5.2.2 Receptor Identification

Receptor selection was based on fundamental ecological considerations, but was also guided by observations made during a site visit, and information solicited from members of the local community. The following criteria were considered in selecting receptors for use in this ERA:

- keystone species known to be central to ecosystem function;
- exposed to surface soils, sediments, and/or freshwater at the site;
- representative of lower and higher trophic feeding levels (i.e., herbivorous and carnivorous animals);
- present on or near the site for some or most of the year;
- of significant cultural and/or economic significance; and
- possible endangered or sensitive species.

5.2.3 Valued Environmental Components (VECs)

Valued environmental components (VECs) are defined as resources or environmental features important to human populations, that have economic and/or social value, and/or have intrinsic ecological significance. These components also provide a baseline from which the impacts of development can be evaluated, including changes in management or regulatory policies.

Based on the above criteria, and using information gathered by a Jacques Whitford biologist during a site visit (Jacques Whitford 2004), the following ecological receptors were selected for the FOX-C site: collared lemming, ermine, Arctic hare, ptarmigan, Snowy Owl, Arctic fox, and caribou. The presence of each of these animals has been documented on or near the site. The receptors are briefly described below.

The Willow Ptarmigan (*Lagopus lagopus*) or Rock Ptarmigan (*L. mutus*) are small grouse-like birds, weighing approximately 0.5 kg, which live year-round throughout alpine and Arctic tundra. Ptarmigan nest on the ground soon after the snow melts. These birds are mainly herbivorous, feeding on willow buds and twigs throughout the year, and any other vegetation that might be available. Ptarmigan, especially chicks, will also feed on insects. Ptarmigan are estimated to consume approximately 0.124 kg (wet-weight) of food per day and drink 0.037 L of water, or its equivalent, per day. They are valued for their meat and hunted by local residents.

The Snowy Owl (*Nyctea scandiaca*), which weighs on average 2.05 kg, is a top predator that is found in the Canadian Arctic. By virtue of its location in the food chain, it may be susceptible to contaminants that accumulate in the tissue of its prey. Snowy Owls breed in the Arctic tundra and may make southerly migrations for the winter (as far as the northern United States), although some remain in the Arctic year-round. The diet of the Snowy Owl consists mainly of small mammals and birds (e.g., lemmings, Arctic hares, ptarmigan, seabirds). On average, Snowy Owls will consume approximately 0.093 kg of dry-weight food per day (0.290 kg of wet-weight food per day) and will consume 0.095 L of water, or its equivalent, per day.

The collared lemming *(Dicrostonyx groenlandicus*) is a small burrowing rodent, which weighs approximately 0.04 kg and lives on the tundra throughout the high Arctic. It is the smallest of the mammals in the high Arctic and is a key species in Arctic ecosystems. The lemming is herbivorous, feeding on whatever vegetation exists within its habitat. In the winter, lemmings do not hibernate; rather, they forage in the space that forms between the snow and soil. Lemmings are an important food source for Arctic fox, Snowy Owl and other predatory species. On average, a lemming is estimated to consume 0.023 kg of wet-weight food per day and 0.009 L of water, or its equivalent, per day.

The Arctic hare (*Lepus arcticus*) is the largest hare in North America. Weighing approximately 4.3 kg, it inhabits the tundra regions of Canada from Newfoundland west to the Mackenzie Delta and north to the tip of Ellesmere Island. Immature Arctic hares are hunted by Arctic foxes, gyrfalcons, snowy owls, and ermine, however, as adults they have few enemies but wolves and people. Arctic hares are mainly herbivores and eat willow leaves, bark, shoots, other leaves, grasses, and herbs. They have also been observed to eat carrion and the meat from hunters' traps. An adult Arctic hare will consume approximately 1.149 kg of wet-weight food per day and 0.368 L of water, or its equivalent, per day.

Ermine, or short-tailed weasel *(Mustela erminea*), is one of the smaller predatory animals found on the Arctic tundra, weighing on average 0.128 kg. Ermine do not migrate, despite significant food shortages during the winter months. Ermine population densities fluctuate with prey abundance and home ranges vary from 10 to 20 ha. Home ranges of males are usually twice the size of female home ranges. Ermine play an important role in the small mammals communities in which they live. They are ferocious hunters that specialize in small mammals, preferably of rabbit size and smaller. When mammalian prey is scarce, ermine may eat (depending upon availability) birds, eggs, frogs, fish, insects, or berries. On average, an ermine will consume approximately 0.008 kg of dry-weight food per day (0.026 kg of wet-weight food per day) and will consume 0.009 L of water, or its equivalent, per day.

