Table 9 Summary of Receptor Characteristics for Each Age Group

Characteristic	Receptor Values						Source
	Infant	Toddler	Child	Teen	Adult	Composite	
Age	0 - 6 mo.	7 mo. – 4 yr	5 – 11 yr	12 - 19 yr	20 - 75 yr	over 75 year lifetime	HC, 1994
AT (years)	0.5	4.5	7	8	56	75	
BW (kg)	8.2	16.5	32.9	59.7	70.7	62.33	HC(2003)
IR_{soil} (mg/h)	0.83	3.33	0.83	0.83	0.83	0.98	HC (2003)
IR_{air} (m^3/hr)	0.0875	0.4	0.6	0.7	0.7	0.6	Richardson, 1996
IR_{water} (L/d)	0.3	0.6	0.8	1	1.5	1.319	Richardson, 1997
SA_{hand} (cm^2)	320	430	590	800	890	821	Richardson, 1997
SA_{body} (cm^2)	1780	3010	5140	8000	9110	8206	Richardson, 1997
IR_{fish} (mg/d)	0	95	170	200	220	204.23	Richardson, 1997
IR_{game} (mg/d)	0	85	125	175	270	233.43	Richardson, 1997

Note:
All characteristic acronyms described in Table 9.

4.4 TOXICITY ASSESSMENT

The potential hazards associated with exposures to non-carcinogenic (threshold) substances are assessed differently than the potential risks associated with exposures to carcinogenic (non-threshold) substances. For threshold substances, it is assumed that there is a dose (or concentration) of the chemical of potential concern that does not produce any adverse effect. A Tolerable Daily Intake (TDI) is an estimate of a chemical intake that is unlikely to cause an increased incidence of deleterious health effects during a lifetime of exposure. TDIs are specifically developed to be protective for chronic exposure to a chemical. For the purposes of deriving site-specific threshold levels, a chronic daily intake (CDI) is calculated for the exposed individual and compared to the TDI. If CDI/TDI >0.2, then there is the potential for adverse health effects and further assessment would be required.

For contaminants for which the critical effect is assumed to have no threshold (i.e., carcinogens), it is assumed that there is some probability of harm to human health at any level of exposure (CCME, 1996). There is a linear dose-response relationship that converts estimated daily intakes averaged over a lifetime of exposure directly to an incremental risk of an individual developing cancer. For the purposes of deriving site-specific soil quality guidelines, Health Canada considers that a single increased case of cancer in an exposed population of 100,000 merits action (Health Canada, 2003). As such, a target risk (TR) of one in one hundred thousand or 10^{-5} is used in this risk assessment for carcinogenic effects.

4.5 SELECTION OF TOXICITY REFERENCE VALUES (TRVS)

An essential part of the risk assessment is the identification of appropriate toxicity reference values. This is typically done by a literature review of published toxicological assessments.

Toxicity values have been established by several agencies including Health Canada, the United States Environmental Protection Agency (US EPA), as well as others. Preference has been given to Health Canada TRVs as per Federal Guidance (HC, 2003). In the event that a Health Canada TRV does not exist the most scientifically up to date toxicity values upon which to evaluate health risks were utilized.

Summaries of the toxicity values selected for inclusion in the risk assessment are provided in Table 10 and 11, and detailed rationales for each of the toxicity values are provided in Appendix A.

Table 10 Selected Cancer Toxicity Values

CoPC	Route of Exposure	Exposure Limit $(mg/kg\text{-}d)^{-1}$	Toxicological Basis	Source Agency
Inorganics				
Beryllium	Ingestion	na	na	na
	Inhalation	10.7	Lung cancer	Calculated based on IRIS (2004)
Cadmium	Ingestion	na	na	na
	Inhalation	42.9	Not Specified	Health Canada (2003)
Organics				
PCB's	Ingestion	2.0	liver hepatocellular adenomas, carcinomas, and cholangiomas	IRIS (2004)
	Inhalation	0.4	Not Specified	IRIS (2004)

Table 11 Selected Non-Carcinogenic Toxicity Values

CoPC		Route of Exposure	Exposure Limit (mg/kg-d)	Toxicological Basis	Source Agency
Inorganics					
Antimony		Ingestion	4.00E-04	Decrease lifespan, decrease in glucose levels, altered cholesterol	IRIS (2004)
		Inhalation	na	na	na
Barium		Ingestion	1.6E-02	Not Specified	HC (2003)
		Inhalation	na	na	na
Beryllium		Ingestion	2.0E-03	Small Intestinal Lesions	IRIS (2004)
		Inhalation	4.47E-6	Beryllium sensitization and progression to CBD	IRIS (2004)
Cadmium		Ingestion	8.00E-04	Not Specified	HC (2003)
		Inhalation	na	na	na
Copper		Ingestion	0.01	Not Specified	CCME (1999)
		Inhalation	na	na	na
Lead		Ingestion	3.57E-04	Blood levels in young children	HC (1996b)
		Inhalation	na	na	na
Tin		Ingestion	6.0E-01	Not Specified	HEAST (1997)
		Inhalation	na	na	na
Organics					
PCBs		Ingestion	0.001	Not Specified	HC (2003)
		Inhalation	na	na	na
Petroleum Hydrocarbons CWS Fractions					
F2	Aliph>C10-C12	Ingestion	0.1	Hepatic and hematological changes	CCME (2000)
		Inhalation	na	na	na
	Aliph>C12-C16	Ingestion	0.1	Hepatic and hematological changes	CCME (2000)
		Inhalation	na	na	na
	Arom>C10-C12	Ingestion	0.04	Decreased body weight	CCME (2000)
		Inhalation	na	na	na
	Arom>C12-C16	Ingestion	0.04	Decreased body weight	CCME (2000)
		Inhalation	na	na	na
F3	Aliph>C16-C21	Ingestion	2	Hepatic granuloma	CCME (2000)
		Inhalation	na	na	na
	Aliph>C21-C34	Ingestion	2	Hepatic granuloma	CCME (2000)
		Inhalation	na	na	na
	Arom>C16-C21	Ingestion	0.03	Nephrotoxicity	CCME (2000)
		Inhalation	na	na	na
	Arom>C21-C34	Ingestion	0.03	Nephrotoxicity	CCME (2000)
		Inhalation	na	na	na
F4	Aliph>C34-C50	Ingestion	20	Hepatic granuloma	CCME (2000)
		Inhalation	na	na	na
	Arom>C34-C50	Ingestion	0.03	Nephrotoxicity	CCME (2000)
		Inhalation	na	na	na

