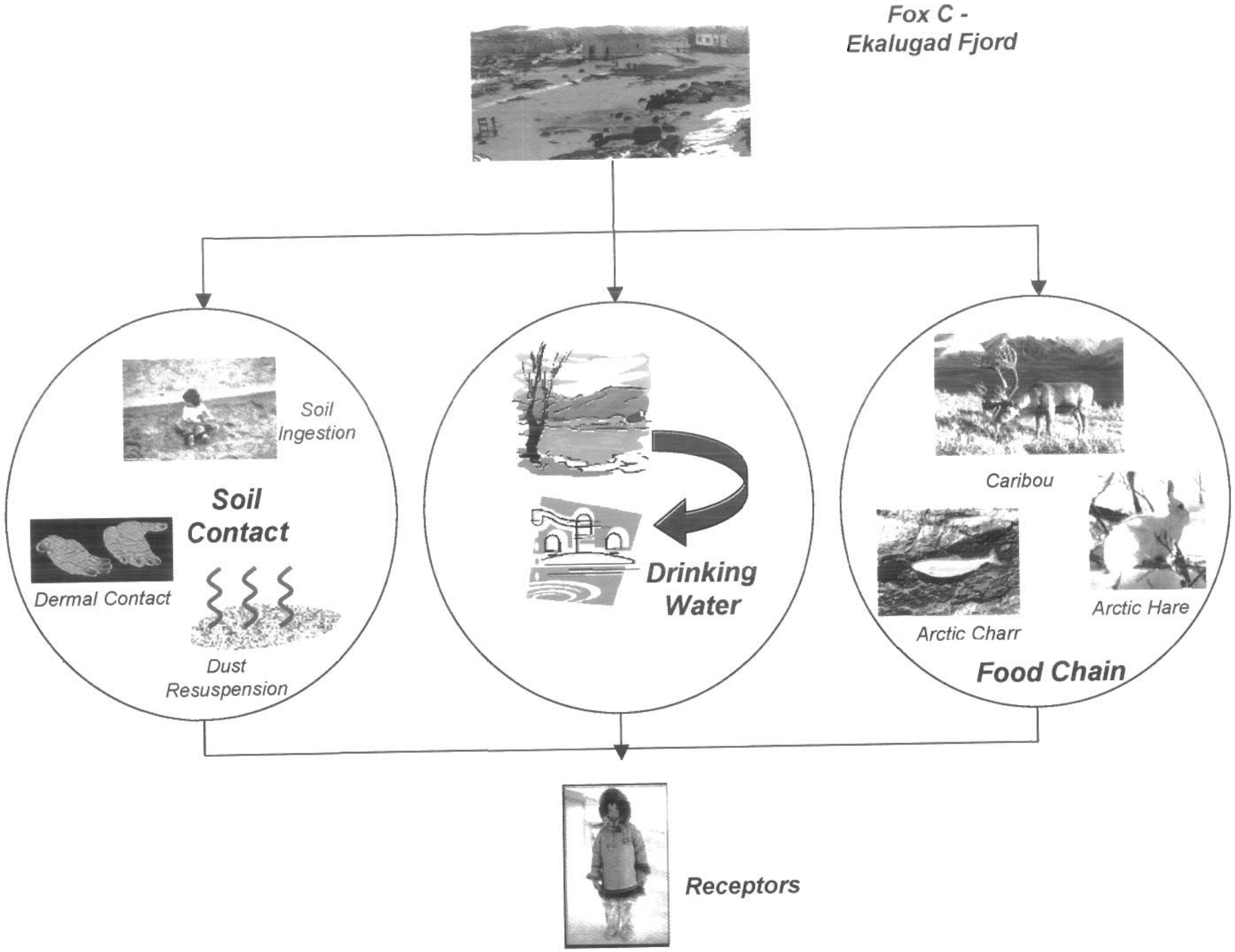
Figure 2 Site Conceptual Model



4.3 RECEPTOR CHARACTERISTICS

As discussed in Section 4.2.3, it is important that the most protective assumptions are made about the potential receptors. For the assessment of risk for beryllium, copper, lead, and the TPH F2, F3 and F4 fractions for exposure to the upper site the most sensitive receptor was a toddler aged 6 months to 4 years old. Similarly, for the assessment of risk for beryllium and the TPH F3 fraction for exposure to the lower site, the most sensitive receptor was a toddler aged 6 months to 4 years old. In addition, a composite receptor was included in the assessment to examine the carcinogenic effects of beryllium, and total PCBs. A reasonable maximum exposure approach is adopted for a traditional land use of the sites in which it was assumed that the toddler will be at the upper site for 24 hours per day, 14 days per year, while a toddler will be present at the lower site for a conservative 90 days per year. It was also conservatively assumed that the human receptor was exposed to the most highly contaminated soil present on each particular site. This is a very conservative assumption since most contaminated spots are localized to small areas and the receptor would likely wander off those areas at least part of the time while on site. Nevertheless, for this HHRA and to be protective of human health, maximum exposure concentrations were assumed.

Receptor characteristics for the toddler are presented in Table 9 below:

Table 9 Summary of Receptor Characteristics

Characteristics		Values		Source
		Visitor Toddler	Visitor Composite	
Averaging Times and Constant Values				
AT_c	Averaging time – cancer (yrs)	n/a	75	Equal to exposure duration
AT_{nc}	Averaging time – non-cancer (yrs)	4.5	n/a	Equal to exposure duration
ED	Exposure duration (yrs)	4.5	75	CCME (2001)
EF_{upper}	Exposure Frequency – Upper Site (d)	14	14	Based on professional judgement and the size and location of the site.
EF_{lower}	Exposure Frequency – Lower Site (d)	90	90	Based on assumptions proposed in Gartner Lee Inc. (1998)
ET_{ing}	Exposure time – soil ingestion (hrs/d)	24	24	Based on full-time exposure to the site.
ET_{derm}	Exposure time – soil dermal contact (hrs/d)	24	24	Based on full-time exposure to the site.