The Arctic fox (*Alopex lagopus*) is a relatively small canid mammal, weighing approximately 5.75 kg. Arctic fox are widely distributed throughout the Arctic. Each Arctic fox has its own home range which varies in size from 3 to 25 km^2. It is predominately carnivorous, preying mostly on lemmings, but also on ptarmigan and any other available meat (e.g., small birds and mammals, Inuit meat caches, wolf kills). During the summer, the Arctic fox will also forage on any berries that might be available. These animals consume approximately 0.933 kg of wet-weight food per day and 0.478 L of water, or its equivalent, per day. Breeding dens are built in the surface soil and may be used for many generations. The Arctic fox is highly valued for its fur.

The caribou (*Rangifer tarandus*) is representative of a large ungulate found throughout Canada's Arctic and is valued as a food source to both humans and other wildlife.

Caribou are typically migratory in nature and make seasonal migrations from the tundra to the taiga, returning north in the springtime. These migratory patterns of movement can significantly decrease the exposure of caribou to localized contamination, although near-stationary populations of caribou are also known. During calving, even migratory herds may remain at a specific location for an extended period of time.

There are three major types of caribou in Canada: barren-ground, woodland, and Peary. Barren-ground caribou are found in the vicinity of the FOX-C site. The barren-ground caribou weighs on average 117.5 kg and spends much or all of the year on the tundra from Alaska to Baffin Island. Herds may migrate up to 700 km to their calving grounds.

The caribou diet depends on seasonal availability, but lichens are the caribou's primary food source for much of the year. They will also feed on willow, herbs, mosses, flowers, grasses, and leaves of shrubs. On average, a barren-ground caribou will consume approximately 18.66 kg of wet-weight food per day and will consume 7.22 L of water, or its equivalent, per day. Caribou prefer habitats where vegetation is abundant and the ground conditions are dry.

Receptors were selected to be typical and representative of potential wildlife receptors at the site, including birds and mammals; herbivores and predators. This approach was based on the premise that if highly exposed components of the ecosystem are protected, then populations of other exposed biota will also be adequately protected. Although this approach is considered reasonable by CCME (1996a, b), it is recognized that protection of selected ecological receptors for particular endpoints (e.g., reproduction) may not always adequately protect all endpoints for all ecological receptors at the site. The choice of representative receptors was made, in part, on a trophic level approach in that they were chosen to represent lower and higher trophic levels. As a result, representative species were not chosen because of their sensitivity (information on sensitivity of Arctic receptors is lacking), but because of their ecological significance and trophic level.

Lemming, Arctic hare, and ptarmigan were chosen as representative of "highly exposed" biota for herbivore mammals and birds, as they remain in close contact with potentially contaminated soil year-round in a relatively restricted area. Caribou were selected because they are representative of a large ungulate which may use this site, and ermine, Arctic fox, and Snowy Owl were chosen to represent higher trophic levels that might be more likely to be exposed to contaminants via prey. Concentrations of CoPCs in the meat of caribou and small mammals (also considered to be representative of birds) were also estimated in the ERA, for inclusion in the HHRA. Selection of receptors was made to ensure that risk estimates for the specific receptors could be representative of other wildlife receptors at the site.

5.2.4 Rare, Threatened, or Endangered Species and Species of Special Concern

Three species at risk are found in the region of FOX-C (see Table 25).

Table 25 Species at Risk in the FOX-C Area

Common Name	Scientific Name	Status under *Species at Risk Act (SARA)*
Peregrine Falcon, tundrius subspecies	*Falco peregrinus*	Special Concern on Schedule 3
Wolverine, western population	*Gulo gulo*	Special Concern on Schedule 3, pending public consultation for addition to Schedule 1
Polar Bear	*Ursus maritimus*	Special Concern on Schedule 3, pending public consultation for addition to Schedule 1

These species were not chosen as representative receptors because the Snowy Owl, ermine, and Arctic fox have similar exposure pathways but have smaller home ranges and subsequently greater exposure to contaminants at the site. Therefore, if contaminant levels are below toxic thresholds for these species, it can be deduced that concentrations are also safe for the Peregrine Falcon, wolverine, and polar bear.

5.3 Exposure Assessment

5.3.1 Potential Exposure Pathways

In order for chemicals to have deleterious effects, they need to gain access to the organism or receptor. The route by which this occurs is referred to as an exposure pathway, and is dependent on the nature of both the chemical and receptor. A complete exposure pathway is one that meets the following four criteria (USEPA 1989):

- a source of contaminants of concern must be present;
- release and transport mechanisms and media must be available to move the chemicals from the source to the ecological receptors;
- an opportunity must exist for the ecological receptors to contact the affected media; and
- a means must exist by which the chemical is taken up by ecological receptors, such as ingestion, inhalation, or direct contact.

The sources of the contaminants of concern for the study area were surface soil and surface water. Subsurface soils and groundwater were not considered as potential sources of contaminant exposure for wildlife. There were no direct exposure pathways for ecological receptors for either of these environmental media and transport of contaminants from these sources to surface soil, surface water and sediments was expected to be negligible.