na – not available: when no separate inhalation TRV is available, the inhalation dose is summed with the dermal/ingestion doses and compared to the oral TRV.

4.5.1 Bioavailability

Bioavailability refers to "the fraction of the total amount of material in contact with a body portal-of-entry (lung, gut, skin) that enters the blood". Relative bioavailability is the amount of a substance entering the blood via a particular route of exposure (e.g., gastrointestinal) relative to the study used to derive the TRV. These factors were then applied in the risk assessment to more realistically represent the portion of contaminants held in soil that are available. For instance, a relative bioavailability factor of 0.5 indicates that 50% of the administered (e.g., ingested) chemical is absorbed into the bloodstream compared to the absorption in the TRV study. Relative bioavailability via ingestion and inhalation routes of exposure are conservatively assumed to be a factor of 1.0. Table 12 provides the bioavailability factors used in this assessment.

Table 12 Selected Relative Bioavailability Factors

CoPC		Oral	Dermal	Inhalation
Antimony		1	0.1	1
Barium		1	0.1	1
Beryllium		1	0.03	1
Cadmium		1	0.14	1
Copper		1	0.1	1
Lead		1	0.06	1
Tin		1	0.1	1
Total PCBs		1	0.1	1
Petroleum Hydrocarbon CWS Fractions	F2	1	0.2	1
	F3	1	0.2	1
	F4	1	0.2	1

Detailed rationale supporting the selection of each of the values recommended for use in this assessment is provided in Appendix A.

4.5.2 Non-Carcinogens

The potential health effects associated with non-carcinogenic chemicals are assessed differently than those for carcinogenic chemicals. Non-carcinogenic chemicals are generally considered to act through a threshold mechanism where it is assumed that there is a dose (or concentration) that does not produce any adverse effect. As the dose or concentration increases to the point where the body can no longer process or excrete the chemical, an adverse effect may occur. This point is termed the threshold and is different for every chemical.

Approach and Methodology

For risk characterization of non-carcinogenic CoPCs individual hazard quotients (HQs) were derived for each of The estimated daily intakes (EDIs) for the CoPCs in this assessment are not available and thus can not be subtracted from the TDI.

$$HQ = \frac{CDI}{TDI}$$

where

CDI Chronic Daily Intake
= sum of all site-specific intake pathways
= soil/dust ingestion + soil/dust dermal contact + soil particulate/dust inhalation

TDI Tolerable Daily Intake

A target HQ of 0.2 was used for CoPCs, as this risk assessment has not addressed all potential pathways of exposure, including background

exposure from items such as supermarket foods. Using a HQ benchmark of 0.2 permits 80% of a person's CoPC intake to come from non-site related exposures. If the HQ is less than 0.2 then the intake of CoPCs from site exposure does not exceed the tolerable level and no adverse health effects are expected.

4.5.3 Results for CAM-F Non-Carcinogens

HQs for beryllium, copper, lead, total PCBs and TPH F2, F3, F4 fractions, which were derived using the maximum concentration as EPC, are presented in Table 14.

In the Traditional Land Use scenario of the CAM-F site the total exposure risks from maximum antimony, barium, beryllium, cadmium, copper, tin, total PCBs and TPH F3 concentrations on the site are below 0.2, thus exposure to the site results in negligible potential risk to receptors.

However, the total exposure risks from maximum lead, TPH F2 and F4 concentrations on the site were above 0.2, indicating exposure to the site results in potential risk to receptors.

Table 13 Hazard Quotients for Non-Carcinogenic CoPCs at the Site

CoPC	EPC (mg/kg)	Total HQ	Target HQ	Exceeds Target HQ?
Antimony	19.5	7.9E-02	2.0E-01	No
Barium	735	8.5E-02	2.0E-01	No
Beryllium	0.55	4.4E-04	2.0E-01	No
Cadmium	19.2	4.3E-02	2.0E-01	No
Copper	940	3.0E-02	2.0E-01	No
Lead	**800**	**3.0E-01**	**2.0E-01**	**Yes**
Tin	53	6.0E-03	2.0E-01	No
Total PCBs	25.2	6.5E-02	2.0E-01	No
TPH F2 Fraction	**13300**	**2.4E-01**	**2.0E-01**	**Yes**
TPH F3 Fraction	18300	1.8E-01	2.0E-01	No
TPH F4 Fraction	**68000**	**6.4E-01**	**2.0E-01**	**Yes**

Figures 4 to 14 illustrate the relative contributions of the individual pathways assessed to the total HQ. The HQ from each pathway is presented in Appendix B.

