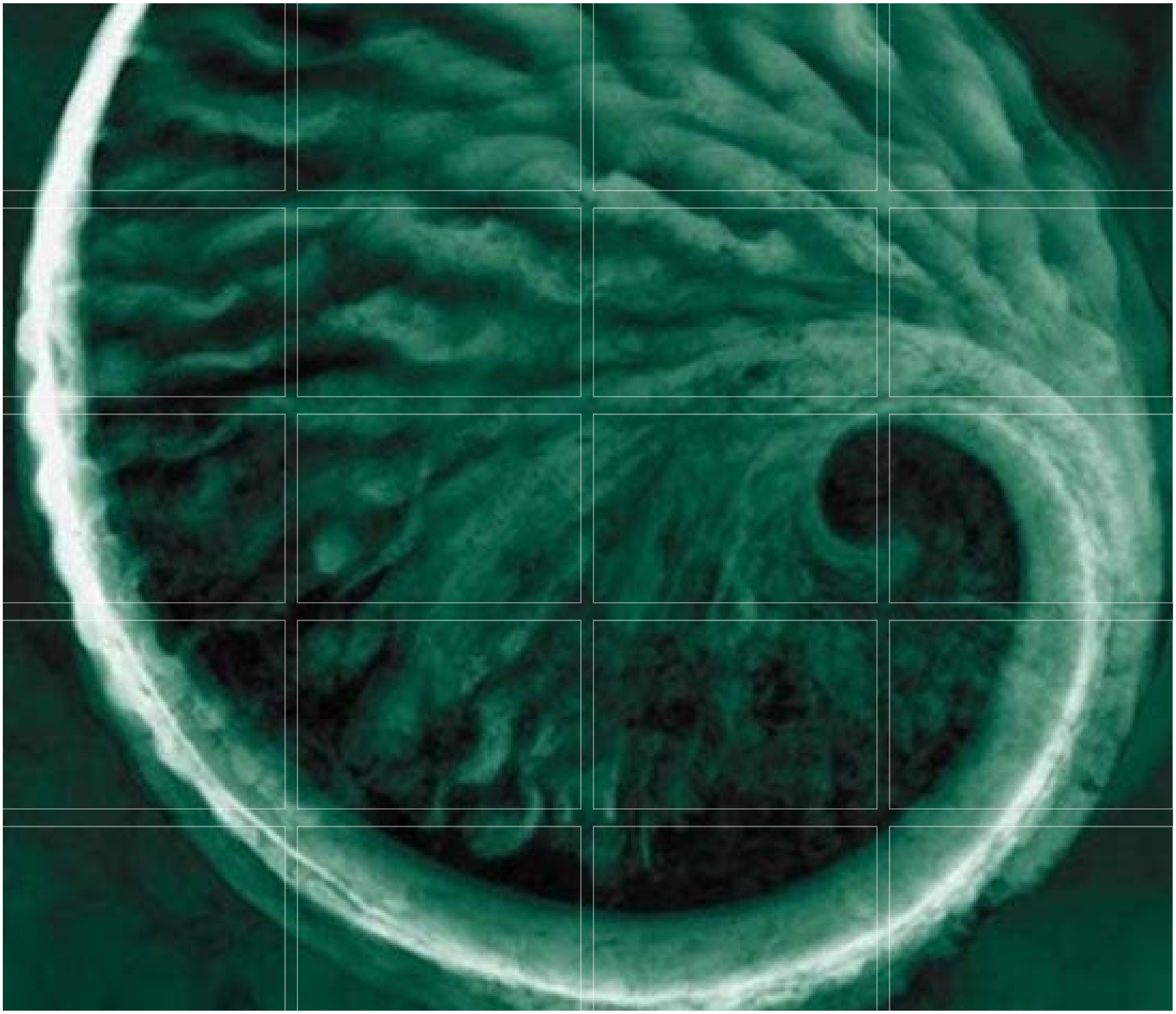
Appendix 21-A

Country Foods Baseline Report

HARPER CREEK PROJECT

Application for an Environmental Assessment Certificate / Environmental Impact Statement



Prepared for:

HARPER CREEK
MINING CORP.

HARPER CREEK PROJECT

Country Foods Baseline Report

August 2014

ERM

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Harper Creek Mining Corporation

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August 2014

Project #0230881-0024

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EXECUTIVE SUMMARY

The Harper Creek Project (the Project) is a proposed open pit copper mine located in south-central British Columbia (BC), approximately 150 km northeast by road from Kamloops. The Project has an estimated 28-year mine life based on a process plant throughput of 70,000 tonnes per day. The Proponent, Harper Creek Mining Corporation, is a wholly owned subsidiary of Yellowhead Mining Inc., which is a public BC junior mineral development company trading on the Toronto Stock Exchange.

People in the region harvest country foods as part of their diet. The quality of country foods is directly related to the quality of the surrounding environmental media (e.g., soil, water, and vegetation). The proposed development of the Project has the potential to impact environmental media, thus assessment of county foods quality is necessary. This assessment provides the concentrations of contaminants of potential concern (COPCs) in country foods and the estimated consumption rates of each food by the harvesters under baseline conditions (i.e., prior to Project construction). The main objective of this country foods baseline assessment is to characterize baseline health risk posed by consumption of country foods within a defined country foods study area for the Project.

The country foods baseline assessment integrated the results of environmental media baseline studies, human receptor characteristics, and regulatory-based toxicity reference values (TRVs). The quality of five country foods was estimated using baseline levels of metals prior to development of the Project. This study evaluated potential health risks associated with the ingestion of naturally-occurring metals concentrations in the country foods.

Animal and plant species were selected for evaluation based on current harvesting and consumption patterns by local people. The Project is located in a relatively remote location and is accessible only via Forestry Service Roads. Thus the primary consumer group of country foods was identified as local First Nations. In total, five different country food groups were evaluated, including: large terrestrial mammals (moose, *Alces alces*), small terrestrial mammals (snowshoe hare, *Lepus americanus*), birds (ruffed grouse, *Bonasa umbellus*), fish (Rainbow Trout, *Oncorhynchus mykiss*/Bull Trout, *Salvelinus confluentus*), and huckleberries (*Vaccinium membanaceum*).

This assessment predicted no unacceptable health risks to people from consuming moose, snowshoe hare, ruffed grouse, Rainbow/Bull Trout, and huckleberries under the existing pre-Project conditions. This means that consumption of these country foods at the quantities and frequencies used in the assessment would be considered safe and would not affect human health.

The estimates of risk due to consumption of country foods from within the study area outlined in this assessment are expected to be over-estimated as conservative assumptions for environmental data and human receptor characteristics were used in the assessment. Conservative assumptions included: the use of the 95% upper confidence limit of the mean (UCLM) of metal concentration to estimate the tissue metal concentrations for all country foods and in the calculation of recommended maximum weekly intakes (RMWIs) and incremental lifetime cancer risks (ILCRs); the duration for which country food animals were assumed to be present within the study area; the consumption frequencies of country foods; and the portion size of country foods consumed.

ACKNOWLEDGEMENTS

This report was produced for Harper Creek Mining Corp. by ERM Rescan. It was written by Cara Lachmuth (M.Sc.) and edited and reviewed by Lesley Shelley (Ph.D.), Mark Branson (M.Sc.), Brett Lawson (M.A.), and Mellissa Winfield (M.Sc.). Mark Branson (M.Sc.) was the project manager and Nicole Bishop (B.Sc.) the project coordinator. GIS production was coordinated by Stephen Jollymore (B.A.) and graphics and report production was coordinated by Nicole Bishop (B.Sc.). Sean Sharpe (M.Sc., R.P. Bio) provided information on the country food wildlife species and consumption information.

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AIR	Application Information Requirements
ASTDR	Agency for Toxic Substances and Disease Registry
BC	British Columbia
BC EAA	British Columbia Environmental Assessment Act
BC EAO	British Columbia Environmental Assessment Office
BTF	Biotransfer factor
BW	Body weight
CEA Agency	Canadian Environmental Assessment Agency
CEAA, 1992	*Canadian Environmental Assessment Act, 1992*
CCME	Canadian Council of Ministers of the Environment
CHHAD	Chemical Health Hazard Division
COPC	Contaminant of potential concern
EA	Environmental Assessment
EDI	Estimated daily intake
EIS	Environmental Impact Statement
ELDE	Estimated lifetime daily exposure
ER	Exposure ratio
FAO	Food and Agriculture Organization
F_s	Fraction of year consuming country food
FSR	Forestry service road
HCMC	Harper Creek Mining Corporation
HQ	Hazard quotient
ILCR	Incremental lifetime cancer risk
IQ	Intelligence quotient
IR	Ingestion rate
IRIS	Integrated Risk Information System
JECFA	Joint FAO/WHO Expert Committee on Food Additives
kg	Kilogram

LOAEL	Lowest observed adverse effect level
M	Million or Mega
MAC	Maximum acceptable concentration
masl	Meters above sea level
MDL	Method detection limit
MRL	Minimal risk level
Mt	Million tonnes
MW	Mega Watts
NOAEL	No observed adverse effect level
NTS	National Topographic System
POP	Persistent organic pollutant
Project, the	The Harper Creek Mining Project
Proponent, the	Harper Creek Mining Corporation
PTDI	Provisional tolerable daily intake
PTWI	Provisional tolerable weekly intake
QA/QC	Quality assurance and quality control
RfD	Reference Dose
RMWI	Recommended maximum weekly intake
t/d	tonne per day
t/y	tonne per year
TD_{05}	Tumourigenic dose (dose that caused tumors in 5% of the exposed animal population)
TDI	Tolerable daily intake
TMF	Tailings Management Facility
TRV	Toxicity reference value
TSX	Toronto Stock Exchange
UCLM	Upper confidence limit of the mean
US EPA	United States Environmental Protection Agency
USL	Upper safe level
WHO	World Health Organization
ww	Wet weight
YMI	Yellowhead Mining Inc.

1. INTRODUCTION

1.1 PROJECT DESCRIPTION

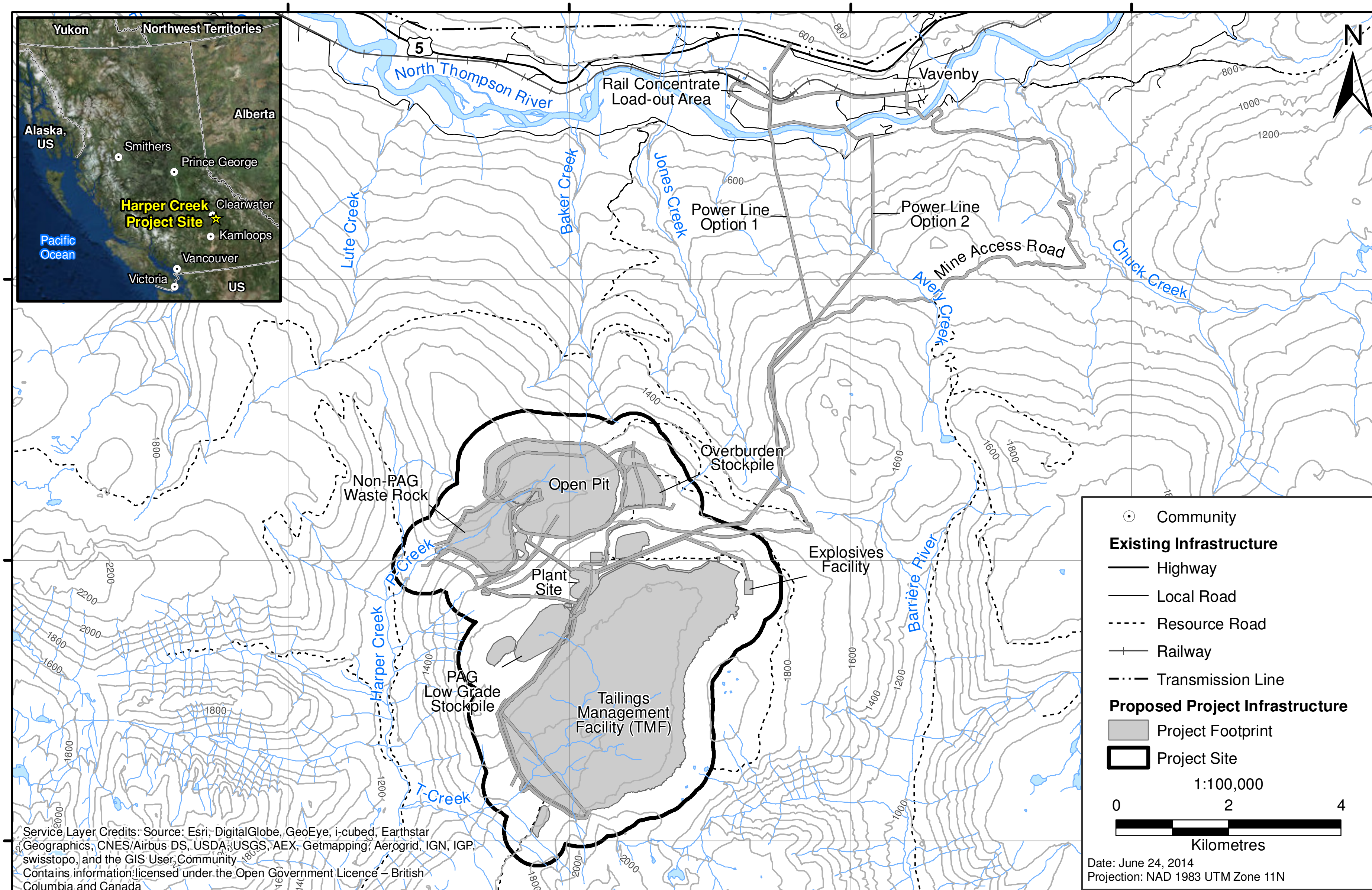
Harper Creek Mining Corporation (HCMC) proposes to construct and operate the Harper Creek Project (the Project), an open pit copper mine near Vavenby, British Columbia (BC). The Project has an estimated 28-year mine life based on a process plant throughput of 70,000 tonnes per day (25 million tonnes per year). Ore will be processed on site through a conventional crushing, grinding and flotation process to produce a copper concentrate, with gold and silver by-products, which will be trucked from the Project Site along approximately 24 km of existing access roads to a rail load-out facility located at Vavenby. The concentrate will be transported via the existing Canadian National Railway network to the existing Vancouver Wharves storage, handling and loading facilities located at the Port of Vancouver for shipment to overseas smelters.

The Project consists of an open pit mine, on-site processing facility, tailings management facility (TMF) (for tailings solids, subaqueous storage of potentially acid-generating (PAG) waste rock, and recycling of water for processing), waste rock stockpiles, low grade and overburden stockpiles, a temporary construction camp, ancillary facilities, mine haul roads, sewage and waste management facilities, a 24 km access road between the Project Site and rail load-out facility located on private land owned by HCMC in Vavenby, and a 12 km power line connecting the Project Site to the BC Hydro transmission line corridor in Vavenby. The Project location and infrastructure is shown in Figure 1.1-1.

This report describes the baseline quality of country foods for the purposes of the Application for an Environmental Assessment (EA) Certificate under the *British Columbia Environmental Assessment Act* (BC EAA; 2002) and the Environmental Impact Statement (EIS) under the *Canadian Environmental Assessment Act* (CEAA; 1992; 2012) in accordance with the approved Project Application Information Requirements (AIR) issued October 21, 2011.

Country foods are animals, plants, and fungi used by humans for nutritional or medicinal purposes that are harvested through hunting, fishing, or gathering of vegetation. The quality of country foods is directly related to the quality of the surrounding environmental media (e.g., water, soil, and vegetation). In the past 15 years, there have been concerns raised regarding the quality of country foods in Canada as elevated concentrations of persistent organic pollutants (POPs), heavy metals, and radionuclides in wildlife tissue have been reported in undeveloped areas of Canada and the Arctic (INAC 2006). POPs are human-generated chemicals, while radionuclides and metals are naturally occurring chemicals. Regardless of the chemical’s source, there are concerns that humans who consume country foods may be exposed to unsafe chemical concentrations present in the edible portions of the food items.

Figure 1.1-1
Project Location and Infrastructure



For the Project, the primary contaminants of potential concern (COPCs) are most likely to be metals, given that the Project includes the development of a metal mine and metals occur naturally in the surrounding environment (e.g., soil, water, and vegetation). Future activities associated with development of the proposed Project could potentially change metal concentrations in environmental media. As a result, metal concentrations in plants and animal tissues could be altered, which could have the potential to affect the health of human consumers of country foods. Thus a baseline assessment of health risk associated with consumption of country foods collected from in the vicinity of the Project (pre-development) was warranted to support the subsequent environmental assessment process. Following Health Canada's guidance on health impact assessments (Health Canada 2010e), this report presents the methods and results of a baseline country foods risk assessment conducted for the Project.

1.2 PROJECT LOCATION

The Project is located in the Thompson-Nicola area of BC, approximately 150 km northeast of Kamloops along Yellowhead Highway #5, approximately 10 km southwest of the unincorporated municipality of Vavenby, BC. The Project is located within National Topographic System (NTS) map sheets 82M/5 and 82M/12, is geographically centered at 51 º30'N latitude and 119º48'W longitude, and is situated at approximately 1,800 meters above sea level (masl). The mineral claims comprising the Project cover an area of 42,636.48 hectares. The Project location is shown in Figure 1.2-1.

Access to the Project is currently from Kamloops to Vavenby via Yellowhead Highway #5, across the North Thompson River and then eastward along the Birch Island - Lost Creek Forestry Service Road (FSR) for approximately 6 km to the Jones Creek FSR (see Figure 1.1-1).

The proposed main access route to the Project Site is from Vavenby via the Vavenby Mountain FSR. This road runs along the western side of Chuck Creek for approximately 6 km before heading west toward Avery Creek and the southeastern part of the Project. This road then meets the Barrière Mountain FSR at approximately 11 km. From there, the Saskum Plateau FSR heads southwest to the eastern and central areas of the Project.