An exposure route is the mechanism by which a receptor species might be exposed to a chemical from the source. For surface soils and terrestrial receptors, including mammals and birds, exposure to contaminants of concern may occur through the following routes:

- dermal contact with soils;
- incidental ingestion of soil (i.e., as a result of feeding or grooming);
- ingestion of plants or prey species that have accumulated chemicals from the soil; or
- inhalation of volatile contaminants migrating from the soil to ambient air.

The inhalation pathway is typically of negligible importance for wildlife receptors in open air situations, and the CoPCs for the ERA typically have low or negligible vapour pressures. Therefore, inhalation has not been considered a significant exposure pathway for the ERA at FOX-C. Assessment of dermal contact with soils is included with incidental ingestion of soil.

The choice of site-specific exposure pathways is dependent on the nature of the CoPCs, their source environmental media, and nature of VECs being considered in the ecological risk assessment. These are explained, for the FOX-C site, in the following section.

5.3.2 Conceptual Site Model

A conceptual site model was developed for FOX-C and is presented in Figure 13. This figure schematically represents the interactions between the VECs and the CoPCs, via the exposure pathways identified. The relevant exposure pathways are designated by arrows leading from the contaminant source media to each VEC. The pathway is considered to be complete (i.e., functioning) for a VEC when the exposure pathway box is marked with an X. The conceptual model shows how the pathways representing soil and water ingestion, and ingestion of food items (including terrestrial plants, and small mammal prey items) have been conceptualized and implemented for each VEC.

Figure 13 Conceptual Site Model for Ecological Risk Assessment

Source Media	Exposure Media	Potential Exposure Pathways	Ptarmigan	Snowy Owl	Lemming	Arctic Hare	Ermine	Arctic Fox	Caribou
Surface Water	Surface Water	Ingestion	X	X	X	X	X	X	X
Surface Soil	Surface Soil	Ingestion	X	X	X	X	X	X	X
[Uptake]	Terrestrial Invertebrate Prey	Ingestion	X				X		
	Plant Food	Ingestion	X		X	X	X	X	X
	Bird/Mammal Prey	Ingestion		X		X	X	X	

SOURCE → RECEPTOR

Note: **X** indicates a potentially complete exposure pathway

5.3.3 Selection of Assessment and Measurement Endpoints

Assessment endpoints are explicit expressions of environmental values or characteristics to be protected at a site, and reflect societal and ecological values (Suter 1993). Societal values address the need to protect species that are endangered, threatened, of special interest, important as game or commercial species, or widely recognized as having aesthetic value. Ecological relevance refers to importance of the species to the function of the ecosystem. Therefore, evaluation of potential for adverse effects at the population level is used to infer potential for adverse effects at higher levels of organization, such as communities and ecosystems. For birds and mammals inhabiting FOX-C, assessment endpoints focus on maintenance and protection of their populations, such that contaminants in the surface water, sediment, or soil would not significantly impact either species abundance or diversity through increased mortality or decreased reproduction.

The information needed to deal directly with the assessment endpoint is difficult to generate and rarely available; thus measurement endpoints are used to bridge the gap. Measurement endpoints are measurable responses to stressors related to assessment endpoints, and are intended to provide a basis for assessing risk potential for the assessment endpoint. They may be defined in terms of an unacceptable level of impact to ecological receptors, such as a certain relative percent decrease in survival, growth or reproduction of ecological populations (Suter 1993). As part of a weight-of-evidence approach, one or more measurement endpoints may be used for each assessment endpoint. Choice of measurement endpoints for each interaction between a VEC and a contaminant of concern is typically limited by available toxicity data. Those most commonly used to quantify the survival, growth and reproduction of receptors in bioassays include the LC_{50} and LD_{50} (concentrations or doses that will be lethal to 50% of exposed organisms, over a defined period of exposure); the EC_{50} and ED_{50} (concentrations or doses that elicit a defined response or effect over a defined period of time); the Lowest Observable Adverse Effect Level (LOAEL); and the No-observable Adverse Effect Level (NOAEL). Although the dose-response relationships derived from these measurement endpoints are characteristic of test species exposed under controlled conditions, appropriate safety factors are included in order to consider the response of species in the natural environment.

The measurement endpoints for the assessment endpoints focus on whether observed concentrations of chemicals in water or soils are likely to result in doses to birds or mammals that are greater than those observed to result in increased mortality or decreased reproduction upon chronic exposure.

Therefore, the key components of this ecological risk assessment are:

- characterization of relationships between amount of a chemical present in surface water or sediments and a thresholds for adverse effects; and
- characterization of relationships between the dose resulting from the amount of a

chemical present in surface soils and a threshold dose for adverse effects.