Figure 4 Relative Contributions to the Antimony Total HQ

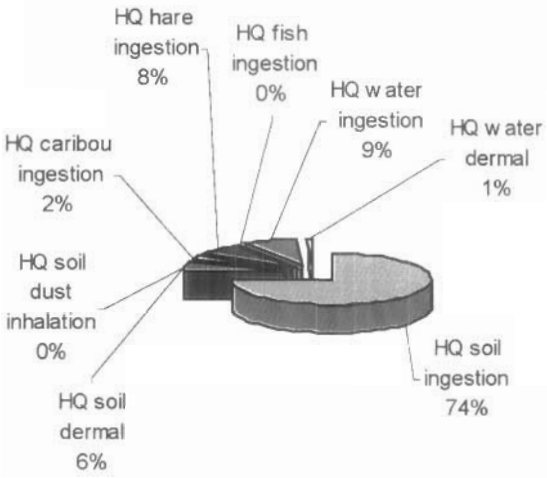


Figure 6 Relative Contributions to the Beryllium Total HQ

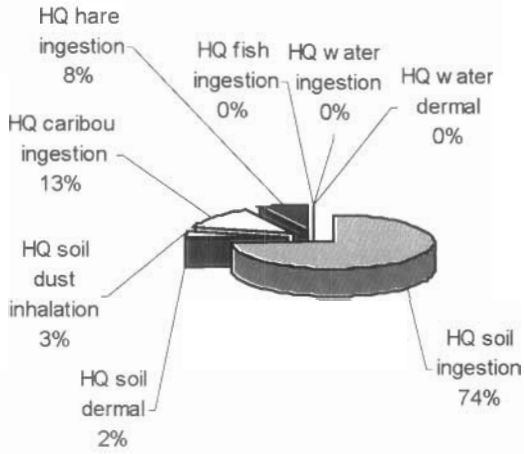


Figure 5 Relative Contributions to the Barium Total HQ

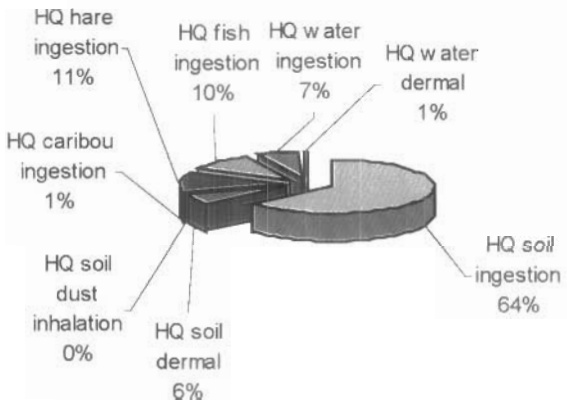


Figure 7 Relative Contributions to the Cadmium Total HQ

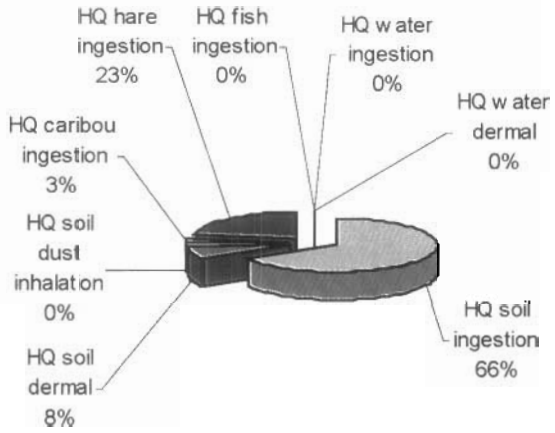


Figure 8 Relative Contributions to the Copper Total HQ

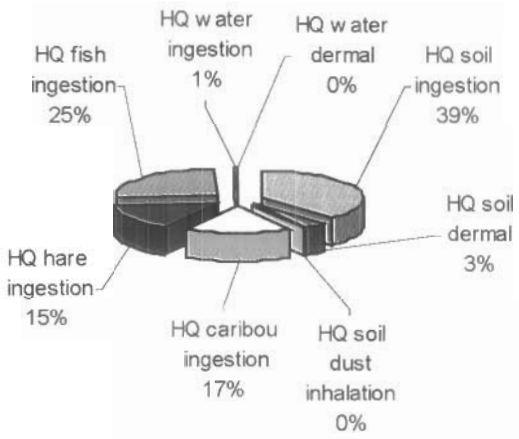


Figure 9 Relative Contributions to the Lead Total HQ

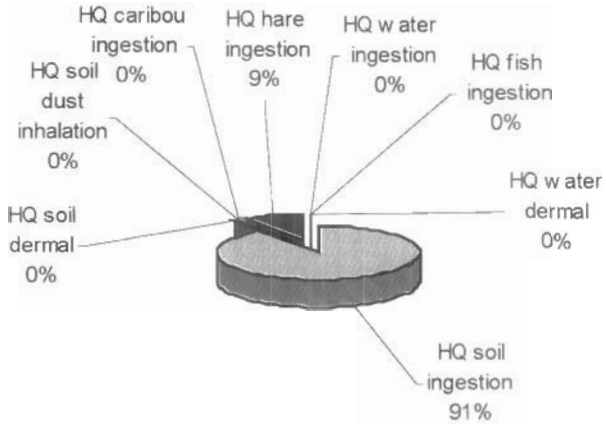


Figure 10 Relative Contributions to the Tin Total HQ

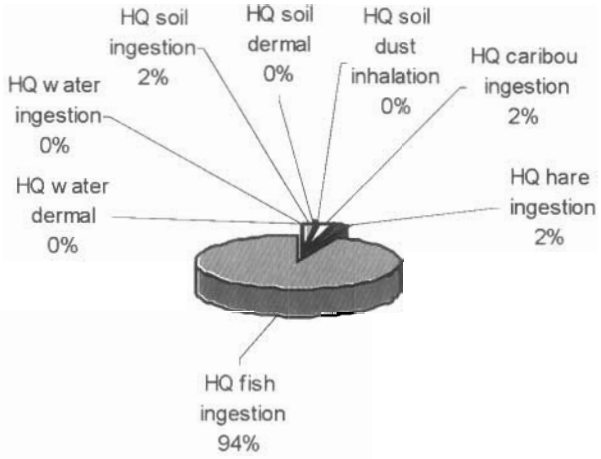