ET_{inh}	Exposure time – soil particulate inhalation (hrs/d)	24	24	Based on full-time exposure to the site.
BW	Body weight (kg)	16.5	62.3	HC (2003)
Ingestion of Surface Soil				
IR_{soil}	Ingestion rate of surface soil (mg/hr)	3.33	0.98	HC (2003)

Characteristics		Values		Source
		Visitor Toddler	Visitor Composite	
Dermal Contact with surface Soil				
SA_{body}	Exposed surface area - body (cm^2)	2580	7385	Richardson (1997)
Sa_{hand}	Exposed surface area - hand (cm^2)	430	821	Richardson (1997)
SAF_{body}	Soil adherence factor – body (mg/cm^2-d)	0.01	0.01	HC (2003)
SAF_{hand}	Soil adherence factor – hand (mg/cm^2-d)	0.10	0.10	HC (2003)
Inhalation of Soil Particles				
IR_{air}	Inhalation rate (m^3/hr)	0.39	0.63	Richardson (1997)
Ingestion of Surface Water				
IR_{water}	Ingestion of surface water (L/d)	0.6	1.32	Richardson (1997)
Dermal Contact with Surface Water				
SA_{water}	Exposed surface area dermal water (cm^2)	430	821	Richardson (1997)
Ingestion of Wild Game				
IR_{game}	Ingestion rate of wild game (mg/d)	85000	233433	Richardson (1997)
F_{site}	Fraction of wild game that is from site (unitless)	1.00	1.00	Conservative site specific assumption
$F_{caribou}$	Fraction of wild game that is caribou (unitless)	0.90	0.90	Assumed based on professional judgement.
F_{hare}	Fraction of wild game that is hare (unitless)	0.10	0.10	Assumed based on professional judgement.
IR_{fish}	Ingestion rate of fish (mg/d)	95000	204233	Richardson (1997)
F_{site}	Fraction of fish that is from site (unitless)	1.00	1.00	Conservative site specific assumption

For non-threshold chemicals (carcinogens), in which any level of exposure is considered to have a potential for adverse health effects, exposures are not calculated within specific age groups (e.g., toddler) but are averaged over a lifetime. In accordance with the reasonable maximum exposure approach, it was assumed that a public visitor to the site grows up in Nunavut from birth to 75 years old. For the purposes of the risk characterization calculations, exposures are averaged over five age groups: (0 to 0.5 years) + (0.5 to 4 years) + (5 to 11 years) + (12 to 19 years) + (20 to 75 years). Receptor characteristics for each age group are presented in Table 10.