The dose-response relationships that have been incorporated into this ERA are based upon LOAELs, in relation to survival or reproduction of birds and mammals after chronic exposure to the CoPCs. These relationships are expressed in terms of the daily ingested dose, normalized to body weight of the test organism (i.e., the reference toxicity dose or RTD value expressed as mg substance ingested / kg body weight-day). Where such data were not available, LOAEL values were estimated from other endpoints including the NOAEL, or the LD_{50} value. Standard conversion factors were implemented including division by 5 to convert an acute dose to a chronic dose; dividing by 6 to convert an LD_{50} value to a LOAEL value, or multiplication by 5 to convert a NOAEL to a LOAEL value. These conversion factors are cumulative, so an acute LD_{50} would be converted to a chronic LOAEL value by dividing by 30.

If data for the specific representative mammalian receptors was not available, a body-size scaling factor (Sample and Arenal 1999) was used for extrapolation of available data between species. The body-size scaling factor is calculated as:

$$\text{Mammal Body Weight SF} = (BWt/BWr)^{0.06}$$

where:

SF	= scaling factor
BWt	= mean body weight for test species
BWr	= mean body weight for receptor species

If data for the specific representative avian receptors was not available, a body-size scaling factor (Sample and Arenal 1999) was used for extrapolation of available data between species. The body-size scaling factor is calculated as:

$$\text{Bird Body Weight SF} = (BWt/BWr)^{-0.20}$$

5.4 RISK CHARACTERIZATION

Risk characterization was the final step of the ecological risk assessment. It includes a quantification of the potential nature and magnitude of adverse effects that may occur to receptor species due to presence of chemicals in identified ecological habitats at the site. In this step, characterization of exposure and characterization of ecological effects for each chemical, was integrated into quantitative estimates (hazard quotients or HQ values) of the potential for adverse effects to ecological receptors.

5.4.1 Approach

For this assessment, ecological hazard quotient (HQ) values were calculated by dividing exposure (as the exposure point concentrations or total ingested dose values) derived for each receptor by their appropriate reference toxicity dose (RTD), as follows:

$$HQ = (\text{Exposure})/(\text{Reference Toxicity Dose})$$

For birds and mammals, the exposure measure is the total ingested dose (mg/kg-day) summed over all exposure pathways.

An HQ value of less than 1.0 indicates the exposure concentration is less than the threshold for adverse effects, and a low probability exists that adverse effects might occur. Given the overall tendency to introduce conservatism (through the use of data or assumptions that are likely to overstate, rather than understate risk) into risk assessments, it is likely no adverse effect would occur. Alternatively, a HQ value of >1.0 does not automatically indicate that there is an unacceptable level of risk. In this case, the conservative approach reduces the certainty of this conclusion, and dictates a need for more careful review of both predicted exposure levels and exposure limit derivations. As a result, HQ values greater than 1.0 should be examined carefully, and further more focused investigations may be required to reduce conservatism and provide a more realistic assessment of the actual risk level. If it is ultimately determined that the HQ value is indeed greater than 1.0, then site management or remedial activities may be appropriate in order to reduce risks to ecological receptors.

5.4.2 Determination of Media to Biota Uptake Factors

The concentrations of substances evaluated in this ERA were measured empirically in water, plants, and soils from FOX-C. However, in order to complete assessment of exposure of the VECs to each substance, it is necessary to estimate concentrations of each CoPC in a variety of biological compartments. This task is accomplished generically using uptake factors (UF) that relate the concentration in various types of biota (such as invertebrates or small mammals) to concentrations in water or soil.

Substances retained in the ERA as CoPCs include TPH, phenanthrene, and selected metals. The approaches used to estimate uptake factors for each of these groups of substances, for each of the required biological food groups, are described below. The specific uptake factors used, with references as to the source of the uptake factor, can be found in the ERA model outputs located in Appendix C. Some general information on the sources of data used for media to biota accumulation factors is presented below.

Soil to Plant Uptake Factors

Soil to plant uptake factors for organic substances were generally calculated using the equation of Travis and Arms (1988):

$$\log(UFSP) = (1.588 - 0.578 \log(Kow)) \times 0.19,$$

where UFSP is the uptake factor from soil to plant (mg/kg dry plant / mg/kg dry soil), Kow is the octanol-water partition coefficient for the organic substance under consideration, and 0.19 is a conversion factor to adjust dry weight plant tissue concentrations to wet weight values.

For inorganic substances, data on plant tissue metal concentrations were collected from the site by the Environmental Sciences Group of the Royal Military College in 1994 (RRMC 1994). EPC values were calculated by taking the average value for each inorganic substance and multiplying them by a conversion factor representing the average dry solids fraction (0.40) to obtain wet-weight tissue concentrations.