1.3 PROJECT PROPONENT

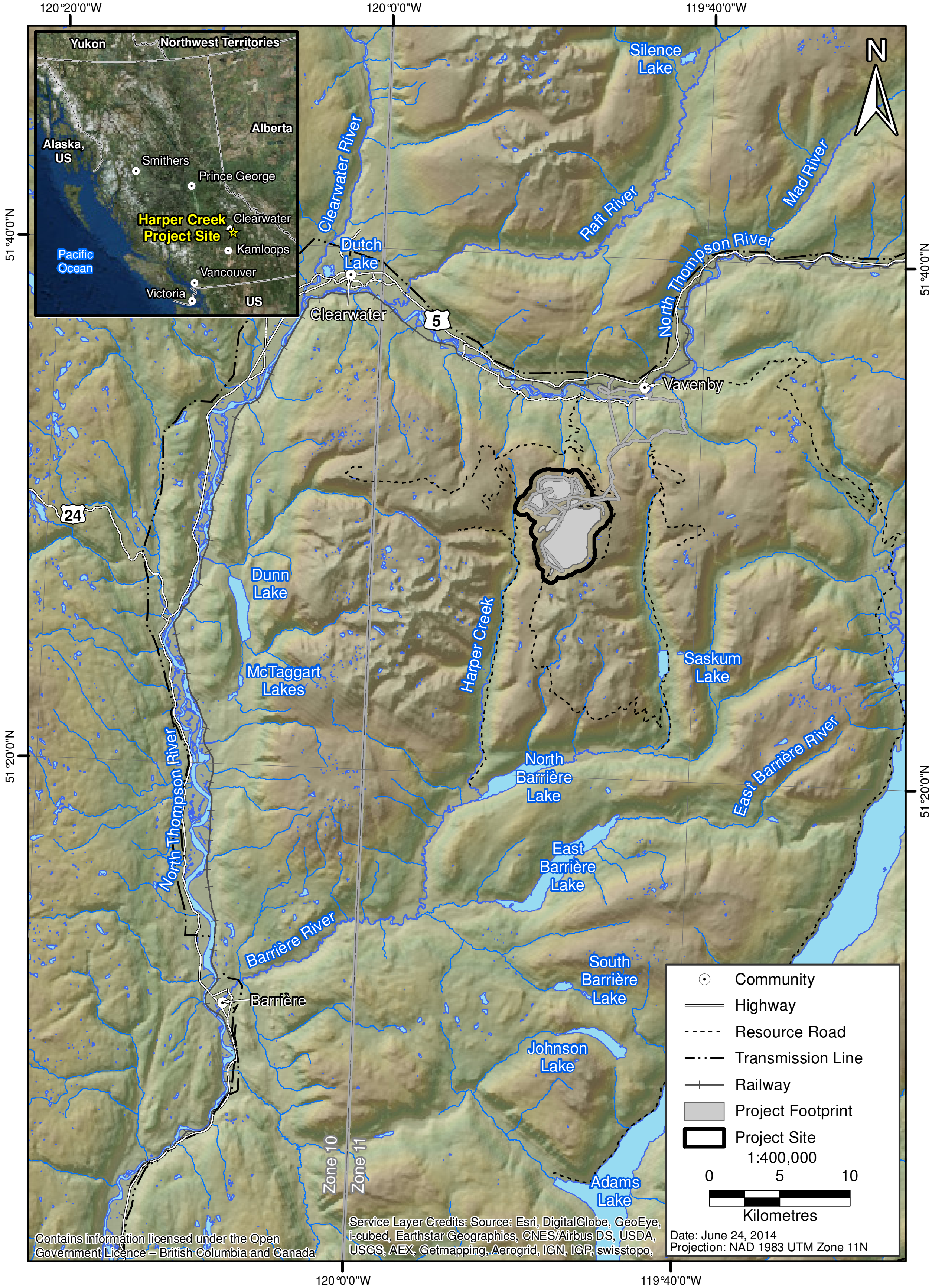
The Proponent of the Project is HCMC, a wholly owned subsidiary of Yellowhead Mining Inc. (YMI). YMI was formed in 2005 as a private BC company specifically to acquire, explore and, if feasible, develop the Project. YMI is now a publicly owned BC-based mineral development company trading on the Toronto Stock Exchange (TSX) in Canada. HCMC's strategy is to engineer, permit, finance, construct, and operate the Project.

1.4 PROJECT SETTING

The Project Site directly overlaps with the Harp Mountain Range Unit and the Grazing License of Mitchell Cattle Co., which uses this area for summer grazing. However, during Construction and Operation phases of the Project, the Project Site will not be available for grazing in the Harp Mountain Range Unit (ERM Rescan 2014a).

Figure 1.2-1

Project Location



There are no Guide Outfitting Licensed areas within the country foods baseline local study area (LSA) or regional study area (RSA; Figure 1.4-1). Section 4 below provides details about the study areas. Adams Lake Outfitters Wilderness Adventures has approval to operate within a small area adjacent to Upper Adams Provincial Lake, which is outside of the country foods RSA (ERM Rescan 2014a).

Other backcountry sports, recreation, and tourism operators within the country foods RSA include (ERM Rescan 2014a):

- the North Barrière Lake Resort, located on the north shore of the lake and approximately 13 km south of the Project Site;
- the Serenity Performing Arts Centre, located between Birch Island and Vavenby near the entrance to the Jones Creek Forest Service Road; and
- Several recreation clubs, located in local communities that facilitate recreation/outdoor experiences, and provide recreational facilities to families in the area (e.g., cross-country skiing, hiking, motorcycling, camping).

Many of these groups utilize available forestry service roads to access remote wilderness areas. Figure 1.4-1 shows the non-traditional use of the area within the country foods local and regional study areas (e.g., public recreation sites and organizations). The Foghorn Mountain Cabin, Harp Mountain Cabin, and the Vavenby Mountain Cabin are close to the country foods LSA boundary and within the country foods RSA (Figure 1.4-1). There are also upper and lower snowmobile pullout areas located within the country foods LSA (Figure 1.4-1).

The Project is located within the asserted traditional territories of the Simpcw First Nation (Figure 1.4-2), and the Lakes Division Secwepemc (represented by the Adams Lake Indian Band and Neskonlith Indian Band; Figure 1.4-3). Little Shuswap Indian Band has indicated that their band's asserted territory does not overlap the Project. Historical and current harvest of country foods for traditional purposes within the LSA and RSA has been noted for the Simpcw First Nation (2012). However, information on country foods harvest by the Lakes Division Secwepemc was unavailable at the time of writing. Current information on other types of land use (other than country foods harvesting) within the RSA and LSA by the Simpcw First Nation and the Lakes Division Secwepemc is lacking.

Figure 1.4-1

Non-traditional Land Use in the Country Foods Local and Regional Study Areas

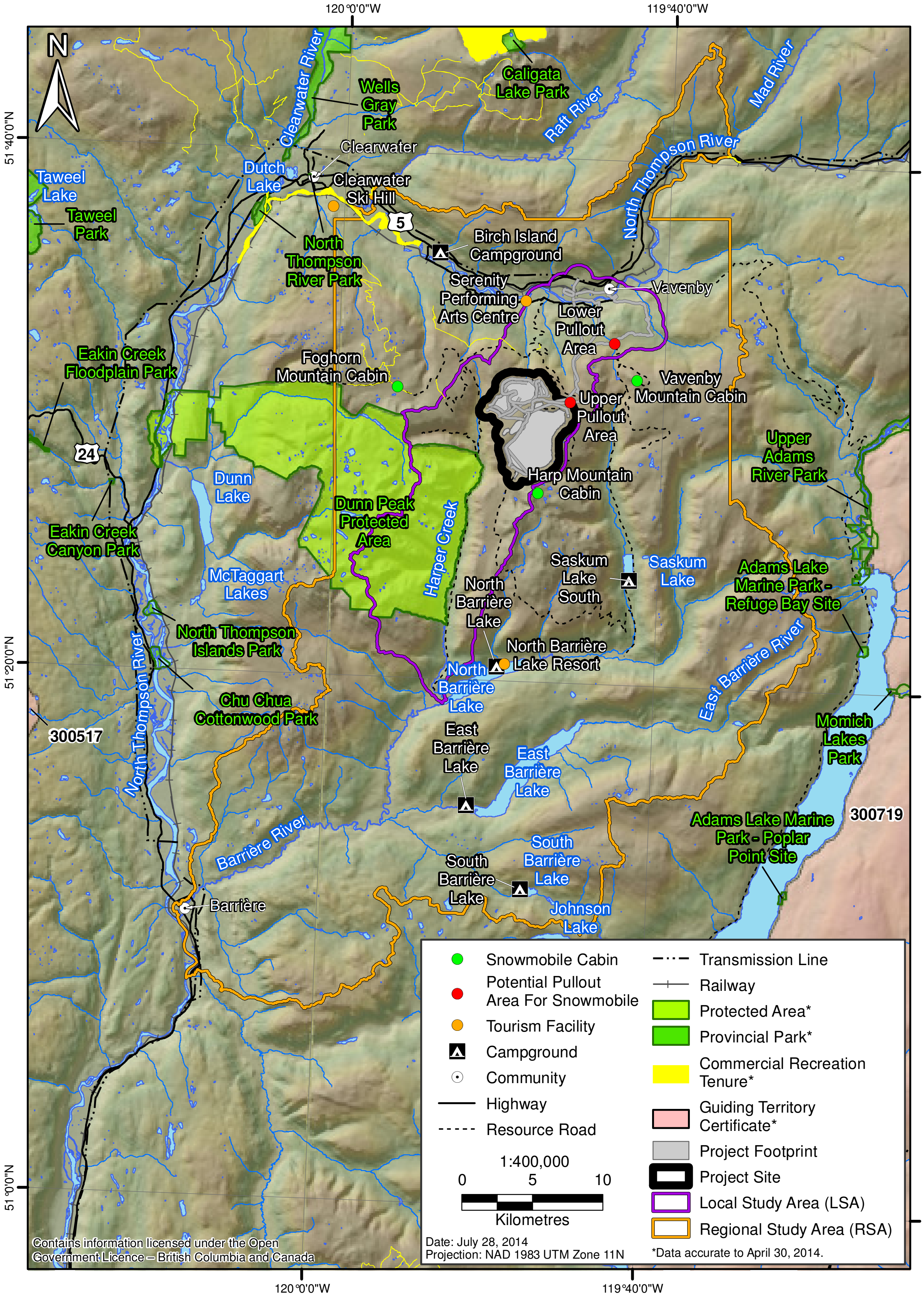


Figure 1.4-2

Simpcw First Nation Traditional Territory in Relation to the Project

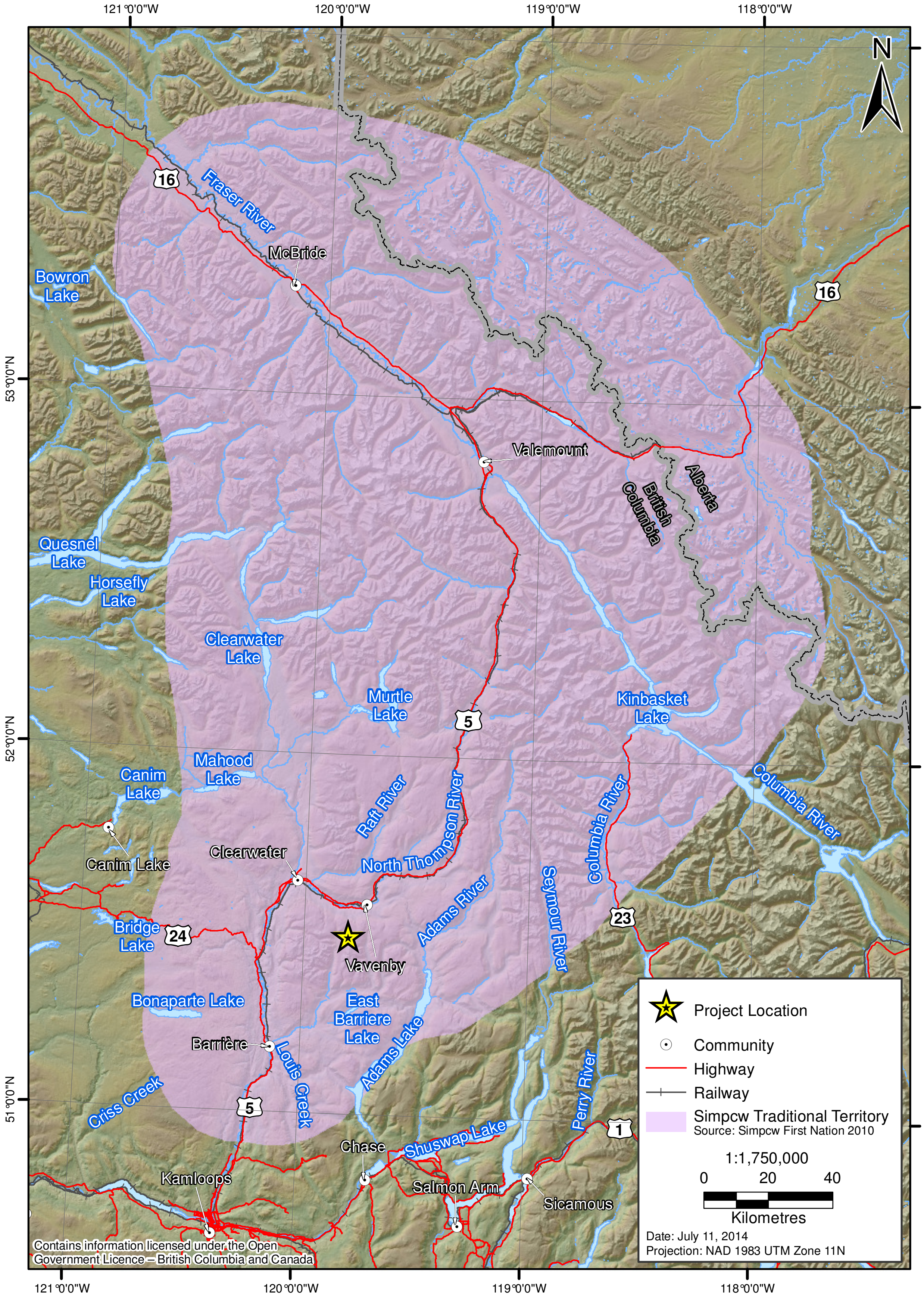
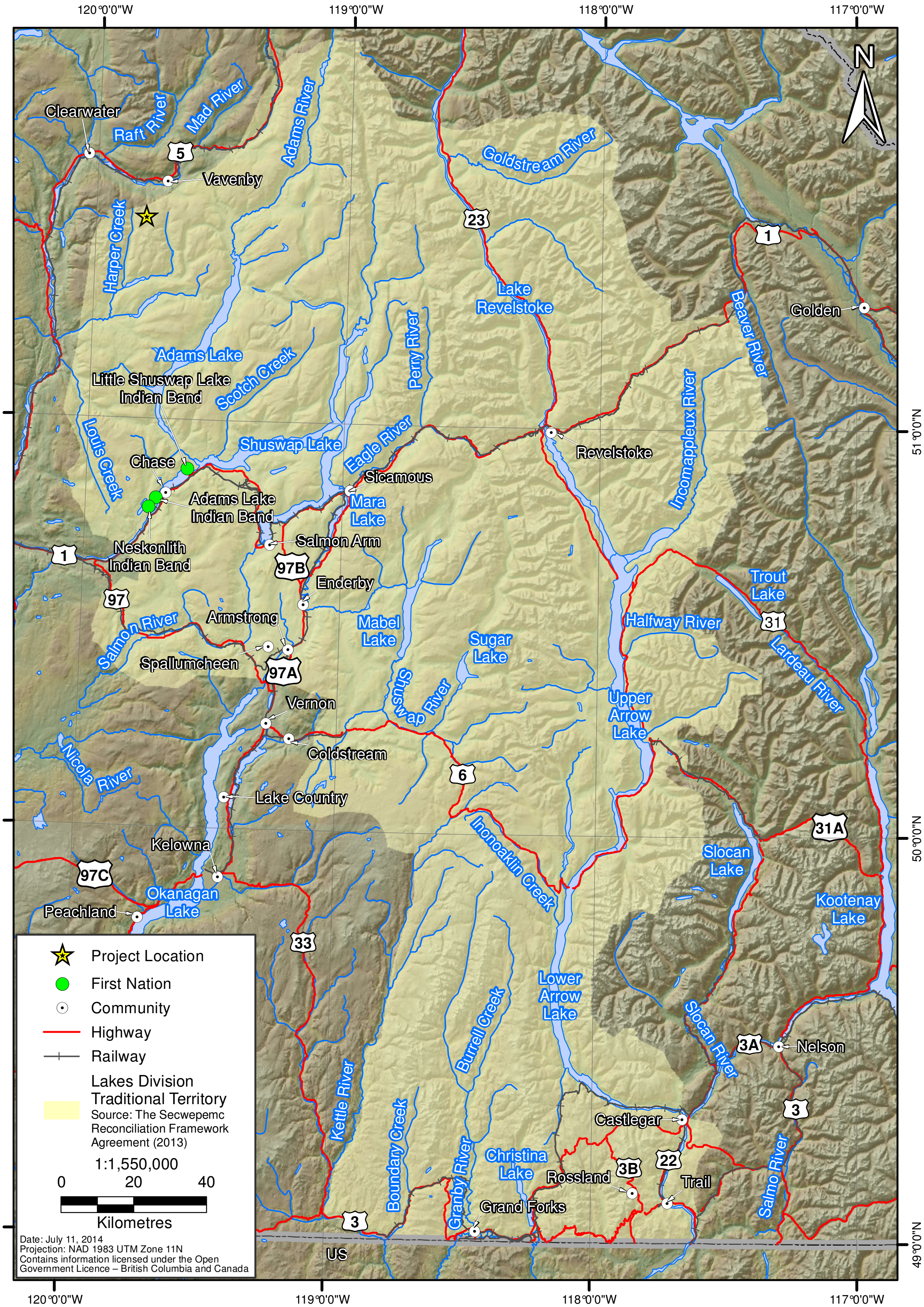


Figure 1.4-3
Lakes Division Secwepemc Traditional Territory in Relation to the Project



2. BACKGROUND REVIEW

2.1 LEGISLATION, REGULATIONS, AND GUIDELINES

The Project is subject to both provincial and federal EAs under the *BC Environmental Assessment Act* (2002) and *Canadian Environmental Assessment Act* 1992 (CEAA: 1992; 2012). The EA will undergo a coordinated review in accordance with the principles of the 2004 Canada-BC Agreement for Environmental Assessment Cooperation. The requirements for the EA are defined in the AIR for the Project, approved by the BC Environmental Assessment Office (EAO) on October 21, 2011. This baseline report has been prepared to support the submission of the Application/EIS.