Figure 11 Relative Contributions to the TPH Fraction F2 Total HQ

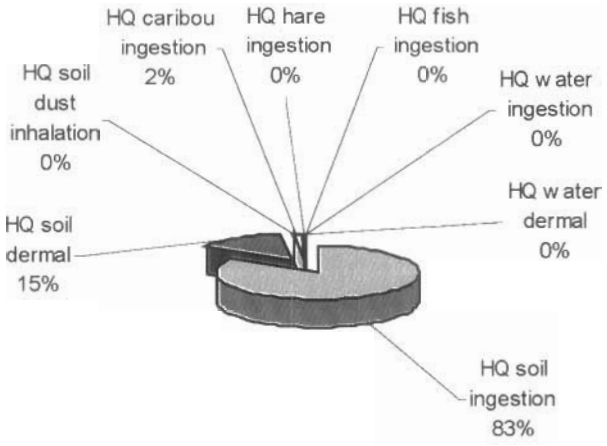


Figure 12 Relative Contributions to the TPH Fraction F3 Total HQ

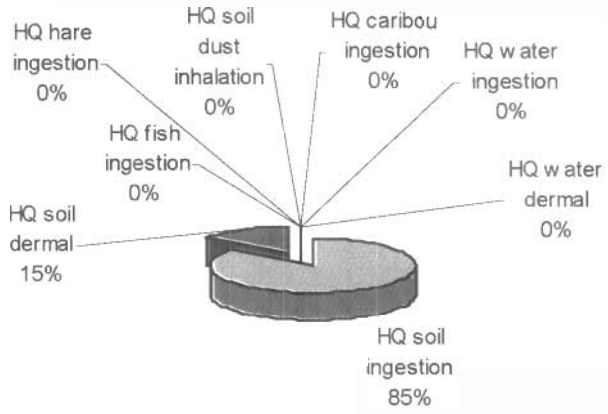


Figure 13 Relative Contributions to the TPH Fraction F4 Total HQ

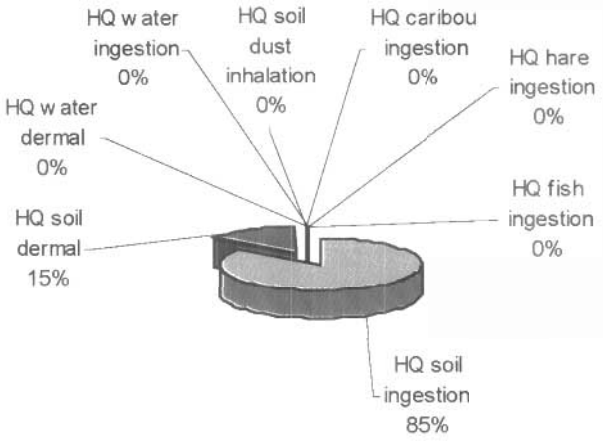
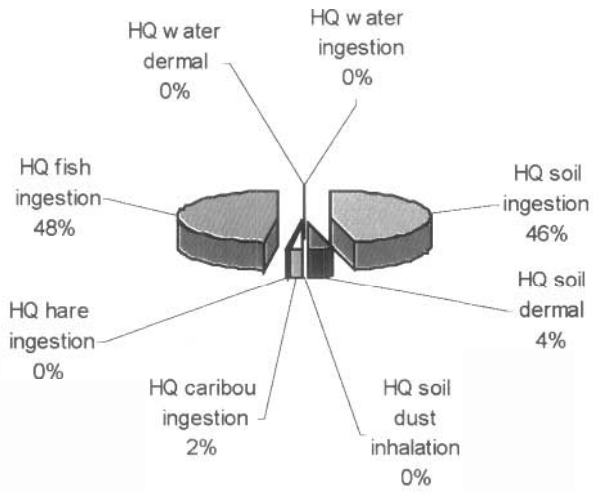


Figure 14 Relative Contributions to the Total PCBs Total HQ



It must be noted that this assessment is based on an exposure point concentration (EPC) equal to the maximum concentration found on the site, and the conservative assumption that the receptor would spend 90 days on the site, and the HQ is therefore very conservative and is likely an over-estimate of the risk.