Soil to Animal Uptake Factors

For organic substances, soil to animal (caribou meat) uptake factors were generally calculated using the equation of Travis and Arms (1988):

$\log(Ba_{p,s,w}) = -7.6 + \log(K_{ow})$,

where $Ba_{p,s,w}$ is the transfer factor from soil to beef (day/kg), which is assumed to also be applicable to caribou meat. These transfer factors are multiplied by the CoPC concentration in soil, feed and drinking water (mg/kg or mg/L), and by the ingestion rates of soil, feed and drinking water (kg/day or L/day) to estimate the concentration in meat (mg/kg). For the TPH substances, which are not as readily absorbed and which are more readily metabolized than the pesticide compounds that form the basis of the Travis and Arms data, a bioavailability factor (which can range from 0 to 1) is also applied.

For inorganic substances in meat, a similar approach is used for concentrations in meat, except that the transfer factors to meat (Bap,s,w) were obtained from the compilation of Baes et al. (1984).

For small animal prey items, including lemming, ptarmigan and Arctic hare, a variety of approaches and data sources were used. For organics, the approach of Travis and Arms (1988) was followed. For inorganic substances, the equations of Sample et al. (1998), which directly calculate the CoPC concentration in small mammal tissues from the soil concentration, are generally preferred. Where these equations are not available, the approach of Baes et al. (1984) was also used.

Soil to Soil Invertebrate Uptake Factors

For soil to soil invertebrate uptake factors (UPSI) for the TPH compounds, conservative default uptake factors of 0.1 were assumed. For inorganic substances, the equations of Sample et al. (1998) were preferred, although an empirical uptake factor of 0.036 was used for tin.

5.4.3 Determination of Reference Toxicity Doses

Reference toxicity doses (RTDs) for terrestrial receptors were included in the risk assessment model results for each receptor, and are presented in Appendix C. The RTD values are unique to each CoPC.

5.4.4 Risk Characterization for Avian Receptors

Tables showing the derivation of risk estimates for avian receptors can be found in Appendix C. The text below provides a synopsis of the risk estimates for each VEC. A summary of HQ values for all receptors can be found in Tables 26 and 27.

Table 26 Ecological Hazard Quotients for each VEC at the FOX-C Upper Site

CoPCs	Ptarmigan	Snowy Owl	Lemming	Arctic Hare	Ermine	Arctic Fox	Caribou
Inorganics							
Beryllium	8.83E-04	4.09E-04	3.55E-04	1.96E-04	1.64E-04	1.66E-04	2.83E-04
Cadmium	5.10E-03	5.43E-04	1.65E-02	9.75E-03	2.39E-03	1.93E-03	7.37E-03
Chromium	9.04E-01	3.50E-02	5.54E-04	3.25E-04	2.94E-05	2.90E-05	2.51E-04
Copper	3.68E-02	5.45E-03	3.74E-01	2.22E-01	5.25E-02	5.46E-02	1.69E-01
Lead	1.40E-01	1.06E-02	5.02E-02	2.96E-02	4.25E-03	4.23E-03	2.27E-02
Zinc	2.20E-01	4.06E-02	1.33E-01	7.95E-02	2.54E-02	2.44E-02	5.96E-02
Organics							
F1 (C_6 - C_{10})	2.04E-04	1.87E-05	5.30E-04	3.00E-04	9.61E-05	8.80E-05	2.55E-04
F2 (>C_{10} - C_{16})	2.03E-02	1.94E-03	2.09E-02	1.23E-02	8.30E-03	5.97E-03	1.14E-02
F3 (>C_{16} - C_{34})	3.60E-02	8.30E-03	4.64E-02	2.70E-02	2.75E-02	1.80E-02	2.89E-02
F4 (>C_{34} - C_{50})	2.11E-03	8.01E-04	3.28E-03	1.91E-03	4.05E-03	2.70E-03	2.63E-03
Total PCBs	1.43E-02	9.76E-04	5.74E-02	4.54E-02	1.29E-01	1.41E-01	2.60E-02

Table 27 Ecological Hazard Quotients for each VEC at the FOX-C Lower Site

CoPCs	Ptarmigan	Snowy Owl	Lemming	Arctic Hare	Ermine	Arctic Fox	Caribou
Inorganics							
Beryllium	1.64E-03	7.60E-04	6.59E-04	3.65E-04	3.05E-04	3.09E-04	5.27E-04
Cadmium	4.90E-03	3.83E-04	1.64E-02	9.70E-03	1.70E-03	1.45E-03	7.34E-03
Chromium	9.19E-01	6.55E-02	5.64E-04	3.31E-04	4.41E-05	4.53E-05	2.60E-04
Copper	3.69E-02	5.61E-03	3.75E-01	2.23E-01	5.39E-02	5.60E-02	1.70E-01
Lead	1.38E-01	8.07E-03	4.99E-02	2.94E-02	3.42E-03	3.44E-03	2.25E-02
Zinc	2.22E-01	4.17E-02	1.33E-01	7.97E-02	2.64E-02	2.50E-02	5.97E-02
Organics							
F1 (C_6 - C_{10})	7.26E-04	4.00E-05	1.75E-03	1.01E-03	2.59E-04	1.82E-04	8.56E-04
F2 (>C_{10} - C_{16})	1.45E-02	1.39E-03	1.49E-02	8.75E-03	5.95E-03	4.29E-03	8.14E-03
F3 (>C_{16} - C_{34})	8.86E-03	2.06E-03	1.14E-02	6.65E-03	6.81E-03	4.46E-03	7.11E-03
F4 (>C_{34} - C_{50})	9.21E-04	3.58E-04	1.45E-03	8.43E-04	1.79E-03	1.21E-03	1.16E-03
Total PCBs	1.32E-02	2.73E-04	5.68E-02	4.49E-02	1.25E-01	1.38E-01	2.54E-02