The inclusion of human health impact assessment, including potential effects on country food quality, in the EA process in Canada has been recognized by the federal government and by the Province of BC under various legislative requirements (Health Canada 1999, 2010f).

Under BC's *Environmental Assessment Act* (2002), an environmental assessment certificate is required and the proponent may not proceed with the project without an assessment of whether the project has "significant adverse environmental, economic, social, heritage or health effects." Under the *Canadian Environmental Assessment Act* (2002; 2012), the definition of an "environmental effect" includes any changes in health or socio-economic conditions that are caused by the project's environmental effects.

For assessing the potential for contamination of country foods under baseline conditions, Health Canada indicates that the human health risk assessment should "consider adequate baseline data and/or modelling of COPCs in country foods prior to any project activities" (Health Canada 2010a). This country foods baseline assessment is intended to fulfill this requirement.

2.2 PREVIOUS ENVIRONMENTAL STUDIES

Data used in this country foods baseline assessment were obtained from recent studies conducted in the area of the Project, primarily to support the 2013 Application for an Environmental Assessment Certificate and Environmental Impact Statement for the Comprehensive Study of the Proposed Harper Creek Project. Data sources reviewed to support this country foods baseline assessment include:

- 2013 Harper Creek Project: Human Health and Ecological Risk Assessment – Baseline Technical Data Report (Sharpe 2013);
- 2013 Harper Creek Project: Fish and Aquatic Habitat Baseline (Knight Piésold Ltd. 2013b);
- 2013 Harper Creek Project: Surface Water and Groundwater Quality Baseline (Knight Piésold Ltd. 2013a);
- 2013 Harper Creek Copper-Gold-Silver Project: Terrestrial Wildlife and Vegetation Baseline Report (Keystone Wildlife Research Ltd. 2013);

- 2013 Harper Creek Project Part C, Section 10.8: Mine Reclamation and Closure Plan (Harper Creek Mining Corp. 2013f);
- 2013 Harper Creek Project Part C, Section 7.1: Social and Economic Conditions (Harper Creek Mining Corp. 2013d);
- 2013 Harper Creek Project Part C, Section 7.2: Land, Water, and Resource Use (Harper Creek Mining Corp. 2013e);
- 2012 Harper Creek Mine Traditional Land Use and Ecological Knowledge Study (Simpcw First Nation 2012);
- 2011 First Nations Food, Nutrition & Environment Study (Chan et al. 2011); and
- 1997 Compendium of Canadian Human Exposure Factors for Risk Assessment (Richardson 1997).

3. OBJECTIVES

The overarching goal of this report is to determine what, if any, risk there is to human consumers of country foods collected from within the country foods study area of the Project prior to development of the proposed Project. This report identifies which country foods harvesters are potentially the highest users of the area (and therefore would experience the highest potential risk from country foods consumption) and which country foods may be gathered and consumed. The concentrations of COPCs within selected country foods were measured or modelled and a human health risk assessment was completed to determine the potential for health effects from consumption of selected country food items in the area under baseline conditions.

The objectives of the country foods baseline risk assessment are consistent with the standard framework for human health risk assessment (Health Canada 2010a, 2010b), which is to:

- summarize the quality of environmental media and select relevant COPCs;
- characterize current levels of country food consumption and estimate the exposure to country food-derived COPCs for human consumers of country foods;
- identify acceptable daily exposure levels to COPCs (toxicity reference values (TRVs), or reference doses (RfDs)) as standards to which exposure estimates from the exposure assessment are compared to, in order to evaluate risk;
- estimate risks by calculation of exposure ratios and recommended maximum weekly intake (RMWI) of country foods;
- evaluate the assumptions and uncertainties made throughout the assessment as well as data gaps and their effects on the conclusions; and
- provide sufficient baseline information upon which to base the assessment of the potential for human health effects due to country food consumption within the human health effects assessment of the Application/EIS.

4. STUDY AREA

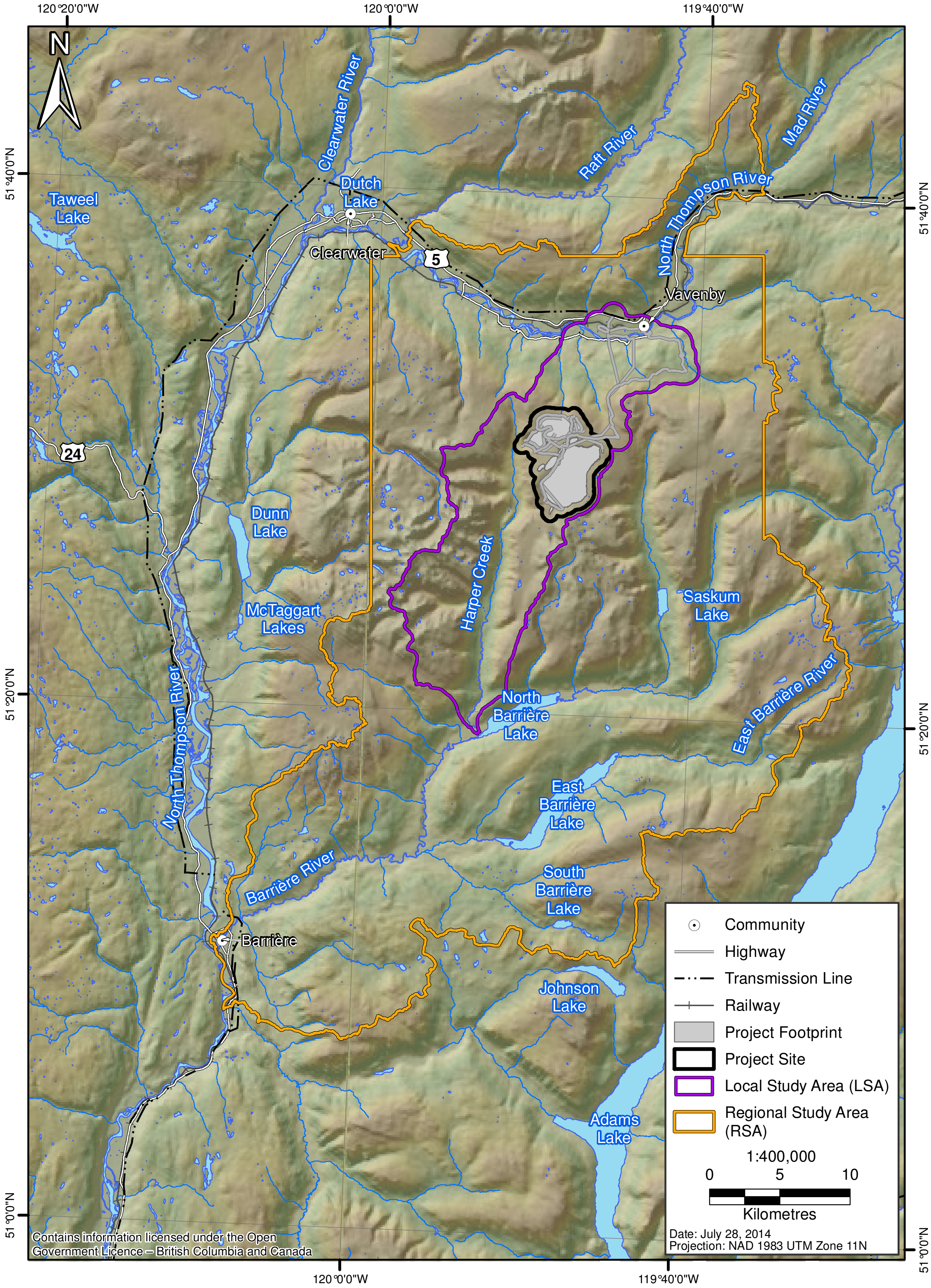
The boundaries for the country foods baseline risk assessment were selected so that the same study areas could be subsequently used in the Application/EIS effects assessment for human health. Watershed height-of-land borders are often used to define study areas, as they are physical barriers to transference (via water) of potential Project-related effects. Buffers around infrastructure are used to define study area boundaries to account for the potential effects of Project-related dust deposition. In addition, other physical features such as waterways were used to define the country foods study area, when they were considered likely to be the limit of the potential future effects of the Project.

The country foods LSA and RSA are shown in Figure 4-1. The country foods LSA is the same as the Wildlife LSA and the boundaries are defined by a buffer that extends 1 km from all sides of proposed Project infrastructure.

The country foods RSA is defined as the outer boundary formed by the overlay of the Wildlife and Water Quality RSAs and the Air Quality Modelling Domain. The Wildlife and Water Quality RSAs include the Vavenby and Barrière Landscape Units (provincially-defined areas used for long-term planning of resource management activities including biodiversity, old growth forest retention, wildlife habitat maintenance and timber harvesting) and is large enough to include species with large home ranges (e.g., grizzly bears), and includes watersheds that drain into the North Thompson River (i.e., Chuck Creek, Avery Creek, and Barrière River). The Air Quality Modelling Domain is a rectangle that extends 10 km on either side of the Project Site.

Figure 4-1

Country Foods Local and Regional Study Areas



5. APPROACH

The approach for the country foods study was based on Health Canada's guidelines for assessing country food issues in environmental impact assessments (Health Canada 2010b, 2010d). As such, this study is divided into the following five stages:

1. Problem Formulation:

   A conceptual model for conducting the country foods risk assessment was developed in the problem formulation stage. This stage identified the country foods selected for evaluation, COPCs, human receptor characteristics, and the exposure routes considered in the assessment.

2. Exposure Assessment:

   The measured or modelled COPC concentrations in country foods were integrated with human receptor characteristics to calculate the estimated daily intake (EDI) of COPCs. Food chain modelling of COPC uptake into wildlife tissue is generally highly conservative relative to direct measurement and has the potential to overestimate COPC tissue concentrations by orders of magnitude (Health Canada 2010e). This maintains the conservative nature of the screening level human health risk assessment and ensures with a high degree of certainty that risks will not be under-estimated or overlooked (Health Canada 2010e).

3. Toxicity Assessment:

   The TRVs or tolerable daily intakes (TDIs; levels of daily exposure that can be taken into the body without appreciable health risk) were identified.

4. Risk Characterization:

   The exposure and effects assessments were integrated by comparing the EDIs with TDIs to produce quantitative risk estimates (exposure ratios, ERs, or incremental lifetime cancer risk, ILCR). In addition, the RMWI for each country food was calculated.

5. Uncertainty Analysis and Data Gaps:

   The assumptions made throughout the baseline risk assessment and their effects on the confidence in the conclusions were evaluated.

6. Conclusions:

   The potential for risk to human health was assessed based on the results of the risk characterization, with qualitative consideration of uncertainties and data gaps that might influence the quantitative assessment.

6. PROBLEM FORMULATION

6.1 INTRODUCTION

The purpose of the problem formulation stage of the risk assessment is to create a conceptual model for the country foods baseline assessment. This stage identifies data requirements to accurately assess the potential for human health effects due to consumption of country foods collected from within the country foods RSA. The objectives of the problem formulation stage are to:

- identify the most relevant and representative country foods harvested within the country foods study area;
- identify the relevant COPCs within the country foods study area;
- identify potential human receptors, characteristics and the relevant life stages (e.g., adults (greater than 19 years of age) and toddlers (six months to four years of age)) that may harvest or consume country foods; and
- identify the relevant human exposure pathways.

6.2 COUNTRY FOODS SELECTED FOR EVALUATION

Country foods include a wide range of animal, plant, and fungi species that are harvested for medicinal or nutritional use. The primary objective when selecting country foods is to identify the most relevant foods to evaluate. Key considerations when selecting the country foods to evaluate include:

- which country foods may be currently collected in the country foods study area;
- how the country food is used (i.e., food, medicine, or both);
- what part(s) of the country food may be consumed (i.e., specific organs, plant leaves or roots);
- what quantities of each country food may be consumed; and
- what the consumption frequencies may be for each country food.

Since it is not possible to assess all potential country foods, one species is selected as a proxy from each of the following groups of foods: large mammals, small mammals, birds, fish, and vegetation. Representative country foods from the different groups are selected because the relative exposure of organisms in each group to environmental media varies with specific habitat and foraging behaviours (e.g., a moose has a different life history and potential for COPC exposure than a fish). A species that represents the highest consumption level and, therefore, results in the highest potential dietary exposure to COPCs, is selected from within each of these groups. Theoretically, if foods that represent the highest rate of exposure are determined to be safe for consumption, then all other foods within the group would also be considered safe for consumption.

The Project is located within the asserted traditional territories of the Simpcw First Nation (Figure 1.4-2), and the Lakes Division Secwepemc (represented by the Adams Lake Indian Band and Neskonlith Indian Band; Figure 1.4-3). Although historical and current harvest of country foods for traditional purposes within the LSA and RSA has been noted for the Simpcw First Nation (2012), no information on the serving sizes or consumption frequencies is available. Information on country foods use by the Lakes Division Secwepemc was unavailable at the time of writing.

Therefore, First Nations consumption rates were estimated using data from the *First Nations Food Nutrition & Environment Study* (Chan et al. 2011). The data provided in the report for the Lower Nicola/Splatsin (Sapllumcheen) First Nations from Ecozone 3 Montane Cordillera/Plateau are the most recent (2009 survey) and most relevant for the purpose of this country foods baseline assessment as the Project is located within this Ecozone. A total of 93 people participated in the surveys, 41 people from the Lower Nicola First Nation and 52 people from the Splatsin (Spallumcheen) First Nation. The top ten consumed traditional food items reported by First Nation study participants in Ecozone 3 are (Chan et al. 2011):

1. Deer meat
2. Moose meat
3. Salmon (any, type)
4. Salmon, Sockeye
5. Elk meat
6. Blue huckleberry
7. Labrador Tea leaves
8. Soapberries
9. Salmon, Chinook (King/Spring)
10. Red huckleberry

In addition to First Nations as potential consumers of country foods, others may also access the area for hunting or fishing. The country foods RSA is within the Thompson-Nicola Fish and Wildlife Region 3 (south-eastern) and encompasses three Wildlife Management Unit boundaries (3-38, 3-41, and 3-42; BC MFLNRO 2014). Hunting clubs and guide-outfitter businesses are located in the area and hunting takes place during most months of the year (North Thompson Fish and Game Club 2014). Stakeholders interviewed in 2014 estimate several hundred people would access the RSA for hunting purposes on an annual basis (North Thompson Fish and Game Club 2014). Hunting parties have been known to camp at Saskum Lake (summer and fall) to the south east of the Project Site within the RSA (ERM Rescan 2014a). All-terrain vehicles are commonly used for hunting purposes in the RSA to access backcountry locations (ERM Rescan 2014a).

Throughout the country foods RSA hunting occurs for:

- moose and mountain sheep in September and October;
- white-tailed deer and mule deer from September to December;

- cougar, bobcat, lynx, black bear, wolf and coyote variably throughout the year;
- racoon and Columbian ground squirrel throughout the year (no closed season); and
- various game birds and waterfowl typically from September to December (Harper Creek Mining Corp. 2013c).

The following sections provide more detailed information about the country foods that may be harvested from the RSA and the rationale for the selection of representative food items to be evaluated in the risk assessment.

6.2.1 Terrestrial Wildlife Species

Large Terrestrial Mammals

Traditionally the Simpcw First Nation harvested several large terrestrial wildlife species for meat, including: caribou, moose, elk, Big Horn sheep, deer, and occasionally grizzly bear, black bear, and mountain goat (Simpcw First Nation 2012). Information on the species harvested by the Lakes Division Secwepemc was not available at the time of writing this report.

An interview with a member of the North Thompson Fish and Game Club indicated that the terrestrial species hunted for consumption in the country foods RSA include: deer, moose, grouse, and incidental geese/ducks (North Thompson Fish and Game Club 2014). An interview with Sean Sharpe, who collected much of the baseline data for the country foods report, indicated that within the country foods RSA, the primary species hunted is moose, possibly elk and deer, and incidentally caribou (S. Sharpe, pers. comm.).

According to Chan et al. (2011) deer, moose, and elk are large mammals commonly consumed by the First Nations in Ecozone 3. Deer is the most frequently consumed large terrestrial mammal by the First Nation communities (62 days per year), and is a food item they rely on throughout the year (see Section 6.2). The muscle tissue (meat) is most frequently consumed (86% of survey participants); however, deer liver (41% of participants) and kidney (14% of participants) are also consumed on a more infrequent basis. Moose is the second most frequently consumed large terrestrial mammal by the First Nation communities (30 days per year), and is also a food item they rely on throughout the year (see Section 6.2). The muscle tissue (meat) is most frequently consumed (70% of survey participants); however, moose liver (20% of participants) and kidney (10% of participants) are also consumed on a more infrequent basis. Elk is consumed to a lesser extent (40% of survey participants).

For country foods baseline assessments it is preferable to consider species with ranges completely within the area of specific interest (i.e., country foods LSA or RSA). While large mammals may migrate over large areas outside of the country foods RSA, their potential importance to the diet of local people supports their inclusion for assessment in this study.