Table 10 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 toxicity reference values (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 11 and 12, and detailed rationales for each of the toxicity values are provided in Appendix A.

Table 11 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 US EPA, 1998
Organics				
PCB's	Ingestion	2.0	liver hepatocellular adenomas, carcinomas, and cholangiomas	US EPA, 1997
	Inhalation	0.4	Not Specified	US EPA, 1997

Table 12 Selected Non-Carcinogenic Toxicity Values

CoPC		Route of Exposure	Exposure Limit (mg/kg-d)	Toxicological Basis	Source Agency
Inorganics					
Beryllium		Ingestion	0.002	Small Intestinal Lesion s	US EPA, 1998
		Inhalation	4.74E-6	Beryllium sensitization and progression to CBD	US EPA, 1998
Copper		Ingestion	0.03	Not Specified	CCME, 1999
		Inhalation	na	na	na
Lead		Ingestion	0.00357	Blood levels in young children	Health Canada, 1996
		Inhalation	na	na	na
Organics					
PCBs		Ingestion	0.001	Not Specified	Health Canada, 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 13 provides the bioavailability factors used in this assessment.

Table 13 Selected Relative Bioavailability Factors

CoPC		Oral	Dermal	Inhalation
Beryllium		1	0.03	1
Copper		1	0.1	1
Lead		1	0.06	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 CoPCs. The estimated daily intakes (EDIs) for the CoPCs in this assessment were not available and thus can not be subtracted from the TDI.

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

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 Upper Site Non-Carcinogens

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

In the recreational use of the upper FOX-C site scenario the total exposure risks from maximum beryllium, copper, lead, PCBs and TPH F2, F3, F4 concentrations on the site was below 0.2, thus exposure to the site results in negligible potential risk to receptors.

Table 14 Hazard Quotients for Non-Carcinogenic CoPCs at Upper Site

CoPC	EPC (mg/kg)	Total HQ	Target HQ	Exceeds Target HQ?
Beryllium	0.78	8.8E-5	2.0E-1	No
Copper	381	3.8E-2	2.0E-1	No
Lead	1060	6.3E-2	2.0E-1	No
Total PCBs	2.2	5.7E-4	2.0E-1	No
TPH F2 Fraction	8800	2.5E-2	2.0E-1	No
TPH F3 Fraction	31900	4.9E-2	2.0E-1	No
TPH F4 Fraction	57300	8.4E-2	2.0E-1	No

Figures 4 to 10 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 Upper Site Beryllium Total HQ