4.5.4 Carcinogens

As previously discussed, the characterization of potential hazards associated with carcinogenic and non-carcinogenic exposures is assessed separately, based on the differences in the way these two types of chemicals may produce effects in the body. Beryllium and cadmium have both carcinogenic and non-carcinogenic potential, therefore is assessed as both for this HHRA.

Approach and Methodology

In determining the incremental excess increase in lifetime cancer risk associated with exposure to beryllium and cadmium, the estimated dose is compared to the established cancer slope factors as shown below:

$$IELCR = LADD*CSF$$

where:

IELCR	Incremental Excess Lifetime Cancer Risk
LADD	Lifetime Averaged Daily Dose (mg/kg-day)
CSF	Cancer Slope Factor ([mg/kg-day]$^{-1}$)

The Incremental Excess Lifetime Cancer Risk (IELCR) estimates the incremental probability that a person will develop cancer as a result of a lifetime of exposure to the site. This incremental lifetime cancer risk is over and above the probability of developing cancer due to ambient exposures. The characterization of potential IELCR was undertaken using a target risk benchmark established by Health Canada of 1 in 100,000 (theoretically one additional cancer per 100,000 population). Calculation of the Lifetime Average Daily Dose (LADD) is based on methods presented by US EPA (1989), CCME (1996), and OMOE (1996). Details of the equations and parameter values used in the analysis are provided in Appendix B.

In general, exposure pathways and intake values were consistent with those used for the development of the non-carcinogenic HQs but were averaged over a lifetime of exposure rather than being specific to one age group.

4.5.5 Results for Site Carcinogens

IELCRs were derived for beryllium, cadmium and total PCBs at the site, and are presented in Table 14.

The IELCRs for beryllium and cadmium were less than the acceptable benchmark of $1x10^{-5}$. Therefore, exposure to beryllium and cadmium concentrations in soil at the site pose a negligible potential risk to human receptors.

The IELCR for total PCBs was greater than the acceptable benchmark of $1x10^{-5}$. Therefore, exposure to total PCB concentrations in soil at the site pose a potential risk to human receptors.

Table 14 Incremental Excess Lifetime Cancer Risks for Carcinogenic CoPCs

CoPC	EPC (mg/kg)	Total IELCR	Target HQ	Exceeds Target HQ?
Beryllium	0.55	2.69E-10	1.00E-05	No
Cadmium	19.2	2.76E-08	1.00E-05	No
Total PCBs	**25.2**	**4.56E-05**	**1.00E-05**	**Yes**

Because only a carcinogenic inhalation TRV is available for beryllium and cadmium, only the inhalation pathway was assessed the entire IELCR can be attributed to the inhalation of soil particles.

4.5.6 Summary of Site Risk

The HQs for exposure to maximum concentrations of antimony, barium, beryllium, cadmium, copper, tin, total PCBs and TPH F3 during Traditional Land Uses at the CAM-F site were less than 0.2, indicating that those CoPCs pose a negligible risk to human health at the site.

However, the total exposure risks from maximum lead, TPH F2 and F4 concentrations on the site were above 0.2, indicating that exposure to the site could result in the potential to produce adverse effects in human receptors under the exposure scenarios included in the risk assessment.

The IELCRs for exposure to beryllium and cadmium during Traditional Land Uses at the CAM-F site were less than $1x10^{-5}$, indicating that those CoPCs pose a negligible cancer risk at the site.

The IELCR for total PCBs was greater than the acceptable benchmark of $1x10^{-5}$ indicating that exposure to the site could result in the potential to produce adverse effects in human receptors under the exposure scenarios included in the risk assessment.

This assessment has incorporated a number of very conservative assumptions, including exposure times for traditional land use of the site for 90 days, and the use of the maximum concentrations found on the site as the EPC.

4.6 HUMAN HEALTH SITE SPECIFIC TARGET LEVELS

Human health site-specific target levels (SSTLs) are developed based on the exposure characteristics of the user of the site. The SSTL values represent concentrations above, which adverse health effects are possible and further action may be required. These values can be used during any future site assessment activities at the site, only if land use has not changed from those scenarios modeled in this human health risk assessment.

Maximum concentrations of lead, TPH F2 and F4 Fractions resulted in a HQ greater than 0.2 and the maximum total PCB concentration resulted in an IELCR greater than $1x10^{-5}$, indicating that exposure to the site could result in potential to produce adverse effects in human receptors under the exposure scenarios included in the risk assessment.

Consequently, site specific target levels (SSTLs) were calculated for each of these chemicals. The SSTLs were calculated by setting the HQ at 0.2 and the IELCR at $1x10^{-5}$, and determining the corresponding surface soil EPC for that target value, using a backward calculation. The SSTLs for each receptor are shown in Table 15.

Table 15 Site Specific Target Levels in Surface Soils at CAM-F

CoPC	Surface Soil SSTL (mg/kg)
Lead	590
TPH F2 Fraction	11,000
TPH F4 Fraction	21,200
Total PCBs	32.0

4.7 UNCERTAINTY ANALYSIS

Risk estimates normally include an element of uncertainty, and generally these uncertainties are addressed by incorporating conservative assumptions in the analysis. As a result, risk assessments tend to overstate the actual risk. Although many factors are considered in preparation of a risk analysis, the results are generally only sensitive to very few of these factors. The uncertainty analysis is included to demonstrate that assumptions used are conservative, or that the analysis result is not sensitive to the key assumptions.