Generally, moose may spend most of their time within one watershed and can therefore be representative of potential exposure from COPCs from within the RSA. It is assumed that animals distribute the time they spend throughout their home range area equally. Moose prefer shrubby foraging habitat areas in early successional stage forests or areas with open canopies (Stevens and Lofts

1988; Spalding 1990; MacCracken, Van Ballenberghe, and Peek 1997). High-value winter habitat for moose tends to be low-elevation, riparian communities with abundant vegetation, with greater than 30% shrub cover, low density of mature trees, and gentle slopes (Kelsall and Telfer 1974; LeResche, Bishop, and Coady 1974; Doerr 1983; Risenhoover 1985; Van Drimmelin 1987; Thompson et al. 1989; Modaferri 1992; Van Dyke 1995). There are 10.1 km^2 of critical moose winter range in the LSA and the Project Site will overlap 1.3% (0.133 km^2) of this winter range (Keystone Wildlife Research Ltd. 2013).

Moose are generally browsers (Franzmann 1978; Wall, Belisle, and Luke 2011) and suitable shrub habitat is common within the LSA and the RSA due to timber harvesting (Keystone Wildlife Research Ltd. 2013). Habitat suitability for moose in the country foods LSA and RSA has increased due to logging; however, moose are only occasional visitors to the area and are likely only there during the summer for two to three months (August to October) with a conservative abundance of one moose per 4 km^2 (S. Sharpe, pers. comm.). Moose foraging range size during all seasons is 4.6 km^2 (Azimuth 2012). Furthermore, only male bull moose would be present at the higher elevation of the Project Site and during the summer rut (September to October) they spend very little time feeding (S. Sharpe, pers. comm.). Approximately one to two moose from the RSA would be harvested by First Nations and the entire animal would be shared between eight to 10 people (S. Sharpe, pers. comm.). Based on this information, moose (*Alces alces*) was selected as a proxy for the large terrestrial mammal country food assessment.

<u>Small Terrestrial Mammals</u>

Traditionally, Simpcw First Nation harvested porcupine and marmot for meat (Simpcw First Nation 2012). Information on the species harvested by the Lakes Division Secwepemc was not available at the time of writing this report.

There are no small mammals listed in the top ten consumed traditional food items reported by First Nations in Ecozone 3 (Chan et al. 2011). However, the small mammals reported to be consumed by First Nations in Ecozone 3 at lower frequencies were rabbit (snowshoe hare/Jackrabbit/rabbit; 6% of survey participants), groundhog (2% of survey participants), and beaver (1% of survey participants). The home range of snowshoe hares (*Lepus americanus*) is small and estimated to be between 0.057 to 0.1 km^2 (Adams 1959). Since the home range for snowshoe hares is small enough to be entirely within the country foods RSA, snowshoe hare were included in the country foods baseline assessment. It is assumed that hare are present year round in the study area. When harvested, it is assumed that a harvest of six to 10 animals would be reasonable on a two to five day hunting trip, and the entire animal would be consumed (S. Sharpe, pers. comm.).

It is unlikely that First Nations would travel to the higher elevations of the Project Site to harvest hare as they are much more abundant at lower elevations; however, hare, with modelled tissue COPC concentrations based on soil and vegetation samples collected predominantly from the Project Site, were included in the assessment to be conservative.

Red-backed voles (*Myodes rutilus*; n = 17), Western jumping mice (*Zapus princeps*; n = 3), and a masked shrew (*Sorex cinereus*; n = 1) were also collected from 15 sites in the country foods LSA during baseline sampling and analyzed for tissue metal content (Sharpe 2013). Appendix A, Table A-3 provides a statistical summary of metal concentrations measured in the small mammal samples. The small mammals (voles, mice, and shrews) sampled are not actually country foods and were only included for comparative purposes.

Birds

Traditionally Simpcw First Nation harvested grouse and waterfowl for meat (Simpcw First Nation 2012). Information on the species harvested by the Lakes Division Secwepemc was not available at the time of writing this report.

The harvested birds in Ecozone 3 include grouse (blue and ruffed), and various species of ducks and geese (Chan et al. 2011). Sixteen percent of survey participants from Ecozone 3 reported eating grouse. Most grouse have a relatively small home range and, with the exception of sage grouse, are not known to migrate (Parks Canada 2011). Ruffed grouse (*Bonasa umbellus*) have a home range of 1.04 km^2 (Thompson III and Fritzell 1989), so could spend their entire lives inside the country foods RSA. It is assumed that grouse are year-round residents of the area, with harvesting occurring primarily in the late summer and fall, and that only the breast meat is usually consumed (S. Sharpe, pers. comm.). As metal exposure in the country foods RSA would be most relevant to non-migratory foraging birds, consumption of grouse would likely represent the highest exposure to metals in birds harvested from the country foods RSA. Therefore, ruffed grouse was selected for inclusion in the country foods baseline assessment.

It is unlikely that First Nations would travel to the higher elevations of the Project Site to harvest grouse as they are much more abundant at lower elevations and the habitat in the LSA is not suitable for them. However, grouse, with modelled tissue COPC concentrations based on soil and vegetation samples collected predominantly from the Project Site, were included to be conservative.

6.2.2 Fish Species

The Thompson-Nicola region of BC has a range of lakes and rivers that support a variety of fish species including Bull Trout (*Salvelinus confluentus*), Coho Salmon (*Oncorhynchus kisutch*), Rainbow Trout (*Oncorhynchus mykiss*), Dolly Varden (*Salvelinus malma*), and Mountain Whitefish (*Prosopium williamsoni*; Knight Piésold Ltd. 2013b). As such, fishing and angling are popular local activities in the region. The headwater streams within the Project Site of the proposed Project are not fish-bearing, although runoff from these streams flows into fish-bearing waters in Upper Harper Creek (lowermost T Creek and P Creek), lower Baker Creek, and lower Jones Creek (Knight Piésold Ltd. 2013b).

Traditionally the Simpcw First Nation relied upon seasonal salmon harvests, and other species' fisheries within the country foods RSA (Simpcw First Nation 2012). Information on the species harvested by the Lakes Division Secwepemc was not available at the time of writing this report.

There are 18 freshwater fish species that are harvested and consumed by country food harvesters in Ecozone 3 (Chan et al. 2011). Various species of salmon and trout are the fish that are consumed most frequently by the First Nations in Ecozone 3. Salmon species are consumed by 91% of the people who participated in the survey, while trout (any type) was reportedly consumed by 52% of people. Marine fish or shellfish species are also consumed but were not included in this report because the RSA does not include a marine area.

No fishing is known to occur in rivers, streams, or creeks located within the country foods LSA (ERM Rescan 2014a). Recreational fishing locations within the country foods RSA include Saskum, North Barrière, East Barrière, and South Barrière lakes (ERM Rescan 2014a). Saskum Lake is the closest lake to Project infrastructure (within the RSA) and approximately 20 people (or five boats) are there in the summer on weekends (North Thompson Fish and Game Club 2014); camping is available at the adjacent forestry recreation area (ERM Rescan 2014a). Other lakes within the RSA include North Barrière Lake and East Barrière Lake, both of which have campgrounds and summer residences, while East Barrière Lake has full-time residents (ERM Rescan 2014a). Fish species caught for consumption include Rainbow Trout, Bull Trout, and Dolly Varden (North Thompson Fish and Game Club 2014). Lakes usually begin to freeze over in late October, thus there is limited fishing beyond this time and all streams that are valued for fishing are closed until July 1 (July 16 for Clearwater and North Thompson Rivers) to preserve the unique fishing opportunities provided by these water bodies (ERM Rescan 2014a). Important rivers for fishing include Clearwater River (Chinook Salmon), North Thompson River (Chinook Salmon), Adams River, and Raft River (ERM Rescan 2014a).

Rainbow Trout and Bull Trout are large-bodied fish that live for several years and have both anadromous and resident forms, with the resident type showing generally limited movement and dispersal within stream systems (Raleigh et al. 1984; Ford et al. 1995; McPhail and Baxter 1996). These species possess short- to medium-term longevity (six plus years), prey preference is benthic invertebrates, the age (three to six years) and length at maturation are short (155 to 250 mm), and spawning is site-specific (Raleigh et al. 1984; Ford et al. 1995; McPhail and Baxter 1996). Therefore, tissue residues in Rainbow and Bull Trout are more likely to better represent contaminant loads derived from the study area than non-resident migratory fish species such as salmon. Bull Trout have exacting habitat demands and can be impacted by resource extraction activities, and they are a blue-listed char species that is generally thought to be in a state of decline throughout its global and BC range (BC MOE 2013).

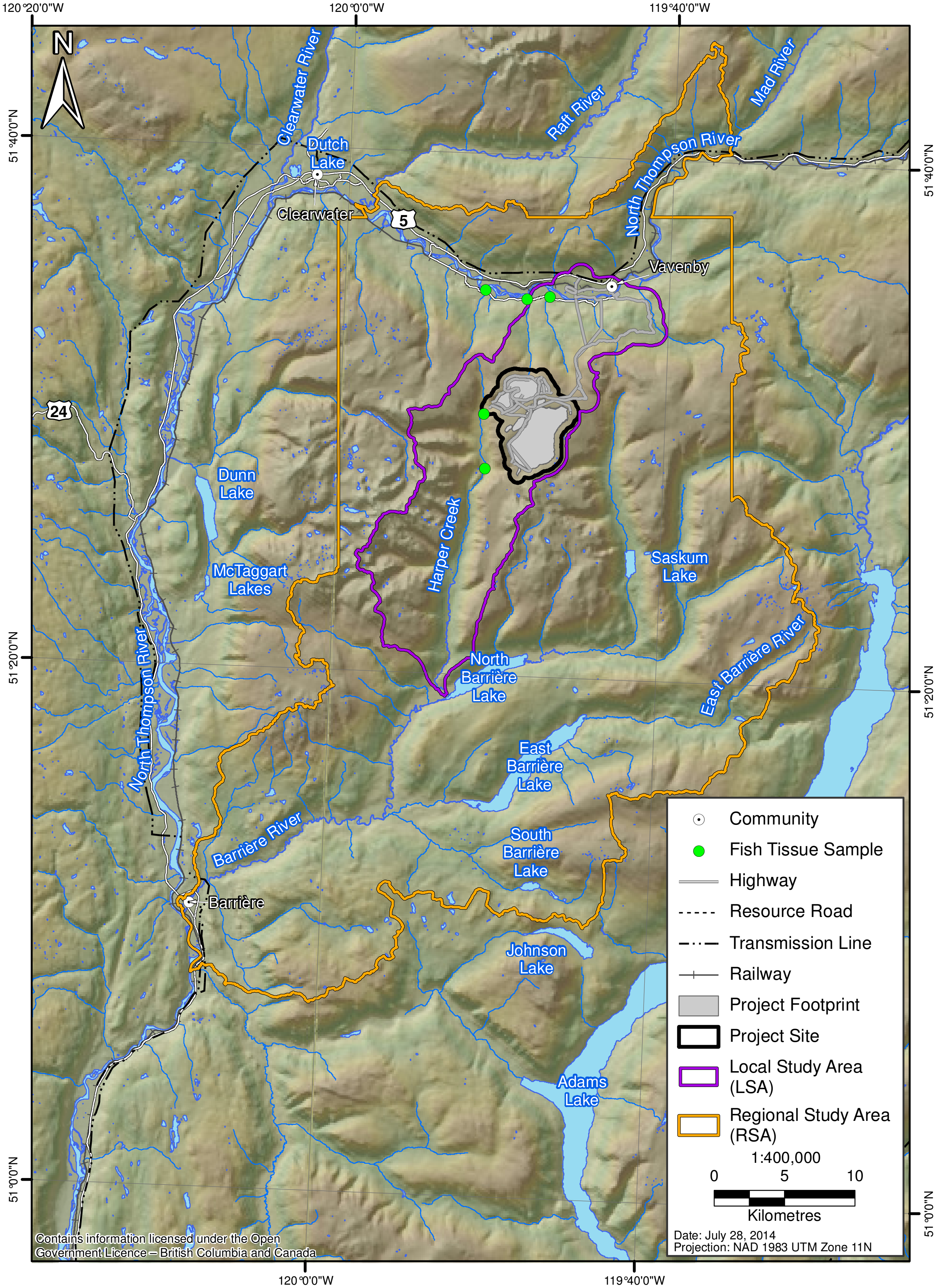
Figure 6.2-1 presents the fish tissue metal sampling locations within the country foods RSA. Fish were collected in the fish-bearing reaches of Baker Creek (Reach 2), Jones Creek (Reach 1), Lute Creek (Reach 1), T Creek (Reach 1), and P Creek (Reach 1). Generally >100 m of sampling was required to collect sufficient numbers of fish for tissue metal analysis (e.g., all of lower P Creek was fished to obtain five fish).

Based on the fish samples collected for tissue metal analysis and the frequency of fish consumption as country foods, Rainbow Trout and Bull Trout were selected for assessment in this baseline country food study.

6.2.3 Vegetation Species

Typically in country foods studies, a vegetation species is selected as a country food for direct human consumption. In addition, where measured wildlife tissue metal concentrations are not available, models require metal concentrations in vegetation to estimate the metal concentrations in wildlife. Therefore, vegetation metal concentration data can be part of the country foods assessment both as direct contributions (i.e., direct ingestion of vegetation or berries) or as indirect contributors through the consumption of wildlife (i.e., intake of vegetation by wildlife and subsequent intake of wildlife by humans).

Figure 6.2-1
Fish Tissue Sampling Locations within the Country Foods Regional Study Area (2011-2012)



The Simpcw First Nation provided a list of several plant species which were harvested in their Traditional Land Use and Ecological Knowledge study for the Harper Creek Mine Project (Simpcw First Nation 2012). Plant and berry gathering trails used to cross the mountains through what is now the country foods RSA (Simpcw First Nation 2012). Traditionally the Simpcw harvested plant products during the spring, summer, and fall months for food, medicinal purposes (250 to 300 species), housing, clothing, and adornment (Simpcw First Nation 2012). The vegetation species harvested included: fir, horsetail, mosses, grasses, paper birch, red cedar, kinnikinnick, Saskatoon berry, soapberries, blueberries, huckleberries, raspberries, strawberries, currents, chokecherries, gooseberries, wild potato, and balsam root (Simpcw First Nation 2012). The medicinal plants used by the Simpcw First Nation included plants such as: mountain alder, alumroot, arnica, aster, balsamroot, bracket fungus, chokecherry, white clematis, cottonwood, balsam poplar, cow parsnip, devil's club, Douglas fir, wild ginger, juniper, kinnikinnick (bearberry), Labrador tea, mint, Oregon grape, paintbrush, lodgepole pine, plantain, creeping and red raspberry, sagebrush, sarsaparilla, skunk cabbage, snowberry, snowbush, soapberry, stinging nettle, tarragon, valerian, and yarrow (Simpcw First Nation 2012). Information on the species harvested by the Lakes Division Secwepemc was not available at the time of writing this report.

First Nations study communities from Ecozone 3 reported collecting a variety of plant species for food or medicine (Chan et al. 2011). Overall, berries are consumed more frequently than any other part of plants (roots, shoots, greens, inner bark, or mushrooms; Chan et al. 2011). Plant species that are among the top ten consumed traditional food items for First Nations living on-reserve in Ecozone 3 (Table 6.2-1) were blue huckleberry (consumed by 56% of people surveyed), Labrador tea leaves (consumed by 28% of people surveyed), soapberries (consumed by 52% of people surveyed), and red huckleberry (consumed by 20% of people surveyed).

The country foods LSA is not productive for berries, but species that do grow in the area are huckleberry and blueberry (S. Sharpe, pers. comm.). Eight huckleberry samples (*Vaccinium membranaceum*) were collected from the country foods LSA and analyzed for metal concentrations (Sharpe 2013). These were included in the assessment directly as a country food consumed by people in the region.

To support food chain modelling of wildlife species, samples of huckleberry leaves (*Vaccinium membranaceum*), Sitka valerian (*Valeriana sitchensis*), willow (*Salix barclayi* and some *Salix drummondiana*), fireweed (*Epilobium anugustifolium*), and sorbus (*Sorbus sitchensis* and *S. scopulina*) were collected from 15 sites within the country foods LSA in 2012 and analyzed for tissue metal concentrations (Sharpe 2013). Only above-ground parts of plants (leaves and berries) were collected. Figure 6.2-2 presents the vegetation sampling locations within the country foods LSA that were used for inputs to the food chain model for estimation of the wildlife (i.e., moose, snowshoe hare, and ruffed grouse) tissue metal concentrations (see Section 7.2).

6.2.4 Summary of Country Foods Selected for Evaluation

A summary of the country foods selected for evaluation is presented in Table 6.2-1.