5.4.4.1 Risk Estimates for Ptarmigan

For the ptarmigan the intake pathways included surface water, soil, soil to plants, and soil to soil invertebrates. The ptarmigan feeds primarily on vegetation such as leaves, flowers, buds and twigs of willow and birch, seeds and berries, and will also consume insects, especially as chicks.

Risks (HQ values) for the ptarmigan were less than 1 for all substances. However, a number of substances had HQ values that lay between 0.1 and 1.0. At both sites, these substances were chromium, lead, and zinc. All other substances that were assessed had HQ values that lay below 0.1. The inorganic substance having the highest HQ values was chromium at both the Upper and Lower Sites (HQ = 0.904 and 0.919, respectively). The HQ values for chromium were dominated by the plant ingestion pathway, based on measured (1994) concentrations of chromium in plant tissue from the FOX-C site. Risks due to ingestion of soil, terrestrial invertebrates, and surface water are negligible.

5.4.4.2 Risk Estimates for Snowy Owl

For the Snowy Owl the intake pathways included surface water, soil, and soil to small mammal prey. The Snowy Owl feeds mainly on small mammals.

Risks (HQ values) for the Snowy Owl were much less than 1 for all substances at both sites, which suggests that the Snowy Owl is not at risk from any of these substances at FOX-C.

5.4.5 Risk Characterization for Mammalian Receptors

Tables showing the derivation of risk estimates for mammalian receptors can be found in Appendix C. The text below provides a synopsis of the risk estimates for each VEC. A summary of HQ values for all receptors can be found in Tables 26 and 27.

5.4.5.1 Risk Estimates for Lemming

For the lemming the intake pathways include surface water, soil, and soil to plants. The lemming feeds on vegetation including grasses and shrubs, and bark and twigs of willow and birch.

Risks (HQ values) for the lemming were less than 1 for all substances. However, a number of substances had HQ values that lay between 0.1 and 1.0. At both sites, these substances were copper and lead. All other substances that were assessed had HQ values that lay below 0.1. The inorganic substance having the highest HQ value for lemming was copper at both the Upper and Lower Sites (HQ = 0.374 and 0.375, respectively).

Examination of the pathways leading to high HQ values for the copper and lead shows that the overall HQ values are dominated by risks from ingestion of terrestrial plants. Risks due to ingestion of soil and surface water are negligible.

5.4.5.2 Risk Estimates for Arctic Hare

For the Arctic hare the intake pathways included surface water, soil, soil to plants, and soil to small mammals. The Arctic hare is primarily herbivorous but will also feed on carrion.

Risks (HQ values) for the Arctic hare were less than 1 for all substances. However, copper had HQ values that lay between 0.1 and 1.0 at both the Upper and Lower Sites (HQ = 0.222 and 0.223, respectively).

Examination of the pathways leading to high HQ values for copper shows that the overall HQ values are dominated by risks from ingestion of terrestrial plants. Risks due to ingestion of soil, mammals, and surface water are negligible.

5.4.5.3 Risk Estimates for Ermine

For the ermine the intake pathways included surface water, soil, soil to small mammal, soil to soil invertebrate, and soil to plants. The ermine feeds mainly on small mammals, but also consumes some invertebrates and plant material as minor components of its diet.

Risks (HQ values) for the ermine were less than 1 for all substances. However, total PCBs had HQ values that lay between 0.1 and 1.0 at both the Upper and Lower Sites (HQ = 0.129 and 0.125, respectively).

Examination of the pathways leading to the high HQ values for PCBs is dominated by ingestion of terrestrial mammals. The risk due to ingestion of soil, terrestrial plants, terrestrial invertebrates, and surface water is negligible.

5.4.5.4 Risk Estimates for Arctic Fox

For the Arctic fox the intake pathways included surface water, soil, soil to small mammal, and soil to plants. The Arctic fox feeds mainly on small mammals, but also consumes some plant material as a minor component of its diet.

Risks (HQ values) for the Arctic fox were less than 1 for all substances. However, total PCBs had HQ values that lay between 0.1 and 1.0 at both the Upper and Lower Sites (HQ = 0.141 and 0.138, respectively).