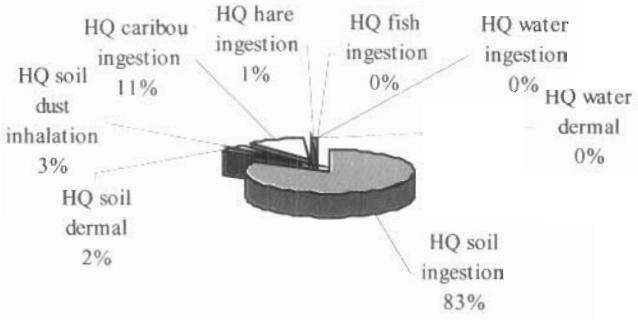


Figure 5 Relative Contributions to the Upper Site Copper Total HQ

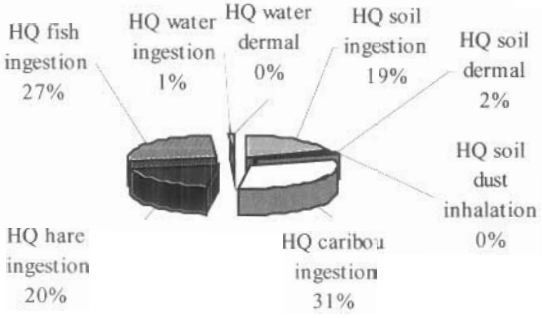


Figure 6 Relative Contributions to the Upper Site Lead Total HQ

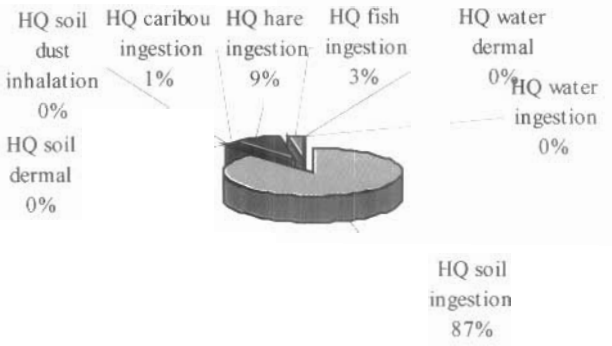


Figure 7 Relative Contributions to the Upper Site F2 TPH Fraction Total HQ

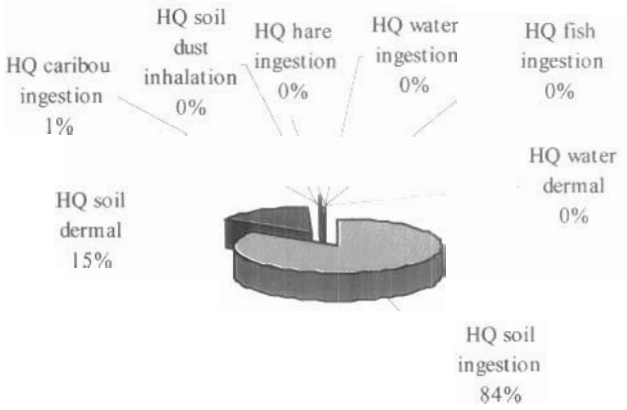


Figure 8 Relative Contributions to the Upper Site F3 TPH Fraction Total HQ

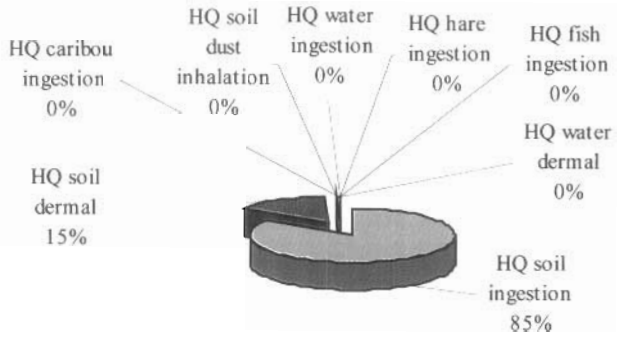


Figure 9 Relative Contributions to the Upper Site F4 TPH Fraction Total HQ

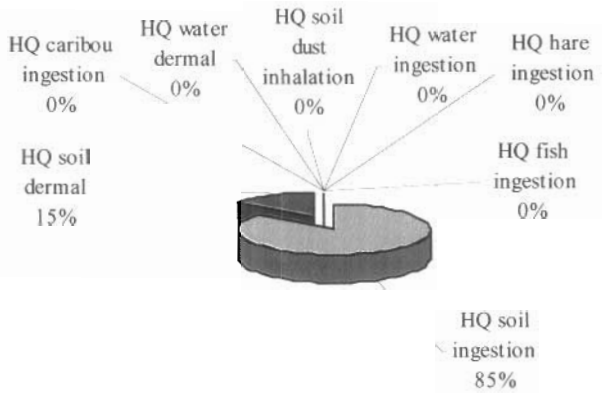
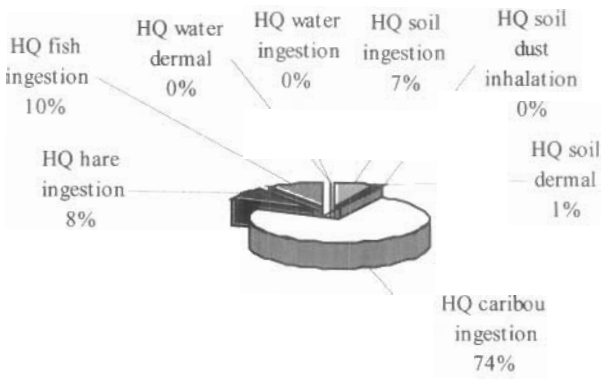


Figure 10 Relative Contributions to the Upper Site PCB Total HQ



4.5.4 Results for Lower Site Non-Carcinogens

HQs for beryllium and the TPH F3 fraction, were derived using the maximum concentration as EPC, are presented in Table 15.

