2.54E-10	--	--	--	--	--	--	--
Beryllium	--	--	3.76E-08	--	--	--	--	--	--	--
Total PCBs	4.71E-06	3.13E-06	4.85E-10	7.84E-06	1.96E-06	2.12E-07	3.55E-05	--	3.77E-05	--

-- = Parameter not evaluated for this pathway