Figure 6.2-2
Sample Locations for Soil, Vegetation, and Small Mammals (2012)

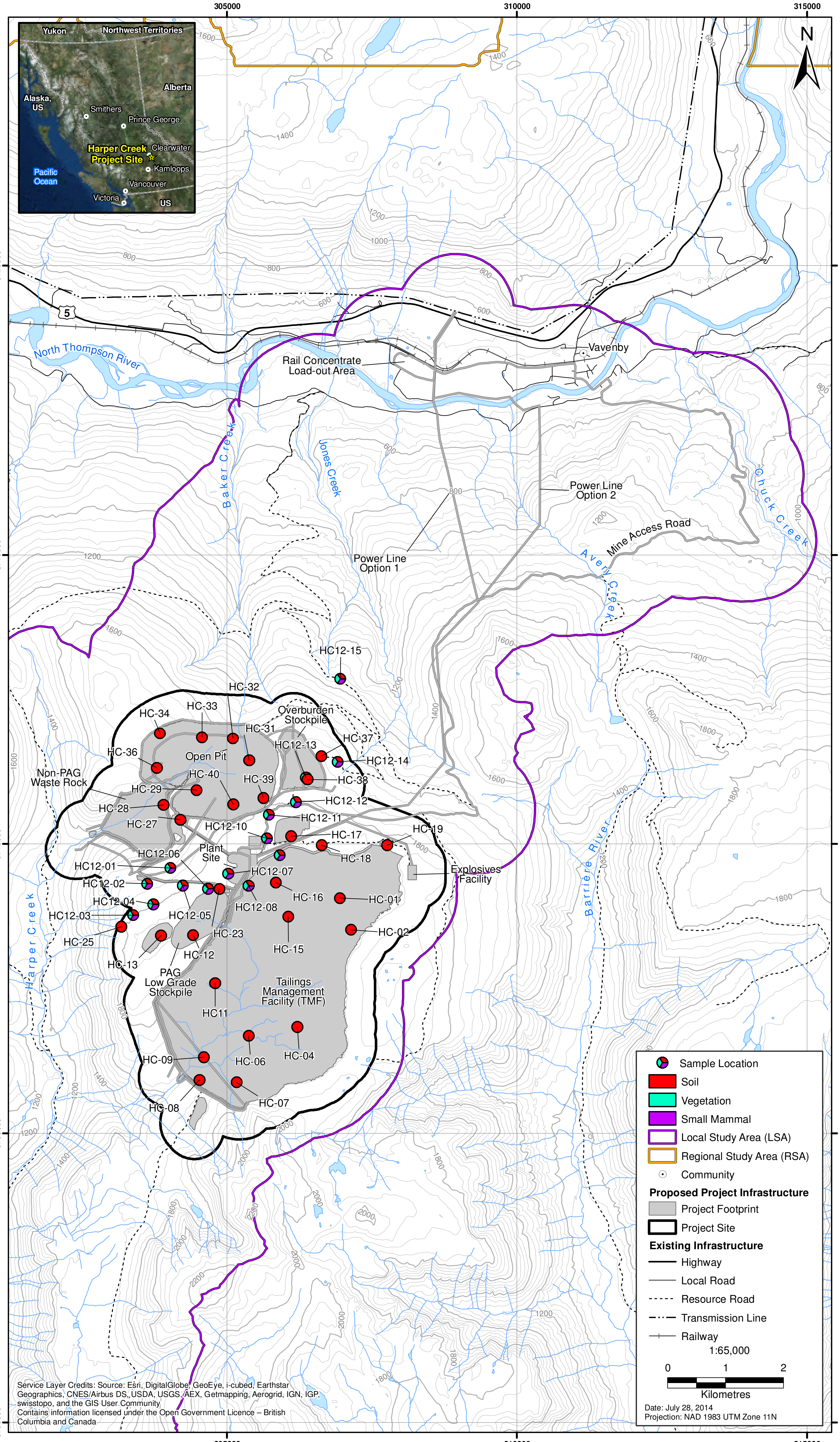


Table 6.2-1. Country Foods Selected for Evaluation

Category	Country Food	Species Name	Parts Consumed
Terrestrial Wildlife	Moose	*Alces alces*	Muscle
	Snowshoe Hare	*Lepus americanus*	Muscle
	Ruffed Grouse	*Bonasa umbellus*	Muscle
Fish	Bull Trout	*Salvelinus confluentus*	Muscle
	Rainbow Trout	*Oncorhynchus mykiss*	Muscle
Plants	Huckleberries	*Vaccinium membranaceum*	Fruit

6.3 CONTAMINANTS OF POTENTIAL CONCERN SELECTED FOR EVALUATION

6.3.1 Criteria for Screening for Contaminants of Potential Concern

The country foods baseline assessment focused on metals as the COPC since they naturally occur in environmental media (e.g., water, soil, sediment) due to local physical and geological processes and their concentrations could potentially change due to future Project activities. The present assessment did not consider other contaminants such as POPs and radionuclides as these are not typically associated with metal mining, and are unlikely to be affected by Project related activities.

Specific metals were selected as COPC if they met at least one of the following three screening criteria:

1. The maximum metal concentration in soil samples considered in the assessment exceeded its Canadian Council of Ministers of the Environment (CCME) soil quality guideline value for agricultural land (CCME 2013a).
2. The maximum total metal concentration in surface water samples included in the assessment exceeded its BC 30-day mean water criteria for the protection of freshwater aquatic life or CCME long-term water quality guideline value for the protection of aquatic life, whichever guideline was lower (BC MOE 2006; CCME 2013b).
3. The metal has a potential to bioaccumulate in organisms or biomagnify in food webs, such that there could be significant transfer of the metal from soil to plants and subsequently into higher trophic levels. Information on the bioaccumulation/biomagnification potential of each metal was obtained from a review of relevant documents from the Joint FAO/WHO Expert Committee on Food Additives (JECFA) and the United States Environmental Protection Agency (US EPA; JECFA 1972, 1982; US EPA 1997b; JECFA 2000; US EPA 2000b; JECFA 2005, 2007a, 2011).

The Project Site, where most of the soil and vegetation samples were obtained, is located on a gently sloping plateau, and is only accessible via Forest Service Roads that connect with Highway #5. It is unlikely that country foods are regularly available or harvested in this area. Using the maximum metal concentrations from these environmental media for screening of the COPCs provides a very conservative approach in the selection of the COPCs within the country foods RSA.

6.3.2 Environmental Media Data Used for Selecting Contaminants of Potential Concern

The country foods RSA encompasses Vavenby and Barrière Landscape Units, the Chuck Creek and Avery Creek watersheds to their confluence with the North Thompson River, the North Thompson River from upstream of Chuck Creek to upstream of Clearwater, and the Barrière River watershed to the confluence with the North Thompson River (Figure 4-1). Environmental media data collected from within the country foods RSA that were incorporated in the assessment include:

- Metal concentrations in stream and lake water samples collected from 20 sites within the country foods LSA and RSA during Project baseline studies between 2007 to 2009 and 2011 to 2014 (Figure 6.3-1; Harper Creek Mining Corp. 2013b) and
- Soil baseline metal concentrations collected in 2012 from 46 sites from within the country foods LSA (Figure 6.2-2; Harper Creek Mining Corp. 2013f; Sharpe 2013).

Metal concentrations in vegetation were also measured within the country foods RSA. However, there are no vegetation tissue residue guidelines for comparison so these data were not included in the COPC screening procedure.

The method detection limit (MDL) is the detectable concentration achievable by the analytical laboratory based on the chemistry of the sample. For the purpose of statistically summarizing the data, when metal concentrations in water or soil were below the MDL, a value of half the MDL was used. Although this methodology for addressing what are essentially missing values does not capture the true frequency distribution of the concentrations (Nosal, Legge, and Krupa 2000), assigning values to undetected concentrations in this manner is conservative and a common practice where it can be assumed the values are not zero, but where the level of risk is low enough not to warrant additional statistical analyses (i.e., with regards to human health; US EPA 2000a).

6.3.3 Contaminants of Potential Concern Selected for Evaluation

Appendix A (Tables A-1 and A-2) present the statistical summaries of metal concentrations measured in samples of soil and surface water from the country foods LSA and RSA. Table 6.3-1 presents the maximum concentrations of metals in soil and water, the applicable guidelines for comparison, whether a metal is bioaccumulative, and identifies the COPCs screened into the country foods baseline assessment. A metal was only included in Appendix A tables if it was measured in all media. Based on the screening methodology outlined in Section 6.3.1, the COPCs selected for the country foods baseline assessment include: aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, mercury, nickel, selenium, silver, thallium, vanadium, and zinc.

Iron was not retained for further assessment as a COPC despite measured concentrations in surface waters that exceed CCME guidelines for the protection of freshwater aquatic life. Iron is an essential element as it is a required component in blood cells for the transportation of oxygen throughout the body (Adriano 2001). Iron is the second most abundant metal in the earth's crust and is abundant in soils and sediment where it is often tightly bound and not available for biological uptake.

Figure 6.3-1

Sample Locations for Surface Water Quality (2009 - 2014)

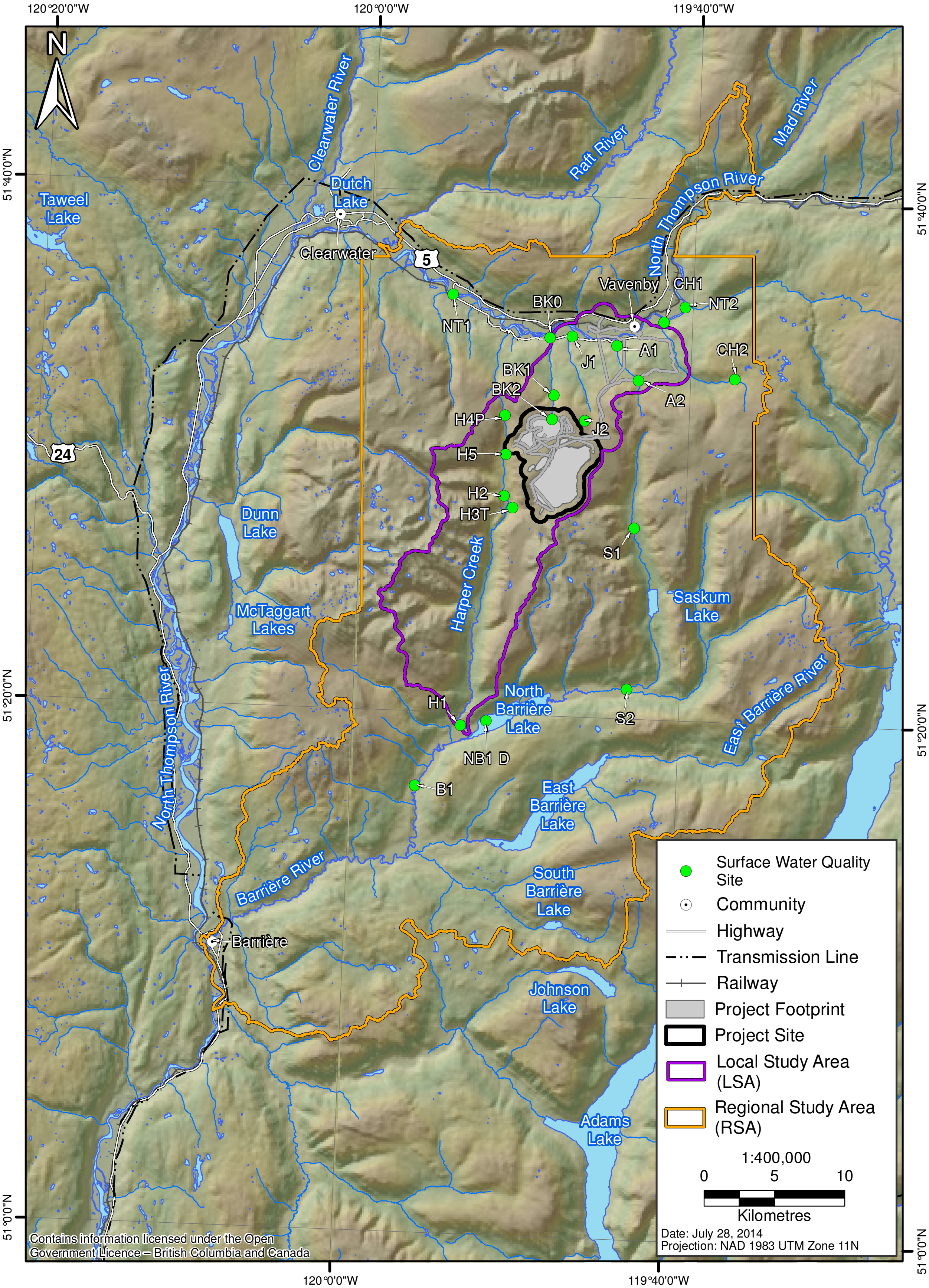


Table 6.3-1. Screening Results for Selection of Contaminants of Potential Concern

Metals	Maximum Soil Concentration in 0-20 cm depth, n = 31 to 46 2012 mg/kg	CCME Soil Guideline Agricultural mg/kg	Maximum Water Concentration n = 30 to 655 2007 to 2009 and 2011 to 2014 mg/L (total metals)	CCME Water Guideline Freshwater Aquatic Life (Long Term) mg/L	BC MOE Water Quality Guidelines Freshwater Aquatic Life (30-Day Mean/Chronic) mg/L	Bioaccumulation Potential	Selected as a COPC?
Aluminum	43000	NG	2.87	0.1	0.05	Low	Yes
Antimony	1.82	20	0.000375	NG	0.02[b]	Low	No
Arsenic	76.5	12	0.0107	0.005	0.005	Variable	Yes
Barium	157	750	0.0383	NG	1[b]	Low	No
Beryllium	0.930	4	0.000500	NG	0.0053[b]	Low	No
Bismuth	2.19	NG	0.000750	NG	NG	Low	No
Boron	NC	2	0.150	1.5	1.2	Low	No
Cadmium	3.32	1.4	0.000200	0.0000218-0.000255[a]	0.00000423-0.0000541[a, b]	Moderate to high	Yes
Calcium	4840	NG	55.2	NG	NG	Low	No
Chromium	136	64	0.00556	0.001	0.001[b]	Low	Yes
Cobalt	118	40	0.00260	NG	0.004	Low	Yes
Copper	5150	63	0.229	0.000306-0.00385[a]	0.00004-0.002[a]	Low	Yes
Iron	120000	NG	4.57	0.3	1[c]	Low	Yes
Lead	159	70	0.00669	0.000152-0.00658[a]	0.00479	Low to high (plants)	Yes
Lithium	22.5	NG	0.00548	NG	0.014	Low	No
Magnesium	17400	NG	15.4	NG	NG	Low	No
Manganese	4690	NG	0.165	NG	0.645-1.38[a]	Low	No
Mercury	0.140	6.6	0.00130	0.000026	NG	High as methylmercury	Yes
Molybdenum	4.19	5	0.00408	0.073	1	Low	No

(continued)

Table 6.3-1. Screening Results for Selection of Contaminants of Potential Concern (completed)

Metals	Maximum Soil Concentration in 0-20 cm depth, n = 31 to 46 2012 mg/kg	CCME Soil Guideline Agricultural mg/kg	Maximum Water Concentration n = 30 to 655 2007 to 2009 and 2011 to 2014 mg/L (total metals)	CCME Water Guideline Freshwater Aquatic Life (Long Term) mg/L	BC MOE Water Quality Guidelines Freshwater Aquatic Life (30-Day Mean/Chronic) mg/L	Bioaccumulation Potential	Selected as a COPC?
Nickel	93.9	50	0.0200	0.0155-0.148[a]	0.025-0.11[a, b]	Low to moderate	Yes
Phosphorus	3290	NG	0.150	NG	NG	Low	No
Potassium	2060	NG	2.04	NG	373-432[b]	Low	No
Selenium	3.35	1	0.000700	0.001	0.002	Moderate to high	Yes
Silicon	NC	NG	6.79	NG	NG	Low	No
Silver	1.71	20	0.000160	0.0001	0.00005-0.0015[a]	Low	Yes
Sodium	727	NG	2.71	NG	NG	Low	No
Strontium	19.7	NG	0.249	NG	NG	Low	No
Thallium	0.157	1	0.000100	0.0008	0.0063[b]	Moderate	Yes
Tin	1.26	5	0.116	NG	NG	Low	No
Titanium	1390	NG	0.239	NG	2 - 4.6[b]	Low	No
Uranium	5.31	23	0.00460	0.15	0.3[b]	Low	No
Vanadium	62.2	130	0.0150	NG	0.006[b]	Low	Yes
Zinc	232	200	0.181	0.03	0.0144-0.140[a]	High	Yes
Zirconium	7.28	NG	0.00100	NG	NG	Low	No

Notes:
NG = no guideline.
NC = not calculated because that parameter was not measured in environmental media data.
[a] *Guideline is hardness-dependent and applicable range is provided.*
[b] *BC MOE working guideline.*
[c] *BC MOE maximum guideline rather than 30-day guideline.*
Shaded cells indicate that the maximum metal concentration in that environmental medium exceeds the relevant guidelines.

Iron toxicity in humans is very rare and most cases of acute poisoning have occurred when children accidentally consume large amounts of iron supplements (intended for adults) as they mistake the pills for candy (EGVM 2003; Tenenbein 2005). Even with increased oral iron intake there is generally no significant iron overload in adults unless the individual has increased iron absorption because the ingested iron is in a highly bioavailable form, the individuals has an accompanying genetic defect, or the individual has increased demand due to a disorder (EGVM 2003). Furthermore, adverse health effects from the ingestion of large amounts of iron have only been associated with iron supplements and not with iron in food (EGVM 2003). Because iron is an essential element for humans and since environmental exposure to iron from food consumption is not likely lead to adverse health effects, iron was not evaluated further in this study.

6.4 HUMAN RECEPTORS

Chemicals that cause health effects are generally divided into two categories: threshold (i.e., non-carcinogenic) and non-threshold (i.e., carcinogenic) responses. These two categories of chemicals are evaluated differently and independently. Therefore, when selecting human receptors to evaluate, the types of chemicals that people may be exposed to must be considered.

The human receptors selected were toddlers (six months to four years of age) and adults (greater than 19 years of age). Toddlers are often most susceptible to chemicals with a threshold response due to their ratio of body size to ingestion rates (IRs) compared to other life stages (Health Canada 2010c, 2010d). Therefore, if an evaluation finds that COPC concentrations in country foods are unlikely to pose a health risk to toddler consumers, all other life-stages would be considered protected. An adult receptor was also selected for both threshold and non-threshold response chemicals based on guidance provided by Health Canada (2010a). For assessing exposure to mercury (in the form of methylmercury), women of child-bearing age were also assessed as a sensitive group.