A risk assessment containing a high degree of confidence will be based on:

- conditions where the problem is defined with a high level of certainty based on data and physical observations;
- an acceptable and reasonable level of conservatism in assumptions that will ensure that risks are overstated; or
- an appreciation of the bounds and limitations of the final solution.

The exposure assessment performed as part of this assessment was based on:

- available data to describe existing surface soil conditions and CoPC distributions;
- sound conservative assumptions for certain parameters, as required; and
- well-understood and generally accepted methods for risk prediction

4.7.1 Uncertainties in Toxicological Information

There is a very limited amount of toxicological information on the effects associated with human exposures to low levels of chemicals in the environment. What human information is available is generally based on epidemiological studies of occupationally exposed workers. These studies are generally limited in scope and provide results that may not be applicable to chronic or continuous exposures to low levels of chemicals. Because human toxicological information is limited, reference doses and cancer potency estimates for many compounds are based on the results of dose-response assessment studies using animals.

The use of experimental animal data to estimate potential biological effects in humans introduces uncertainties into the evaluation of potential human health effects. These estimations require that a number of assumptions be made:

- The toxicological effect reported in animals is relevant and could occur in humans.
- The assumption that extrapolation from high-dose studies to low-dose environmental exposures adequately represents the shape of the dose-response curve in the low-dose exposure range.
- Short-term exposures used in animal studies can be extrapolated to chronic or long-term exposures in humans.
- The uptake of a compound from a test vehicle (drinking water, food, etc.) in animals will be the same as the uptake of the chemical from environmental media (soil, sediment, air-borne particulate matter) in humans.

- The pharmacokinetic processes that occur in the test animals also occur in humans.

There are clearly a number of uncertainties associated with extrapolating from experimental animal data to humans. To address these weaknesses, regulatory agencies, such as the Health Canada and the US EPA, incorporate a large number of conservative assumptions to try and account for the uncertainties associated with this process. The uncertainties are accounted for by the use of Uncertainty Factors that are used to lower the reference dose well below the level at which adverse health effects have been reported in the test species. Uncertainty factors are generally applied by factors of 10 and are used to account for the following types of uncertainties:

- Variation within the population (protection of sensitive members of the population).
- Differences between humans and the test species.
- Differences in using short or medium-term studies to estimate the health effects associated with long-term or chronic exposures.
- Limitations in the available toxicological information.

The magnitude of the uncertainty factors applied by the various regulatory agencies provides an indication of the level of confidence that should be placed in the reference value. Uncertainty factors typically range between 100 and 10,000, although some can be lower than 10. The latter values are found for a few chemicals where sound and substantial human toxicological information is available to enable the setting of toxicological end-point solely on the basis of human epidemiological information.

The application of uncertainty factors is intended to introduce a high degree of conservatism into the risk assessment process and to ensure, as far as possible, that limited exposures that exceed the reference concentrations will not result in adverse human health effects. Because risk assessments that use these regulatory limits incorporate the conservatism used in the development of the toxicological information, the results can generally be viewed as being extremely conservative.

4.7.2 Summation of Hazards for a Single Compound

For some CoPCs, the toxicity values for inhalation and oral exposures are based on different biological end-points. In this case, the summation of exposures or hazard indices is not a sound toxicological practice and will not provide adequate assessments of either the inhalation or ingestion hazard. Therefore, it is necessary to assess the biological end-points separately. The estimate of overall risk would be based on the greater of the two risks. Inhalation and ingestion exposure hazard have been assessed independently and the greater of the two hazards selected as the representative hazard.

However, for the CoPCs considered in this risk assessment the biological end-point is the same for both routes of exposure, estimates of hazard were based on estimates of total exposure.

4.7.3 Summation of Hazards of Multiple Compounds

The summation of hazards between compounds that do not have the same biological end-point or mechanism of action has little practical meaning.

The summation of hazard indices across compounds is only supportable when the individual compounds affect the same target organ and have similar mechanisms of action. In these cases, the summation of hazard indices may provide a better estimate of total risk than evaluations based on exposures to single chemicals. For this risk assessment, the toxicity values for the metals assessed are based on different biological end-points, hence, hazard indices have not been summed to provide an estimate of the overall hazard associated with these exposures.

4.7.4 Modeling Assumptions

Table 16 contains a summary of the assumptions used in this risk analysis, provides an evaluation for each assumption and an opinion as to whether the assumption is acceptable.

Table 16 Modeling Assumptions

Risk Assessment Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk?	Acceptable assumption?
Hazard Identification			
1. Screening of CoPC against human-health based generic CCME, MOE, or US EPA guidelines.	Generic guidelines by nature are very conservative in order that they can be reliably applied to any situation, potentially with little site-specific information available. Substances present at concentrations less than generic guidelines are unlikely to be of concern.	Neutral	Yes
2. Exposure point concentrations (EPCs) based on the maximum concentrations from the site.	Maximum concentrations are used as EPCs to present the most conservative assessment of risk posed by the site, for comparison to guidelines including the DEW Line cleanup criteria.	Over-estimate.	Yes
Receptor Characteristics			
1. For analysis of non-carcinogenic exposure, a toddler (0.5 – 4 years old) was chosen as the receptor.	Young children are the most sensitive age group for assessing non-carcinogenic effects. Resulting risks are over protective for an adult population. This approach is in accordance with accepted practice from Health Canada and the US EPA.	Neutral for young children but will over-estimate risks to adults.	Yes
2. For analysis of potential carcinogenic effects, a lifetime average was used representing yearly exposure to the site from birth to 75 years old.	For carcinogenic chemicals this is the most protective approach. In contrast, CCME only model adult exposure (20-75 years old) and US EPA only model exposure for 25 years (0-25 years old) averaged over a lifetime, both of which are less protective approaches.	Approach likely to over-estimate the risk.	Yes
3. For the Traditional Land Use scenario, both potential receptors (toddler and lifetime) assumed to be present on the site 24 hours per day and 90 days per year. While on the site they are assumed to be hunting and fishing on the site.	These are maximum values providing a reasonable maximum exposure estimate for a toddler but likely overestimating lifetime exposure.	Neutral to over-estimate.	Yes