In the Traditional Land Use of the lower FOX-C site scenario the total exposure risk from the maximum beryllium and TPH F3 Fraction concentrations on the site were below 0.2, thus CoPC exposure from the site results in negligible potential risk to receptors.

Table 15 Hazard Quotients for Non-Carcinogenic CoPCs at Lower Site

CoPC	EPC (mg/kg)	Total HQ	Target HQ	Exceeds Target HQ?
Beryllium	0.58	6.9E-4	2.0E-1	No
TPH F3 Fraction	18000	1.8E-1	2.0E-1	No

It must be noted that this assessment was based on an 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. Figures 11 and 12 illustrate the relative contributions of the individual pathways assessed to the total HQ. The HQs from each pathway is presented in Appendix B.

Figure 11 Relative Contributions to the Lower Site Beryllium Total HQ

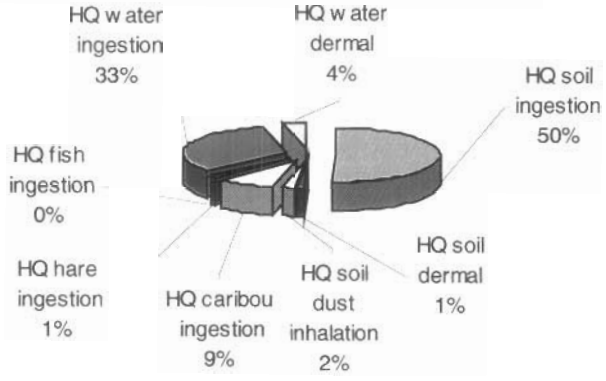
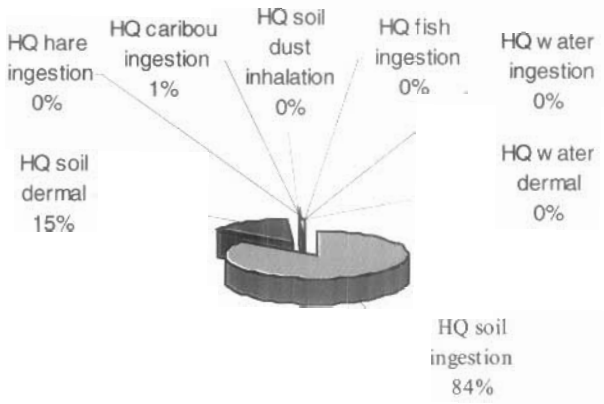


Figure 12 Relative Contributions to the Lower Site F3 TPH Fraction Total HQ



4.5.5 Results for Lower Site Ingestion of PCBs in Wild Game

Because of concerns regarding the bio-accumulation of PCBs in wild game in the Canadian north, the risk posed by ingestion PCBs in Arctic charr, caribou and hare from the site was assessed.

The HQs for PCB ingestion of Arctic charr, were derived using the maximum measured concentration of PCBs in fish. The HQs for the ingestion of caribou and hare were calculated based on PCB concentration modelled using soil-plant-animal uptake factors, as discussed in Section 5.4.2. The HQs for PCB ingestion via wild game are presented in Table 16.

Table 16 Hazard Quotients for PCB in Wild Game

CoPC	EPC (mg/kg)	HQ	Target HQ	Exceeds Target HQ?
Caribou				
PCB	0.0024	0.0042	0.2	No
Hare				
PCB	0.0024	0.00046	0.2	No
Arctic Charr				
PCB	0.0026	0.00057	0.2	No
Total Land Foods				
PCB	--	0.00523	0.2	No

The HQs for ingestion of PCBs in Arctic charr, caribou and hare from the site were all less than 0.2. Additionally, the total PCB exposure from the site is less than 0.2, indicating that exposure from wild game from the site resulted in a negligible potential risk to receptors.