Examination of the pathways leading to the high HQ values for Arctic fox is dominated by ingestion of terrestrial mammal prey. The risk due to ingestion of soil, terrestrial plants, and surface water is negligible.

5.4.5.5 Risk Estimates for Caribou

For the caribou, total HQs were summed across the study area (Upper and Lower Sites) to generate an overall HQ for each CoPC based on exposure to the entire DEW Line site. In addition, a further area of exposure was defined as "background" for caribou. This was done because the study area is very small in comparison with the typical home range for a caribou. Expected background concentrations for inorganic CoPCs were calculated by taking the geometric mean of all soil samples at the FOX-C site. Background concentrations for organic CoPCs in surface soil were set to zero (CCME 2001), and background concentrations in plant tissues were calculated by the model.

For caribou the intake pathways included surface water, soil, and soil to plants. The caribou feeds on vegetation, primarily lichens.

Table 28 presents the HQ for the caribou receptor. Total risks (HQ values) for caribou were much less than 1 for all substances, which suggests that caribou is not at risk from any of these substances at FOX-C.

Table 28 Ecological Hazard Quotients for Caribou

CoPC	Upper Site HQ	Weighting Factor	Lower Site HQ	Weighting Factor	Background HQ	Weighting Factor	Total HQ
Inorganics							
Beryllium	2.83E-04	0.002	5.27E-04	0.04	2.73E-04	0.958	2.83E-04
Cadmium	7.37E-03	0.002	7.34E-03	0.04	9.62E-04	0.958	1.23E-03
Chromium	2.51E-04	0.002	2.60E-04	0.04	1.44E-05	0.958	2.47E-05
Copper	1.69E-01	0.002	1.70E-01	0.04	2.29E-02	0.958	2.91E-02
Lead	2.27E-02	0.002	2.25E-02	0.04	1.25E-03	0.958	2.14E-03
Zinc	5.96E-02	0.002	5.97E-02	0.04	6.44E-03	0.958	8.68E-03
Organics							
F1 (C_6 - C_{10})	2.55E-04	0.002	8.56E-04	0.04	0.00E+00	0.958	3.48E-05
F2 (>C_{10} - C_{16})	1.14E-02	0.002	8.14E-03	0.04	0.00E+00	0.958	3.48E-04
F3 (>C_{16} - C_{34})	2.89E-02	0.002	7.11E-03	0.04	0.00E+00	0.958	3.42E-04
F4 (>C_{34} - C_{50})	2.63E-03	0.002	1.16E-03	0.04	0.00E+00	0.958	5.17E-05
Total PCBs	2.60E-02	0.002	2.54E-02	0.04	0.00E+00	0.958	1.07E-03

5.5 CONCENTRATION OF COPCS IN MEAT

Estimated concentrations of CoPCs in caribou meat are provided in Table 29. Meat concentrations were summed across the study area (Upper and Lower Sites) to generate an overall value for each CoPC based on exposure to the entire DEW Line site. In addition, a further area of exposure was defined as "background" for caribou. This was done because the study area is very small in comparison with the typical home range for a caribou. Expected background concentrations for inorganic CoPCs were calculated by taking the geometric mean of all soil samples at the FOX-C site. Background concentrations for organic CoPCs in surface soil were set to zero (CCME 2001), and background concentrations in plant tissues were calculated by the model.

Estimated concentrations of CoPCs in small mammals are provided in Table 30. Meat concentrations are provided for both the Upper and Lower Sites. Additionally, a weighted average including background meat concentrations is provided to estimate the amount of exposure to humans consuming small mammals across the landscape (to be used in the HHRA).

Table 29 Estimated Concentrations of CoPCs in Caribou Meat at FOX-C

CoCP	Upper Site Caribou Meat Conc. (mg/kg-fresh wt.)	Weighting Factor	Lower Site Caribou Meat Conc. (mg/kg-fresh wt.)	Weighting Factor	Background Caribou Meat Conc. (mg/kg-fresh wt.)	Weighting Factor	Total Caribou Meat Conc. (mg/kg-fresh wt.)
Inorganics							
Beryllium	1.08E-04	0.002	2.00E-04	0.04	1.04E-04	0.958	1.08E-04
Cadmium	5.99E-03	0.002	5.97E-03	0.04	7.78E-04	0.958	9.96E-04
Chromium	2.77E+00	0.002	2.84E+00	0.04	1.39E-01	0.958	2.52E-01
Copper	4.01E+00	0.002	4.03E+00	0.04	5.26E-01	0.958	6.73E-01
Lead	8.02E-02	0.002	7.95E-02	0.04	4.11E-03	0.958	7.28E-03
Zinc	2.82E+02	0.002	2.82E+02	0.04	3.02E+01	0.958	4.08E+01
Organics							
F1 (C_6 - C_{10})	5.45E-03	0.002	9.51E-03	0.04	0.00E+00	0.958	3.91E-04
F2 (>C_{10} - C_{16})	2.81E+00	0.002	2.03E+00	0.04	0.00E+00	0.958	8.68E-02
F3 (>C_{16} - C_{34})	1.27E+01	0.002	3.18E+00	0.04	0.00E+00	0.958	1.53E-01
F4 (>C_{34} - C_{50})	1.14E+00	0.002	5.16E-01	0.04	0.00E+00	0.958	2.29E-02
Total PCBs	5.69E-01	0.002	5.60E-01	0.04	0.00E+00	0.958	2.35E-02