6.4.1 Human Receptor Characteristics

All major components of the proposed Project infrastructure (e.g., plant site, access road, and transmission corridors) lie within the asserted traditional territories of the Lakes Division Secwepemc and the Simpcw First Nation. However, no consumption data were available at the time of writing this report. Therefore, traditional diet consumption data from a study of all BC First Nations (Chan et al. 2011) were used instead in this baseline assessment, since it included First Nations from Ecozone 3 where the proposed Project is located (Chan et al. 2011).

Stakeholders interviewed in 2014 (North Thompson Fish and Game Club 2014), indicated that the country foods RSA is also used by local hunters and guide outfitting companies who collect and consume country foods from the area (ERM Rescan 2014a). However, First Nations consumption of country foods is typically assumed to be higher than other resident and non-resident users (Health Canada 2010a). Assessing the group(s) with the highest consumption rates provides the most conservative estimate of the potential human health risk to all consumers since groups or individuals with lower consumption rates would have a lower level of exposure and lower risk.

The human receptor characteristics used to calculate the EDI of COPCs were body weight (kg) and consumption rate (kilograms of each country food per person per day) of the selected country foods. The body weight for adults (70.7 kg) and toddlers (16.5 kg) were based on guidance provided by Health Canada (2010b). It was assumed that a toddler would eat country foods at the same frequency as adults, since toddlers most likely consume the same meals together with adults. The assumed toddler consumption rates were calculated as 43% of the adult consumption rates, as suggested by Richardson (1997). It is anticipated that this consumption overestimates actual toddler serving sizes.

Country foods consumption rates used in this baseline country foods assessment presented in Table 6.4-1 are based on the study by Chan et al. (2011) of BC First Nations traditional diets. The typical daily amount of traditional food consumed was based on a 24-hour recall study (Chan et al. 2011), where study participants were asked to recall the type and amount of foods that they consumed the previous day. In general, men consumed larger amounts of traditional food per serving than women, and the middle age group (51-70 years of age) consumed the largest servings when compared to other age groups (19-50 and 71+ years).

Table 6.4-1. Consumption Rate of Country Foods[a]

Traditional Food	95th Percentile Consumption Rate for Adults (kg/day) [b]	95th Percentile Consumption Rate for Toddlers [b, c] (kg/day)
Moose meat	0.105	0.0452
Rabbit meat	0.00293	0.00126
Grouse	0.00164	0.000705
Blue Huckleberries	0.00581	0.00250
Trout, any	0.0114	0.00490

Notes:
[a] Source: Chan et al. (2011). The data is the estimated 95th percentile ("high") consumption rate of traditional foods using traditional food frequency results for all BC First Nations surveyed.
[b] Assumes ingestion frequency of 365 days per year.
[c] Toddler serving sizes are assumed to be 43% of adult serving sizes based on Richardson (1997).
Consumption rates for rabbit meat are assumed to be equivalent to consumption rates for snowshoe hare meat.
Consumption of "trout, any" is assumed to be equivalent to the consumption rate for Rainbow and Bull Trout.
Blue huckleberries are assumed to be equivalent to huckleberries.

Chan et al. (2011) multiplied the serving size by the frequency of consumption of each traditional food and obtained the estimated intake of major traditional foods in kilograms per day averaged over one year. The 95th percentile 'high' consumption amount as calculated by Chan et al. (2011) is presented in Table 6.4-1 and was used as a conservative input for the calculation of exposure ratios; this consumption rate inherently assumes that consumption frequency is 365 days per year. The consumption rate of each country food was assumed to accurately represent the consumption pattern of people who consume the most of each country food from the study area (Table 6.4-1).

6.5 HUMAN EXPOSURE PATHWAYS

Human exposure pathways are the routes by which people are exposed to chemicals. Food-related exposure pathways were selected for the country foods assessment based on the ingestion of:

- terrestrial animals that have taken up metals through the ingestion of soil, vegetation, and surface water;
- aquatic species that have taken up metals from their diet, sediments, and surrounding water; and
- plants that have taken up metals from the soil and water.

Human exposure pathways (via diet) are illustrated along with sources of COPCs, residency media (e.g., terrestrial animals, fish, and vegetation), and exposure routes to human receptors in Figure 6.5-1.

6.6 CONCEPTUAL MODEL

The conceptual model for this assessment is presented in Figure 6.6-1, which shows how metals in the environment move into the food chain and subsequently into humans through their diet.

Figure 6.5-1
Human Exposure Pathways

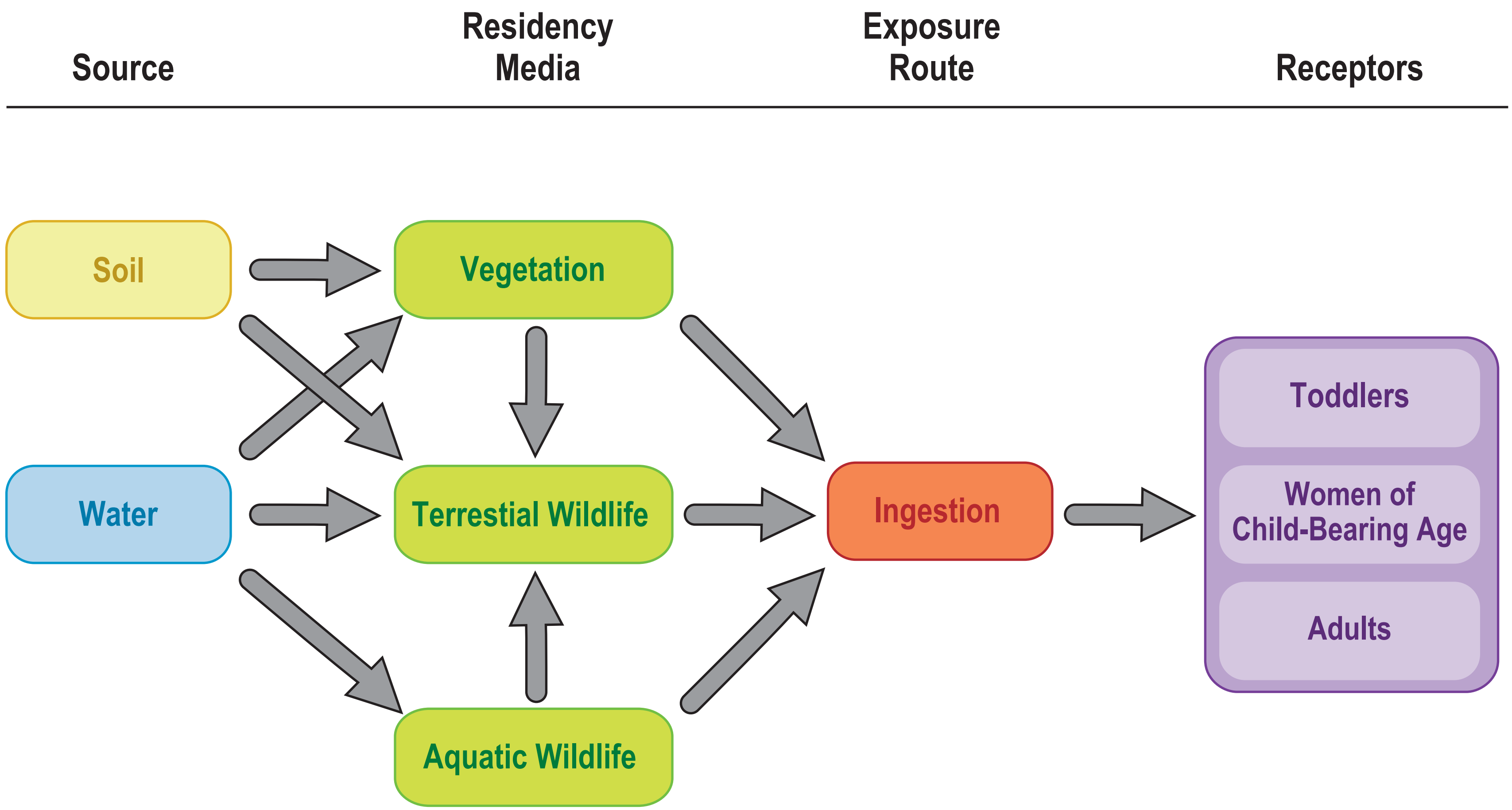
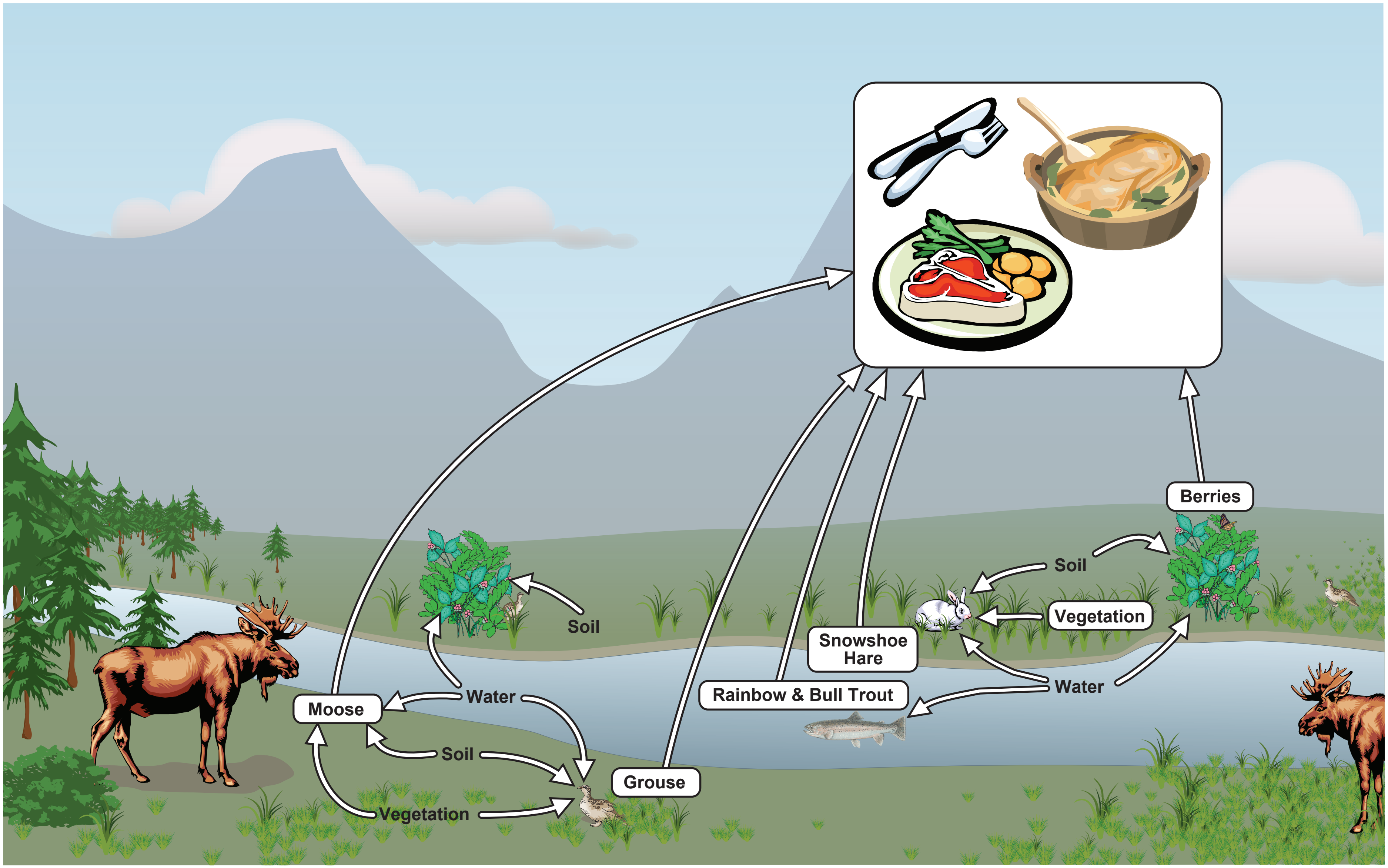


Figure 6.6-1
Country Foods Conceptual Model



7. EXPOSURE ASSESSMENT

7.1 INTRODUCTION

The amount of COPCs that people are exposed to from consuming country foods depends on several factors including:

- the concentration of metals in terrestrial wildlife resulting from their ingestion of environmental media (e.g., vegetation, water, and soil);
- the concentration of metals in aquatic species resulting from their uptake of metals from the water, sediment, and their diet;
- the concentration of metals in vegetation resulting from their uptake of metals from environmental media; and
- human receptor characteristics (e.g., consumption amount, frequency, body weight; described in Section 6.4.1).

These parameters are included in the exposure estimate equations to determine the EDI of each metal through the consumption of representative country foods. EDIs are based on either measured concentrations in country foods or modeled concentration estimates based on measured metal concentrations in the environmental media.

7.2 TERRESTRIAL WILDLIFE TISSUE CONCENTRATIONS

Except for small mammals (red-backed voles, Western jumping mice, and a masked shrew), no terrestrial wildlife species from the country foods study area were harvested to obtain tissue samples. Rather, moose, snowshoe hare, and ruffed grouse tissue metal concentrations were estimated using a food chain model described in Golder and Associates (2005) and recommended by Health Canada (2010a). The model used the 95% Upper Confidence Limit of the Mean (UCLM) baseline metal concentrations in soil, water, and vegetation (huckleberries and huckleberry leaves, fireweed, sorbus, willow, and Sitka valerian) in addition to animal-specific ingestion rates and metal-specific biotransfer factors (BTFs; Appendix B, Table B-2). The 95% UCLM concentrations in environmental media provide a more balanced and realistic approach in estimating the metal concentrations in country foods when compared to the maximum concentrations, while providing a more conservative estimate of the metal concentrations when compared to the mean metal concentrations. The 95% UCLM concentrations were used in all cases except for sorbus; since only two sorbus samples were collected, a 95% UCLM could not be calculated and the maximum measured metal concentrations were used instead.

Each terrestrial wildlife species was assumed to take up metals from every environmental medium (soil, water, and vegetation), based on information known about the species life histories. Table 7.2-1 presents the modelled mean moose, snowshoe hare, and ruffed grouse muscle tissue concentrations for each of the COPCs. As seen in Table 7.2-1, the food chain model predicts grouse have a higher tissue concentration of aluminum than the other wildlife species modelled (i.e., moose and hare), which is due to their elevated soil ingestion rate (see Appendix B). Appendix B describes the food chain model used to predict the tissue concentrations.

Table 7.2-1. Measured and Modelled Metal Concentrations in Country Foods

COPC	Moose	Hare	Grouse	95% UCLM Metal Concentration in Fish	95% UCLM Metal Concentration in Berries
Aluminum	1.43	0.153	52.5	0.497	7.28
Arsenic *	0.00180	0.000203	0.0536	0.0946	0.00
Cadmium	0.000655	0.0000195	0.00046	0.0127	0.01
Chromium	0.00667	0.000717	0.0163	0.0106	0.01
Cobalt	0.0116	0.000900	0.100	0.0497	0.00
Copper	0.206	0.0205	0.646	0.427	1.50
Lead	0.000420	0.0000468	0.0793	0.018	0.01
Mercury	0.00185	0.000108	0.00000698	0.0286	0.00
Nickel	0.0262	0.00122	0.0000801	0.0339	0.11
Selenium	0.000153	0.0000114	0.00316	0.499	0.01
Silver	NC	NC	NC	NC	NC
Thallium	0.000225	0.0000188	0.00298	0.00319	0.00
Vanadium	0.00419	0.000460	0.0000349	0.0035	0.00
Zinc	0.0087	0.000279	0.00542	7.94	3.03

Notes:
All values expressed in mg/kg wet weight.
COPC = contaminant of potential concern.
NC = not calculated because that parameter was not measured in environmental media data.
** Inorganic arsenic concentrations in wildlife tissues were estimated based on proportions of inorganic arsenic to total arsenic concentrations in Schoof et al. (1999) and were used in the country foods baseline assessments calculations. See Section 8.2.2 for further explanation.*

Red-backed voles (*Myodes rutilus*; n = 17), Western jumping mice (*Zapus princeps*; n = 3), and a masked shrew (*Sorex cinereus*; n = 1) were also collected from 15 sites in the country foods LSA during baseline sampling and analyzed for tissue metal content (Sharpe 2013). Appendix A, Table A-3 provides a statistical summary of metal concentrations measured in the small mammal samples. The small mammals (voles, mice, and shrews) sampled are not actually country foods and were only included for comparative purposes.

7.3 FISH TISSUE CONCENTRATIONS

Knight Piésold Ltd. collected 20 Bull Trout (*Salvelinus confluentus*) from P and T creeks and 30 Rainbow Trout (*Oncorhynchus mykiss*) from Baker, Lute, and Jones creeks during baseline sampling in 2011 and 2012 (Knight Piésold Ltd. 2013b) from sites within the country foods RSA (Figure 6.2-1). The fish were analyzed for tissue metal residues and Table 7.2-1 presents the 95% UCLM of tissue metal concentrations for the selected COPCs measured in Rainbow Trout and Bull Trout samples combined. Appendix A, Table A-4 provides a summary of the results for all metals analyzed in the Rainbow/Bull

Trout tissue samples. Metal concentrations with values below the detection limit were replaced with half the value of the detection limit for summary calculations. The 95% UCLM COPC concentration of all fish species and samples were used to calculate human exposure ratios.

The BC MOE (Beatty and Russo 2014) recently updated selenium screening values for three levels of fish consumption to protect human health. For a high fish consumption rate of >220 g/day, the recommended selenium concentration in fish tissue is below 1.83 mg/kg wet weight (ww). For a moderate fish consumption rate of 111 g/day, the recommended selenium concentration in fish tissue is below 3.63 mg/kg ww. For a low fish consumption rate of 21 g/day, the recommended selenium concentration in fish tissue is below 18.74 mg/kg ww. All measured fish tissue selenium concentrations (Appendix A, Table A-4) were lower than the screening value for high fish consumption of 1.83 mg/kg ww.