4.5.6 Carcinogens

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

Approach and Methodology

In determining the incremental increase in lifetime cancer risk associated with exposure to beryllium, 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.

Results of the risk characterization are presented in Sections 4.5.7 and 4.5.8.

4.5.7 Results for Upper Site Carcinogens

IELCRs have been derived for beryllium and Total PCBs at the upper site, and are presented in Table 17.

The IELCRs of the composite visitor engaging in traditional land use on the upper site was less than the acceptable benchmark of $1x10^{-5}$. Therefore, exposure to beryllium and total PCB concentrations in soil at the upper site the site pose a negligible potential risk to human receptors.

Table 17 Incremental Excess Lifetime Cancer Risks for Carcinogenic CoPCs at Upper Site

CoPC	EPC (mg/kg)	Total IELCR	Target IELCR	Exceeds Target IELCR?
Beryllium	7.8E-01	5.6E-11	1.00E-5	No
Total PCBs	2.20E+00	7.89E-6	1.00E-5	No

Because only an inhalation carcinogenic TRV is available for beryllium, only the inhalation pathway was assessed, and the entire increased lifetime cancer risk can be attributed to the inhalation of soil particles.

4.5.8 Results for Lower Site Carcinogens

An IELCR was derived for beryllium inhalation at the lower site, and is presented in Table 18.

The IELCRs of the composite visitor engaging in traditional land use on the lower site were less than the acceptable benchmark of 1 x 10^{-5}. Therefore, exposure to beryllium concentrations in soil at the lower site of the site pose a negligible potential risk to human receptors.

Table 18 Incremental Excess Lifetime Cancer Risks for Carcinogenic CoPCs at Lower Site

CoPC	EPC (mg/kg)	Total IELCR	Target IELCR	Exceeds Target IELCR?
Beryllium	5.8E-1	2.68E-10	1.00E-5	No

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

4.5.9 Summary of Site Risk

The HQs for exposure to all non-carcinogenic CoPCs during traditional land uses at both the upper and lower FOX-C sites were less than 0.2, indicating that CoPCs pose a negligible risk to human health at the site.

The IELCRs for exposure to all carcinogenic CoPCs during Traditional Land Uses at both the upper and lower FOX-C sites were less than 1 x 10^{-5}, indicating that CoPCs pose a negligible cancer risk at the site.

This assessment has incorporated a number of very conservative assumptions, including exposure times for traditional land use of the upper site for 14 days and of the lower site for 90 days, and the use of the maximum concentrations found on the site as the EPC. However, even with such conservative assumptions, the result of the risk assessment is that the CoPCs on site do not pose a risk to human receptors

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 could 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. However, in this case, none of the maximum CoPC concentrations resulted in a HQ greater than 0.2, and therefore there is a negligible risk to receptors on site. Because the current maximum concentrations do not pose a risk to the human receptor, the derivation of SSTLs is unnecessary and remediation or risk management plans are not required.

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 19 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 19 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 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 upper site 24 hours per day, 14 days per year, and on the lower site for 24 hours	These are maximum values providing a reasonable maximum exposure estimate for a toddler but likely overestimating lifetime exposure.	Neutral to over-estimate.	Yes

Risk Assessment Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk?	Acceptable assumption?
per day and 90 days per year. While on the site they are assumed to be hunting and fishing on the site.			
Toxicological Information			
1. Most current toxicity information available from Health Canada, US EPA Integrated Risk Information (IRIS) database.	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,	Neutral	Yes

Risk Assessment Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk?	Acceptable assumption?
	no soil exposure is expected during winter months.		
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	Neutral	Yes

Risk Assessment Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk?	Acceptable assumption?
	against some level of increased lead absorption sue to dietary deficiencies.		
4. Target risk for IELCR set at 1 in 100,000 (10^{-5}).	This is the value adopted by CCME for "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}.	Neutral	Yes
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 evaluated the potential for adverse effects to non-domesticated fauna, based on current conditions and habitats at the FOX-C DEW line site (FOX-C) located on the Ekalugad Fjord, Baffin Island (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 FOX-C 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 effect 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.