Table 16 Modeling Assumptions

Risk Assessment Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk?	Acceptable assumption?
Toxicological Information			
1. Most current toxicity information available from Health Canada, US EPA Integrated Risk Information (IRIS) database, was employed.	This approach is in accordance with standard practice and provides the most recent scientific basis for toxicity values.	Neutral	Yes
2. Potential antagonistic/additive/ synergistic effects of chemical mixtures were not quantitatively assessed.	The summation of hazards between compounds that do not have the same biological end-point or mechanism of action has little practical meaning. Summation of hazard indices across compounds is only supportable when the individual compounds affect the same target organ and have similar mechanisms of action.	Neutral	Yes
Risk Characterization			
1. Exposure was modeled for three potential exposure pathways: soil/dust ingestion, dermal contact, and inhalation; wild game ingestion; and drinking water ingestion and dermal contact.	CCME base the generic guidelines on only soil ingestion. Therefore, this multi-pathway approach is more protective.	Neutral	Yes
2. Default CCME soil ingestion rate of 80 mg/day adopted.	CCME employed a soil ingestion rate of 80 mg/day for toddlers when they developed the 1999 soil quality guidelines. In Nunavut, climate considerations mean that outdoor exposure to soil likely only occurs over a limited period of time each year. During the winter months, residents may still be exposed to soil-derived household dust. For hunting exposure, no soil exposure is expected during winter months.	Neutral	Yes

Table 16 Modeling Assumptions

Risk Assessment Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk?	Acceptable assumption?
3. Assessment of the current nutritional health status of local receptors was not included in the scope of work.	Inuit peoples of the Canadian Arctic can have different nutritional status to southern populations due to dietary differences. Micronutrient deficiency (e.g., Ca, Fe, Vitamin D) has been reported and may affect the absorption of other chemicals into the body (e.g., increased absorption of lead). However, quantitative data is not available to determine the scope or magnitude of this effect and no quantitative information is available on the current health status of Arctic Bay residents who generally have a mixed diet of supermarket foods and country foods. Assessment of current health status, past exposures, and lifestyle factors (e.g., smoking) are beyond the scope of this risk assessment, which is a forward-looking process that considers current and future exposures based on post-reclamation site conditions. However, it should be noted that the dietary intakes of lead were not adjusted for relative bioavailability compared to the toxicity study, which was based on metabolic studies in infants. Absorption of lead is known to be higher in infants and young children and the TDI was extended by Health Canada to older age groups, where lead absorption is significantly lower, to protect other sensitive population groups. Therefore, a factor of safety is built into the TDI that would protect against some level of increased lead absorption sue to dietary deficiencies.	Neutral	Yes
4. Target risk for IELCR set at 1 in	This is the value adopted by CCME for	Neutral	Yes

Table 16 Modeling Assumptions

Risk Assessment Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk?	Acceptable assumption?
100,000 (10^{-5}).	"acceptable" target risk. Health Canada uses target risks in the range of 10^{-5} to 10^{-6}. The CCME soil quality guidelines correspond to IELCRs of approximately 10^{-5} to 10^{-6}.		
5. Target Hazard Quotient for evaluating CoPC exposure = 0.2.	CCME guidelines assume that guidelines may also have to be established for other contaminated media at a site (e.g., water) and therefore only apportion 20% of the allowable daily intake to soil exposure.	Neutral	Yes

5.0 ECOLOGICAL RISK ASSESSMENT

The following sections present the results of an ecological risk assessment (ERA), which evaluates the potential for adverse effects to non-domesticated fauna, based on current conditions and habitats at the CAM-F DEW line site (CAM-F). The site is located on a hill approximately 2 km north of the west arm of Sarcpa Lake on Melville Peninsula (Figure 1.1).

Ecological risk assessment is a process that evaluates the likelihood that adverse environmental effects may occur, or are occurring, because of exposure to one or more stressors (Suter 1993). The potential hazards or chemicals of potential concern (CoPCs), identified within the study area are chemical substances in environmental media (soil, water and terrestrial vegetation) from sources associated with past operations at the CAM-F site. Therefore, the purpose of this ERA was to provide a qualitative and quantitative analysis of the likelihood and potential magnitude of adverse environmental effects to Valued Environmental Components (VECs), which are ecological receptors (mammals and birds) present, or potentially present, in the study area.

Objectives

This ERA has been conducted according to principles laid out in Canadian guidance documents (CCME 1996, 1997). The objectives of the ERA are to:

- Qualitatively characterize the potential ecological receptors that have been observed or could be present in terrestrial habitats on or adjacent to the site.
- Assess potential exposures of ecological receptors to CoPCs in various environmental media within terrestrial habitats under current conditions.
- Quantify the risks associated with exposures of ecological receptors to CoPCs in various environmental media under current conditions.
- If unacceptable risk is identified, determine acceptable concentrations of contaminants (site specific target levels, or SSTLs) that would allow re-establishment of the habitat and would not pose ongoing risks.