7.4 Berry Tissue Concentrations

Huckleberries were considered as a possible source of metal intake through direct human consumption. In total, eight huckleberry samples (*V. membranaceum*) were collected from within the country foods LSA (Figure 6.2-2) and analyzed for metal concentrations (Sharpe 2013). Table 7.2-1 provides a summary of the 95% UCLM COPC concentrations in berries used for the assessment. Appendix A, Table A-3 summarizes the results for all metals analyzed in berry tissue.

7.5 Estimated Daily Intake

An EDI of each COPC for toddlers and adults was based on the predicted (moose, snowshoe hare, and ruffed grouse) and measured (huckleberries and Rainbow/Bull Trout) tissue concentrations and the human receptor characteristics.

The following equation was used to estimate the EDI of COPCs from the consumption of country foods:

$$EDI_{food} = \frac{IR \times C_{food} \times F_s}{BW}$$

where:

EDI_{food} = estimated daily intake of COPCs from country food (mg COPC/kg BW/day)

IR = ingestion rate (kg/day)

C_{food} = mean concentration of COPCs in food (mg/kg)

F_s = fraction of year consuming country food (unitless; assumed to be 1)

BW = body weight (kg BW)

The EDI of each COPC for toddler and adult receptors is presented in Table 7.5-1. For this baseline assessment, it was assumed that 100% of the country foods consumed were harvested from the country foods RSA and that 100% of the COPCs present in the foods were bioavailable; these assumptions are not entirely possible and therefore provide a highly conservative estimate of the potential for risk to human health.

Table 7.5-1. Estimated Daily Intake of Contaminants of Potential Concern by Human Receptors

COPC	Estimated Daily Intake of COPC (mg/kg BW/day) by Adult Receptor				
	Moose	Hare	Grouse	Berries	Rainbow/Bull Trout
Aluminum	2.12×10^{-03}	6.36×10^{-06}	1.22×10^{-03}	5.99×10^{-04}	8.01×10^{-05}
Arsenic *	2.09×10^{-08}	6.56×10^{-11}	1.29×10^{-08}	7.89×10^{-08}	1.53×10^{-06}
Cadmium	9.72×10^{-07}	8.08×10^{-10}	1.08×10^{-08}	6.49×10^{-07}	2.05×10^{-06}
Chromium	9.91×10^{-06}	2.97×10^{-08}	3.77×10^{-07}	6.19×10^{-07}	1.71×10^{-06}
Cobalt	1.73×10^{-05}	3.73×10^{-08}	2.32×10^{-06}	1.64×10^{-07}	8.01×10^{-06}
Copper	3.06×10^{-04}	8.52×10^{-07}	1.50×10^{-05}	1.23×10^{-04}	6.89×10^{-05}
Lead	6.24×10^{-07}	1.94×10^{-09}	1.84×10^{-06}	4.23×10^{-07}	2.90×10^{-06}
Mercury	2.75×10^{-06}	4.49×10^{-09}	1.62×10^{-10}	4.11×10^{-08}	4.61×10^{-06}
Nickel	3.89×10^{-05}	5.08×10^{-08}	1.86×10^{-09}	9.43×10^{-06}	5.47×10^{-06}
Selenium	2.28×10^{-07}	4.72×10^{-10}	7.34×10^{-08}	8.22×10^{-07}	8.05×10^{-05}
Silver	NC	NC	NC	NC	NC
Thallium	3.34×10^{-07}	7.77×10^{-10}	6.90×10^{-08}	1.64×10^{-08}	5.64×10^{-07}
Vanadium	6.22×10^{-06}	1.90×10^{-08}	8.09×10^{-10}	1.64×10^{-07}	5.64×10^{-07}
Zinc	1.30×10^{-05}	1.16×10^{-08}	1.26×10^{-07}	2.49×10^{-04}	1.28×10^{-03}
COPC	Estimated Daily Intake of COPC (mg/kg BW/day) by Toddler Receptor				
	Moose	Hare	Grouse	Berries	Rainbow/Bull Trout
Aluminum	3.90×10^{-03}	1.17×10^{-05}	2.24×10^{-03}	1.10×10^{-03}	1.48×10^{-04}
Arsenic *	3.84×10^{-08}	1.21×10^{-10}	2.38×10^{-08}	1.45×10^{-07}	2.81×10^{-06}
Cadmium	1.79×10^{-06}	1.49×10^{-09}	1.98×10^{-08}	1.20×10^{-06}	3.77×10^{-06}
Chromium	1.83×10^{-05}	5.47×10^{-08}	6.95×10^{-07}	1.14×10^{-06}	3.15×10^{-06}
Cobalt	3.19×10^{-05}	6.87×10^{-08}	4.27×10^{-06}	3.03×10^{-07}	1.48×10^{-05}
Copper	5.63×10^{-04}	1.57×10^{-06}	2.76×10^{-05}	2.27×10^{-04}	1.27×10^{-04}
Lead	1.15×10^{-06}	3.57×10^{-09}	3.39×10^{-06}	7.80×10^{-07}	5.35×10^{-06}
Mercury	5.07×10^{-06}	8.27×10^{-09}	2.98×10^{-10}	7.57×10^{-08}	8.50×10^{-06}
Nickel	7.16×10^{-05}	9.35×10^{-08}	3.43×10^{-09}	1.74×10^{-05}	1.01×10^{-05}
Selenium	4.20×10^{-07}	8.70×10^{-10}	1.35×10^{-07}	1.51×10^{-06}	1.48×10^{-04}
Silver	NC	NC	NC	NC	NC
Thallium	6.15×10^{-07}	1.43×10^{-09}	1.27×10^{-07}	3.03×10^{-08}	1.04×10^{-06}
Vanadium	1.15×10^{-05}	3.51×10^{-08}	1.49×10^{-09}	3.03×10^{-07}	1.04×10^{-06}
Zinc	2.39×10^{-05}	2.13×10^{-08}	2.32×10^{-07}	4.59×10^{-04}	2.36×10^{-03}

Notes:
NC = not calculated because that parameter was not measured in environmental media data.
COPC = contaminant of potential concern.
Highlighted numbers denote country food with highest estimated daily intake for a toddler or adult of a particular COPC.
** Arsenic EDIs are based on inorganic arsenic concentrations. See Section 8.2.2 for further explanation.*

Appendix C presents a sample calculation of the EDI of aluminum for toddlers consuming moose tissue. An assessment of the EDIs in country foods shows that toddlers and adults had the highest EDI for aluminum, chromium, cobalt, copper, nickel, and vanadium from consuming moose, and the highest EDI for arsenic, cadmium, lead, mercury, selenium, thallium, and zinc from consuming Rainbow/Bull Trout (Table 7.5-1). The lowest EDIs of COPCs were associated with the consumption of snowshoe hare, ruffed grouse, and huckleberries. It is important to note that the EDIs are based on the 95% UCLMs of metal concentrations measured in the environmental media and in the country foods. Therefore, these values are conservative in nature and may overestimate the true EDIs.

8. TOXICITY REFERENCE VALUE ASSESSMENT

8.1 INTRODUCTION

The TRV assessment involves determining the amount of a COPC that can be taken into the human body without experiencing adverse health effects. Toxicity information is typically derived from laboratory studies, where dose-response information is extrapolated from animal test subjects to humans by applying uncertainty or safety factors. In most cases, uncertainty factors of 100 to 1,000 are applied to the laboratory-derived no observed adverse effect levels (NOAELs). NOAELs are the highest concentration used in a toxicity test that results in no observed or measured chronic health effects. These uncertainty factors account for interspecies extrapolation and the protection of the most susceptible portion of the population (i.e., children and the elderly). Therefore, TRVs based on animal studies generally have large margins of safety to ensure that the toxicity or risk of a substance to people is not underestimated. Lowest observed adverse effect levels (LOAEL) from human studies have smaller uncertainty factors because no extrapolation from animals to humans is required.

The TRVs in this assessment are presented as TDIs or Provisional Tolerable Daily Intakes (PTDIs). The TDI is defined as the amount of metal per unit body weight that can be taken into the body each day (e.g., mg/kg BW/day) with no risk of adverse health effects. The term tolerable is used because it signifies permissibility rather than acceptability for the intake of contaminants unavoidably associated with the consumption of otherwise wholesome and nutritious (country) foods (Herrman and Younes 1999). Use of the term "provisional" expresses the tentative nature of the evaluation, in view of the paucity of reliable data on the consequences of human exposure at levels approaching those indicated.

Health Canada guidelines were used preferentially (i.e., Health Canada's Bureau of Chemical Safety, Chemical Health Hazard Division [CHHAD]) unless they were not available for certain COPCs, in which case alternative sources of guidelines were used. Other sources of guidelines included:

- United States Environmental Protection Agency's (US EPA) Integrated Risk Information System (IRIS) guidelines;
- Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO) Joint Expert Committee on Food Additives and Contaminants (JECFA) guidelines;
- Health Effects Assessment Summary Table (US EPA 1997a); and
- toxicological profiles for metals from the Agency for Toxic Substances and Disease Registry (ASTDR).

The TRVs used in this baseline assessment are presented in Table 8.1-1. It is noted that the US EPA uses the term reference dose (RfD) rather than TDI, but for consistency within the report, RfDs will be reported as TDIs. Toxicity studies on which the TDIs were based and the rationale for their selection are briefly summarized in Section 8.2.

Table 8.1-1. Toxicity Reference Values for Contaminants of Potential Concern

COPC	TRV (mg/kg BW/day)		Reference
	Adult	Toddler	
Aluminum	1.0	1.0	ATSDR (2008)
Arsenic	0.0003	0.0003	US EPA (2014)
Cadmium	0.0010	0.0010	Health Canada (2010c)
Chromium	0.001	0.001	Health Canada (2010c)
Cobalt	0.01	0.01	ATSDR (2004)
Copper	0.141	0.091	Health Canada (2010c)
Lead	0.00357	0.00357	Health Canada (2011)
Mercury [a]	0.0003	0.0003	Health Canada (2010c)
Methylmercury [b]	0.00047	0.00023	Health Canada (2011)
Nickel	0.025	0.025	Health Canada (2011)
Selenium	0.00570	0.00620	Health Canada (2010c)
Silver	0.0050	0.0050	US EPA (2014)
Thallium	0.00007	0.00007	Health Canada (2011)
Vanadium	0.0090	0.0090	US EPA (2014)
Zinc	0.57	0.48	Health Canada (2010c)

Notes:
COPC = contaminant of potential concern.
TRV = toxicity reference value.
BW = body weight.
[a] *Total mercury TRV for adults and toddlers eating biota other than fish.*
[b] *Methylmercury TRV for general public eating fish is 0.00047 mg/kg BW/day, while that for children, women of child-bearing age, and pregnant women eating fish is 0.00023 mg/kg BW/day.*

8.2 TOXICITY REFERENCE VALUES

8.2.1 Aluminum

Health Canada (2011) provides a PTDI of 0.3 mg/kg BW/day for aluminum. No rationale is provided for the derivation of this PTDI. JECFA provides an estimate for a provisional tolerable weekly intake (PTWI) of 1 mg/kg BW/week which is equivalent to a PTDI of 0.14 mg/kg BW/day (JECFA 2007a). The Agency for Toxic Substances and Disease Registry (ATSDR 2008) has derived an intermediate-duration and a chronic-duration oral minimal risk level (MRL) of 1 mg aluminum/kg BW/day. The chronic-duration MRL is based on a LOAEL of 100 mg aluminum/kg BW/day for neurological effects in mice exposed to aluminum lactate in the diet during gestation, lactation, and post-natally until two years of age (Golub et al. 2000). The MRL was derived by dividing the LOAEL by an uncertainty factor of 300 (3 for the use of a minimal LOAEL, 10 for animal to human extrapolation, and 10 for intra-human variability) and a modifying factor of 0.3 to account for the higher bioavailability of the aluminum lactate used in the principal study compared to the bioavailability of aluminum in the human diet and drinking water. Since Health Canada does not provide any rationale for the PTDI they recommend, the TDI of 1 mg/kg BW/day provided by JECFA was used in this assessment as it has scientific research to support it.

8.2.2 Arsenic

Health Canada does not provide a TRV for non-carcinogenic risks for arsenic. For assessment of non-cancer risks from arsenic, IRIS (US EPA 2014) provides 0.0003 mg/kg BW/day for a chronic oral TDI, while JECFA recommends a TDI of 0.001 mg/kg BW/week for oral exposures (JECFA 2010). The more conservative US EPA value of 0.0003 mg/kg BW/day was used in the assessment.

Arsenic is the only metal in this report that is considered carcinogenic via the ingestion pathway. For carcinogens, slope factors are used as the TRVs (Health Canada 2010c). A slope factor is the upper bound estimate of the probability of a response-per-unit intake of a material of concern over an average human lifetime. It is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of arsenic. Upper-bound estimates conservatively exaggerate the risk to ensure that the risk is not underestimated if the underlying model is incorrect. The oral slope factor for arsenic cancer risk is 1.8 per $(mg/kg\ BW/day)^{-1}$ (Health Canada 2010c), based on a tumourigenic dose (TD_{05}). Of the various species of arsenic that exist, inorganic arsenic has been identified as the primary carcinogenic form, while organic arsenic compounds have relatively low carcinogenic activity but a higher bioaccumulation potential (Roy and Saha 2002).

To account for the low proportion of inorganic arsenic in food, it was assumed that 10% of the total detected arsenic in the fish is inorganic based on a study done by Slejkovec, Bajc, and Doganoc (2004). Based on a market basket survey with chicken breasts (with ribs baked with skin until done at 350° F), the proportion of inorganic to total arsenic in chicken was 0.0104, or 1.04% (Schoof et al. 1999), which was used to estimate the concentration of inorganic arsenic in grouse. Similarly, the proportion of inorganic to total organic arsenic in beef (used as a surrogate for moose and snowshoe hare) baked 30 minutes at 350° F was 0.0078, or less than 0.78% (Schoof et al. 1999).

Berries were not analyzed in the food market study (Schoof et al. 1999); however, a variety of fruits including apples, bananas, grapes, oranges, peaches, and watermelons were included in the study. The average inorganic to total arsenic proportion in fruits analyzed by Schoof et al. (1999) was calculated to be 0.48. Therefore, for this assessment, it was assumed that 48% of the total arsenic concentration in berries was in the inorganic form.

8.2.3 Cadmium

Health Canada (2010c) provides a PTDI of 0.001 mg/kg BW/day, which was used in this assessment. Health Canada's PTDI is similar to JECFA's provisional tolerable monthly intake of 0.025 mg/kg BW/month (equivalent to 0.00083 mg/kg BW/day; JECFA 2011), which accounts for the long half-life of cadmium in the body. The JECFA TDI of 0.0008 mg/kg BW/day will ensure cadmium concentrations in the renal cortex do not exceed 50 mg/kg; this level is thought to protect normal kidney function. IRIS (US EPA 2014) provides a TDI of 0.001 mg/kg BW/day for oral exposures to cadmium based on recommendations by JECFA (1972, 2005).

8.2.4 Chromium

Health Canada (2010c) provides a TDI of 0.001 mg/kg BW/day for total chromium. This value was based on water intake and was derived from multiplication of the maximum acceptable concentration (MAC) for total chromium of 0.05 mg/L by a water consumption rate of 1.5 L/day, and divided by the body weight of 70 kg. IRIS provides an TDI of 0.003 mg/kg BW/day (US EPA 2014), which was derived from a NOAEL of 2.5 mg/kg BW/day based on a one year chronic toxicity study with rats (MacKenzie et al. 1958). An uncertainty factor of 900 was applied to the NOAEL: 10 for interspecies extrapolation, 10 for inter-human variability, 3 as modifying factor, and 3 to address concerns from other studies (Zhang and Li 1987). The more conservative Health Canada TDI of 0.001 mg/kg BW/day was used in this assessment.

8.2.5 Cobalt

Oral exposure to elevated levels of cobalt results in a range of immunological, neurological, cardiac, and respiratory effects. Neither Health Canada nor the US EPA has derived a TDI for cobalt. Similarly, no cancer classification has been performed by Health Canada or the US EPA. ATSDR (2004) derived an MRL of 0.01 mg/kg BW/day for intermediate-duration oral exposure, based on a LOAEL of 1 mg/kg BW/day for polycythemia (increased blood volume proportion occupied by red blood cells) in human volunteers (Davis and Fields 1958). No other inhalation or oral MRLs were derived.

8.2.6 Copper

Health Canada (2010c) reports a TDI of 0.091 to 0.141 mg/kg BW/day for copper based on specific age groups. Copper is an essential nutrient. JECFA recommends a PTDI of 0.5 mg/kg BW/day (WHO 1982). However, recommendations by JECFA were made for further collection of information on copper with emphasis on epidemiological surveys to study the evidence of copper-induced ill-health. TDIs of 0.091 mg/kg BW/day and 0.141 mg/kg BW/day were used for toddlers and adults, respectively, in this report.

8.2.7 Lead

Health Canada (2010c) is currently reviewing the TDI for lead. However, an unpublished PTDI provided by Health Canada (2011) of 0.00357 mg/kg BW/day for lead was established, which is equivalent to the PTWI of 0.025 mg/kg BW/week recommended by the JECFA (2000). However, JECFA withdrew this PTWI in 2011 (JECFA 2011) because the intake value was associated with a decrease of at least three Intelligence Quotient (IQ) points in children and an increase in systolic blood pressure of approximately 3 mmHg (0.4 kPa) in adults. Because the dose–response analysis done by JECFA does not provide any indication of a threshold for the key effects of lead, the Committee concluded that it was not possible to establish a new PTWI that would be protective of health. Until re-evaluation by Health Canada, the previously established PTDI of 0.00357 mg/kg BW/day was used for this assessment.

8.2.8 Mercury

Health Canada (2010c) provides a TDI of 0.0003 mg/kg BW/day for inorganic mercury exposure for the general public, based on CCME soil quality guidelines and supporting documentation on health-based guidelines prepared by Health Canada. As data are not readily available on the mercury species present in the local vegetation and terrestrial animals, for moose, grouse, hare, and plant tissues, total mercury was compared to the Health Canada (2010c) inorganic mercury PTDI as a TRV.