Table 30 Estimated Concentrations of CoPCs in Small Mammal Meat at FOX-C

CoPC	Upper Site Small Mammal Meat Conc. (mg/kg-fresh wt.)	Weighting Factor	Lower Site Small Mammal Meat Conc. (mg/kg-fresh wt.)	Weighting Factor	Background Small Mammal Meat Conc. (mg/kg-fresh wt.)	Weighting Factor	Total Small Mammal Meat Conc. (mg/kg-fresh wt.)
Inorganics							
Beryllium	1.08E-04	0.002	2.00E-04	0.04	1.04E-04	0.958	1.08E-04
Cadmium	8.71E-02	0.002	6.17E-02	0.04	6.78E-02	0.958	6.76E-02
Chromium	1.04E+00	0.002	1.84E+00	0.04	1.02E+00	0.958	1.05E+00
Copper	3.95E+00	0.002	4.03E+00	0.04	3.81E+00	0.958	3.82E+00
Lead	1.26E+00	0.002	9.89E-01	0.04	9.85E-01	0.958	9.86E-01
Zinc	3.78E+01	0.002	3.87E+01	0.04	3.72E+01	0.958	3.73E+01
Organics							
F1 (C_6 - C_{10})	5.45E-03	0.002	9.51E-03	0.04	0.00E+00	0.958	3.91E-04
F2 (>C_{10} - C_{16})	2.81E+00	0.002	2.03E+00	0.04	0.00E+00	0.958	8.68E-02
F3 (>C_{16} - C_{34})	1.26E+01	0.002	3.17E+00	0.04	0.00E+00	0.958	1.52E-01
F4 (>C_{34} - C_{50})	1.14E+00	0.002	5.15E-01	0.04	0.00E+00	0.958	2.29E-02
Total PCBs	5.57E-01	0.002	5.48E-01	0.04	0.00E+00	0.958	2.30E-02

5.6 ECOLOGICAL SITE SPECIFIC TARGET LEVELS

Based upon the results of the ecological risk assessment, no HQ values greater than 1.0 were identified for any of the VECs. The CoPCs with HQ values between 0.1 and 1.0 were chromium, copper, lead, zinc, and total PCBs. The following VECs were identified as having the highest HQ for each of these CoPCs:

- ptarmigan at the Lower Site (chromium and zinc);
- ptarmigan at the Upper Site (lead);
- lemming at the Lower Site (copper); and
- Arctic fox at the Upper Site (total PCBs).

Consequently, site specific target levels (SSTLs) were calculated for each of these receptors. The SSTLs were calculated by setting the HQ at 1.0, and determining the corresponding surface soil EPC for that HQ, using a backward calculation. The SSTLs for each receptor are shown in Table 31.

Table 31 Site Specific Target Levels in Surface Soils at FOX-C

VEC	CoPC	Maximum Soil Conc. (mg/kg)	Surface Soil SSTL (mg/kg)
Ptarmigan	Chromium	116	320
Ptarmigan	Lead	1,060	6,000
Ptarmigan	Zinc	1,400	46,250
Lemming	Copper	381	3,375
Arctic fox	Total PCBs	2	50

SSTLs for chromium, lead, zinc, copper, and total PCBs are all well above the maximum concentrations in surface soils. These results indicate that there are no documented instances of contamination at the FOX-C site that require clean-up in order to protect ecological receptors. The overall ERA results also indicate that the existing conditions at FOX-C are not likely to result in adverse effects to exposed biota at the population level.

5.7 UNCERTAINTY ANALYSIS

Uncertainties are inherent in every aspect of the ERA process. The most effective way to decrease uncertainty is to collect site-specific data. Application of site-specific information assists in reduction of uncertainty by allowing removal of generic data that may be broadly and inaccurately applicable to a wide range of sites and cases. For FOX-C, much site-specific data has been collected, representing soils, surface water, biota, and lake sediments.

Despite incorporation of a considerable amount of site-specific data, the ERA involves many assumptions, and incorporates simplifications and uncertainty with respect to the characteristics of the receptors, exposure pathways, and CoPC concentrations in the environment. This section qualitatively discusses some significant aspects of uncertainty inherent in this risk assessment.

Data Limitations.

The quality of a risk assessment calculation often hinges on the size, extent and condition of the supporting data. In addition to making use of existing site data, a large number of samples were collected for this risk assessment, and a