This ERA used a general framework similar in concept to the approach used for the human health risk assessment, but is distinctive in its emphasis in three areas

- The ecological risk assessment does not consider effects on individuals of a single species, rather, it is concerned with potential effects at population, community, or ecosystem levels. In order to achieve this goal, the toxicity reference values that are used to evaluate whether ecological exposures may lead to effects are based on Lowest Observed Adverse Effect Level (LOAEL) data from the ecotoxicological

literature, with a focus on sublethal reproductive or developmental endpoints.

- There is no single set of ecological values or resources to be protected that can be generally applied to every site, so the selection of VECs and exposure pathways for the ERA is site-specific

- If appropriate, the ecological risk assessment can consider non-chemical, as well as chemical, stressors.

5.1 ECOLOGICAL RISK ASSESSMENT FRAMEWORK

Conceptually, the ecological risk assessment consists of three main steps:

- **Problem Definition** - This is a review of available physical and biological data for the site and receptor habitats that may be affected by releases of chemicals to environmental media. This step i) identifies potential ecological receptors (i.e., biological communities, populations, individuals, or habitats potentially at risk); ii) determines contaminants of concern and other stressors for ecological receptors; iii) identifies potential exposure pathways; and iv) determines appropriate assessment and measurement endpoints for the ecological risk assessment. Each of these elements is integrated into a conceptual model that is specific to the site.

- **Analysis (Exposure and Effects Assessments)** - This includes estimation of exposure of the ecological receptors to the contaminants of concern, and identification of exposure-response standards based on the concentrations of these chemicals in various environmental media.

- **Risk Characterization** - This is a description of the nature and magnitude of potential ecological risks, which is achieved by comparing exposure estimates for various media, exposure-response standards for the ecological receptors, and results of the site-specific surveys and bioassays. Exposure may be based directly on the concentration of a CoPC in an environmental medium, or it may be based on an estimated dose or intake rate for the CoPC. The exposure response standards can be either biological responses (such as mortality or impairment) associated with the measured or estimated concentration, or can be toxicological responses to the estimated dose (such as impaired reproduction or development). Risk characterization also includes a discussion of the uncertainties in the analysis, an evaluation of the necessity for remedial action, and may involve estimating the maximum chemical concentrations, or site-specific threshold levels (SSTLs) consistent with an acceptable level of risk.

The organization of this ERA is consistent with these elements of an ecological risk assessment. The hazard identification process is described in Section 5.2.1; the ecological receptors (VECs) are identified in Section 5.2.3; and the exposure pathways by which the VECs may be exposed to contaminant substances are outlined in Section 5.3.1. The information in these three sections is brought together in Section 5.3.2, which describes the conceptual site model, and

the selection of assessment and measurement endpoints. The actual risk characterization for the CAM-F DEW Line Site is presented in Section 5.4. Site specific threshold levels for ecological receptors are calculated and presented in Section 5.5, for those substances where a significant risk may exist to one or more ecological receptors. The uncertainty analysis for the ERA is presented in Section 4.6.

5.2 RISK SCREENING

The ERA was concerned primarily with substances that are present in environmental media that are accessible to wildlife. Therefore, CAM-F data was screened to consider surface soils (0 to 30 cm depth), sediments, and surface waters. Subsurface soils and groundwater samples were not considered in the ERA because they were not considered to be accessible to wildlife. The locations of soil and surface water and samples used in this study are presented by EarthTech in their report (2004). Screening for inorganic elements also included analysis of samples collected by the Environmental Sciences Group of the Royal Roads Military College in 1994 (RRMC 1994).

5.2.1 Hazard Identification

This step involved the selection of chemical substances that have potential for adversely impacting ecological receptors in habitats associated with the site. CoPCs were selected based on their concentration in soils, surface water or sediments, and their potential toxicity to ecological receptors. Identification of CoPCs was based on a comparison of site data to both toxicity-based screening criteria and (for inorganic substances) site-specific background concentrations.

An initial generic assessment of the potential for adverse effects associated with site-originated chemicals was conducted. This assessment compared the maximum detected concentration in soils with the generic CCME soil quality guidelines for the protection of ecological health (CCME 1999, 2001). For those substances for which CCME guidelines have not been developed, concentrations were screened using guidelines from the Ontario Ministry of Environment (OMOE 1997).

Table 17 illustrates the screening of CoPCs for CAM-F. The table lists the maximum observed soil concentration and number of samples for each substance, and the relevant guideline. If the substance is carried forward, its Exposure Point Concentration (EPC) is calculated. The EPC is intended to be a conservative (i.e., pessimistic, but not necessarily worst-case) estimator of the average on-site concentration that wildlife may be exposed to. Where sufficient data are available (i.e., if n=5) the EPC is estimated as the 95% upper confidence limit of the geometric mean value. Where few data are available (i.e., n<5), the EPC was assumed to be the maximum observed soil concentration from the CAM-F site-specific data. For context, the EPC is also compared (for inorganic substances) with site-specific background data and Ontario Typical Range (OTR; OMOE 1993) data for that substance, if available. The purpose of this comparison is to avoid inclusion of naturally occurring substances in the ERA that may have locally high background conditions. Finally, a decision is rendered regarding whether each substance is present at a