For fish, mercury was assumed to be present 100% as methylmercury (Health Canada 2007). For methylmercury, JECFA (2007b) recommends a PTDI of 0.00047 mg/kg BW/day for the general public, and 0.00023 mg/kg BW/day for sensitive groups (i.e., children and women who are pregnant or who are of child-bearing age). This was also adopted by Health Canada (2010c).

8.2.9 Nickel

Health Canada (2010c) provides a TDI of 0.011 mg/kg BW/day. The TDI for total nickel (as soluble salts) was based on a dietary study in rats that found a NOAEL of 5 mg/kg BW/day for altered organ to body weight ratios (Springborn Laboratories Inc. 2000). An uncertainty factor of 200 was applied to the NOAEL: 10 for interspecies variation, and 10 to protect sensitive populations. A modifying factor of 2 was also applied to account for the inadequacies of the reproductive studies. Health Canada (2011) updated the soluble nickel TDI to 0.025 mg/kg BW/day, and this more conservative value was used in this assessment.

8.2.10 Selenium

Selenium is an essential element and is required for human nutrition. Health Canada (2010c) provides an age- and body weight-adjusted tolerable upper limit for selenium of 0.0062 to 0.0057 mg/kg BW/day (toddlers and adults, respectively). This was based on a NOAEL in adults of 0.8 mg/kg/day in a cohort study by Yang and Zhou (1994) and a NOAEL in children of 0.007 mg/kg/day (Shearer and Hadjimarkos 1975). Health effects due to an exposure to elevated levels of selenium are described as selenosis (gastrointestinal disorders, hair loss, sloughing of nails, fatigue, irritability, and neurological damage).

8.2.11 Silver

Health Canada does not provide a TRV for silver. However, US EPA's IRIS provides an oral TDI of 0.005 mg/kg/day based on a LOAEL of 0.014 mg/kg BW/day from a study in humans (Gaul and Staud 1935). An uncertainty factor of 3 was applied to account for minimal effects in a subpopulation that has exhibited an increased propensity for the development of argyria. Argyria is the critical effect that can occur in humans ingesting silver, and is a medically benign (but permanent), photo-sensitive bluish-gray discoloration of the skin. Silver compounds have been employed for medical uses for centuries.

8.2.12 Thallium

Thallium is a wide-spread heavy metal, often naturally co-occurring with sulphide materials processed for recovery of gold and copper, with high toxicity similar to effects caused by cadmium, lead, and mercury exposure. Thallium is readily assimilated by plants from soils, which can cause concern for human health. Thallium salts are easily absorbed by the skin, the intestinal tract, and through inhalation of dust (Peter and Viraraghavan 2005). Polyneuritic symptoms, sleep disorders, headache, fatigue, and psychological disorders were found to be the major health effects associated with increased thallium levels in urine and hair. Thallium accumulates in bones, the renal medulla, and the central nervous system (Peter and Viraraghavan 2005). It is not known what the effects are from ingesting low levels of thallium over a long time.

Health Canada (Health Canada 2011) provides a PTDI of 0.00007 mg/kg BW/day for thallium. Health Canada does not provide a rationale for the derivation of this PTDI, but states that the PTDI is considered temporary as it was derived from an incomplete data set. The PTDI of 0.00007 mg/kg BW/day for thallium was used for this assessment.

8.2.13 Vanadium

Health Canada does not provide a TRV for vanadium. US EPA's IRIS provides an oral TDI of 0.009 mg/kg BW/day, which was used in this assessment, based on a lower dose level from available sub-chronic and chronic studies (17.9 mg/kg vanadium pentoxide; Stokinger et al. 1953). In this chronic study, an unspecified number of rats were exposed to dietary levels of 10 or 100 mg/kg vanadium (about 17.9 or 179 mg/kg vanadium pentoxide) for 2.5 years. The criteria used to evaluate vanadium toxicity were growth rate, survival, and hair cystine content. The only significant change reported was a decrease in the amount of cystine in the hair of animals ingesting vanadium.

8.2.14 Zinc

Health Canada (2011) provides a TDI of 0.7 mg/kg BW/day. This value was based on the upper safe level (USL) established by the Expert Group on Vitamins and Minerals (EGVM 2003). A LOAEL of 50 mg/day was found for both men and women exposed to zinc supplements (i.e., additional zinc exposure besides that incurred through normal food and water intake). The LOAEL was converted to a NOAEL by dividing it by an uncertainty factor of 2 to give a NOAEL of 25 mg/day, which is 0.42 mg/kg BW/day in a 60 kg person. Thus, the USL for zinc supplements is 0.42 mg/kg BW/day. If the maximum zinc intake of 17 mg/day (0.28 mg/kg BW/day) from food is added to the USL, the maximum total intake for zinc is equivalent to 0.7 mg/kg BW/day.

However, Health Canada (2010c) provides more conservative TRVs for zinc for adults (using a body weight of 70.7 kg) and toddlers (average of the TRV for toddlers 7 months to 8 years old, using a body weight of 16.5 kg) of 0.57 and 0.48 mg/kg BW/day, respectively. These more conservative TRVs were used in this assessment.

9. RISK CHARACTERIZATION

9.1 INTRODUCTION

In a screening level risk assessment, such as this country foods baseline assessment report, it is common to make a number of very conservative assumptions during the assessment process which will tend to overestimate the actual risk to human health. If no unacceptable risks are identified using this conservative approach, then it is very unlikely that human health will be affected by consumption of country foods at the frequencies and quantities used in the assessment.

Using the results of the exposure assessment and TRV assessment, human health risks from the consumption of country foods were quantified using exposure ratios (ERs). The ER is the ratio between the EDI and the TDI and provides a measure of exposure to a COPC through the consumption of country foods. The RMWI rates were then calculated for each country food evaluated. The RMWIs were compared to current weekly consumption rates of the country foods. In addition, the ILCR was determined for metals (i.e., arsenic) that may be associated with carcinogenic potential.

9.2 ESTIMATION OF NON-CARCINOGENIC RISKS

Human health risk estimates were quantified using ERs, and were calculated as:

$$\textit{Exposure Ratio (ER)} = \frac{\textit{Estimated Daily Intake (EDI)}}{\textit{Tolerable Daily Intake (TDI)}}$$

For non-carcinogenic COPCs in country foods, Health Canada (2004b) suggests that an ER of less than 0.2 indicates that the exposure does not pose a significant health risk to human receptors. An ER of 0.2 is used (instead of 1.0) because the assessment does not consider intake of contaminants from all potential exposure routes.

An ER value greater than 0.2 does not necessarily indicate that adverse health effects will occur since the TRVs are conservative (i.e., protect human health by including additional uncertainty factors) and many of the assumptions made in the assessment are very conservative. However, an ER of greater than 0.2 does suggest that the potential risk to human health may require a more detailed evaluation.

Table 9.2-1 presents the ERs based on the modelled metal concentrations in wildlife and measured fish and huckleberry metal concentrations. Calculated ERs for moose, snowshoe hare, ruffed grouse, huckleberries, and Rainbow/Bull Trout were all below 0.2. Thus, it is expected that consumption of these country foods at the rates used in the calculations do not pose a risk to human health for any human life stages for any of the metals evaluated.

Table 9.2-1. Human Exposure Ratios Based on Predicted and Measured Tissue Concentrations in Country Foods

COPC	Exposure Ratio for Adult Receptor				
	Moose	Snowshoe Hare	Grouse	Huckleberries	Rainbow/Bull Trout
Aluminum	2.12×10^{-03}	6.36×10^{-06}	1.22×10^{-03}	5.99×10^{-04}	8.01×10^{-05}
Arsenic [a]	6.95×10^{-05}	2.19×10^{-07}	4.31×10^{-05}	2.63×10^{-04}	5.08×10^{-03}
Cadmium	9.72×10^{-04}	8.08×10^{-07}	1.08×10^{-05}	6.49×10^{-04}	2.05×10^{-03}
Chromium	9.91×10^{-03}	2.97×10^{-05}	3.77×10^{-04}	6.19×10^{-04}	1.71×10^{-03}
Cobalt	1.73×10^{-03}	3.73×10^{-06}	2.32×10^{-04}	1.64×10^{-05}	8.01×10^{-04}
Copper	2.17×10^{-03}	6.04×10^{-06}	1.06×10^{-04}	8.75×10^{-04}	4.88×10^{-04}
Lead	1.75×10^{-04}	5.43×10^{-07}	5.15×10^{-04}	1.19×10^{-04}	8.13×10^{-04}
Mercury [b]	9.18×10^{-03}	1.50×10^{-05}	5.39×10^{-07}	1.37×10^{-04}	NA
Methylmercury [c]	NA	NA	NA	NA	9.81×10^{-03}
Nickel	1.55×10^{-03}	2.03×10^{-06}	7.44×10^{-08}	3.77×10^{-04}	2.19×10^{-04}
Selenium	4.00×10^{-05}	8.29×10^{-08}	1.29×10^{-05}	1.44×10^{-04}	1.41×10^{-02}
Silver	NC	NC	NC	NC	NC
Thallium	4.77×10^{-03}	1.11×10^{-05}	9.86×10^{-04}	2.35×10^{-04}	8.06×10^{-03}
Vanadium	6.91×10^{-04}	2.12×10^{-06}	8.99×10^{-08}	1.83×10^{-05}	6.27×10^{-05}
Zinc	2.28×10^{-05}	2.03×10^{-08}	2.21×10^{-07}	4.37×10^{-04}	2.25×10^{-03}
COPC	Exposure Ratio for Women of Child-Bearing Age Receptor				
	Moose	Snowshoe Hare	Grouse	Huckleberries	Rainbow/Bull Trout
Methylmercury	NA	NA	NA	NA	2.01×10^{-2}
COPC	Exposure Ratio for Toddler Receptor				
	Moose	Snowshoe Hare	Grouse	Huckleberries	Rainbow/Bull Trout
Aluminum	3.90×10^{-03}	1.17×10^{-05}	2.24×10^{-03}	1.10×10^{-03}	1.48×10^{-04}
Arsenic [a]	1.28×10^{-04}	4.03×10^{-07}	7.95×10^{-05}	4.85×10^{-04}	9.37×10^{-03}
Cadmium	1.79×10^{-03}	1.49×10^{-06}	1.98×10^{-05}	1.20×10^{-03}	3.77×10^{-03}
Chromium	1.83×10^{-02}	5.47×10^{-05}	6.95×10^{-04}	1.14×10^{-03}	3.15×10^{-03}
Cobalt	3.19×10^{-03}	6.87×10^{-06}	4.27×10^{-04}	3.03×10^{-05}	1.48×10^{-03}
Copper	6.19×10^{-03}	1.72×10^{-05}	3.04×10^{-04}	2.50×10^{-03}	1.39×10^{-03}
Lead	3.22×10^{-04}	1.00×10^{-06}	9.49×10^{-04}	2.18×10^{-04}	1.50×10^{-03}
Mercury [b]	1.69×10^{-02}	2.76×10^{-05}	9.94×10^{-07}	2.52×10^{-04}	NA
Methylmercury [c]	NA	NA	NA	Na	3.69×10^{-02}
Nickel	2.86×10^{-03}	3.74×10^{-06}	1.37×10^{-07}	6.95×10^{-04}	4.03×10^{-04}
Selenium	6.77×10^{-05}	1.40×10^{-07}	2.18×10^{-05}	2.44×10^{-04}	2.39×10^{-02}
Silver	NC	NC	NC	NC	NC
Thallium	8.78×10^{-03}	2.05×10^{-05}	1.82×10^{-03}	4.33×10^{-04}	1.49×10^{-02}
Vanadium	1.27×10^{-03}	3.90×10^{-06}	1.66×10^{-07}	3.36×10^{-05}	1.16×10^{-04}
Zinc	4.99×10^{-05}	4.44×10^{-08}	4.83×10^{-07}	9.56×10^{-04}	4.91×10^{-03}

Notes:

COPC = contaminant of potential concern.

NC = not calculated because that parameter was not measured in environmental media data.

NA = not applicable.

[a] *Arsenic exposure ratios are based on inorganic arsenic concentrations.*

[b] *Exposure ratio of mercury for toddlers and adults was only calculated for terrestrial organism since in fish 100% of mercury is assumed to be in its methylated form (methylmercury).*

[c] *Methylmercury concentrations were not measured; however, mercury in fish is assumed to be present 100% as methylmercury (Health Canada 2007). Therefore, for fish, ERs were calculated for toddlers, adults, and women of child-bearing age.*

9.2.1 Estimation of Non-carcinogenic Risks for Voles, Mice, and Shrews

Red-backed voles (*M. rutilus*; n = 17), Western jumping mice (*Z. princeps*; n = 3), and masked shrews (*S. cinereus*; n = 1) were also collected and analyzed for whole-body tissue metal concentrations. Thus EDIs, ERs, ELDEs, ILCRs, and RMWIs for these small mammals were calculated for comparison (see Appendix F) using the 95% UCLM of the pooled tissue concentrations (Appendix A). The IR and exposure time used in the calculations were assumed to be the same as those for snowshoe hare.

Calculated ERs for small mammals were all below 0.2 for non-carinogenic effects (Table F-2). Thus, it is expected that consumption at the rates used in the calculations do not pose a risk to human health for any human life stages for any of the metals evaluated.

9.3 ESTIMATION OF CANCER RISKS

Of the metals evaluated, only arsenic is considered carcinogenic through ingestion. Carcinogenic risks were calculated as ILCR estimates according to the following formula (Health Canada 2010b):

$$ILCR = \text{Estimated lifetime daily exposure (ELDE; mg/kg BW/day)} \times \text{Oral cancer slope factor (mg/kg BW/day)}^{-1}$$

The following equation was used to calculate the estimated lifetime daily exposure (ELDE) (Health Canada 2010b):

$$ELDE_{country\ food} = \frac{IR \times F_s \times C_{food} \times P_{as} \times YE}{BW \times LE}$$

where:

$ELDE_{country\ food}$	= estimated lifetime intake of country food (mg COPC/kg BW/day)
IR	= ingestion rate (kg/day)
F_s	= fraction of year consuming country food (unitless; assumed to be 1)
C_{food}	= concentration of COPC in food (mg/kg)
P_{as}	= proportion of inorganic arsenic relative to total arsenic concentration
YE	= years exposed (yr; assumed to be 80 years)
BW	= body weight (kg BW)
LE	= life expectancy (yr; assumed to be 80 years)

For the ELDE, measured or modelled arsenic concentrations in tissue were used in the exposure calculations and the results are presented in Table 9.3-1. The oral slope factor for arsenic cancer risk is 1.8 per (mg/kg BW/day)$^{-1}$ (Health Canada 2010c). Appendix D provides a sample calculation for the estimated lifetime daily exposure of arsenic for an adult consuming snowshoe hare. An ILCR estimate that is less than 1×10^{-05} is normally considered acceptable (Health Canada 2010b).

Table 9.3-1. Estimated Daily Lifetime Exposure and Incremental Lifetime Cancer Risk for Adult Human Receptors Exposed to Arsenic in Country Foods

Country Food	ELDE mg/kg/day	ILCR unitless
Moose	2.09×10^{-08}	3.76×10^{-08}
Snowshoe hare	6.56×10^{-11}	1.18×10^{-10}
Grouse	1.29×10^{-08}	2.33×10^{-08}
Berries	7.89×10^{-08}	1.42×10^{-07}
Rainbow/Bull Trout	1.53×10^{-06}	2.75×10^{-06}

Notes:
ELDE = estimated lifetime daily exposure.
ILCR = incremental lifetime cancer risk.
An ILCR estimate less than 1×10^{-05} is normally considered acceptable (Health Canada 2010b).
Arsenic ELDEs and ILCRs are based on inorganic arsenic concentrations.

The results of the ILCR calculations from exposure to arsenic in country foods are presented in Table 9.3-1. The ILCR for arsenic from moose, snowshoe hare, ruffed grouse, huckleberries, and Rainbow/Bull Trout were less than 1×10^{-05} and can be considered safe for consumption at the consumption rates used in this assessment.

9.3.1 Estimation of Cancer Risks for Voles, Mice, and Shrews

The ILCR for arsenic from small mammals (red-backed voles, Western jumping mice, and masked shrews) was 1.93×10^{-05} (Table F-3) when calculated using the 95% UCLM tissue metal concentration, which is greater than what is considered safe for consumption (1×10^{-05}) at the assumed consumption rates. However, when the mean arsenic tissue concentration is used in the ILCR calculation, the value is less (7.29×10^{-8}) than what is considered safe for consumption (Table F-3).

The elevated ILCR when calculated with the 95% UCLM is likely not an issue for country food harvesters, especially given that the ILCR is acceptable when mean metal concentrations are used instead of the 95% UCLM concentrations. The small mammals included (red-backed voles, jumping mice, and masked shrews) have different life histories than snowshoe hare, which was the small mammal considered a country food item. Voles are mainly herbivorous and mostly consume green succulent vegetation as well as roots, bark, seeds, fungi, arthropods, and animal matter (Johnson and Johnson 1982; Lomolino 1984; Stalling 1990). Shrews are primarily vermivorous (feed on worms, grubs, or insect vermin) and insectivorous, but may also consume small birds and mammals (US EPA 1993). Mice primarily consume seeds but some also consume small invertebrates regularly (US EPA 1993). The diets of these rodents contrast with those of rabbits and hares which are strictly herbivorous (US EPA 1993), which may help explain the difference in metal concentrations since carnivorous and insectivorous small mammals tend to have higher tissue metal concentrations than herbivores (Wijnhoven et al. 2007). Furthermore, the food chain model predicts muscle tissue metal concentrations (Golder Associates Ltd. 2005), whereas the small mammals were analyzed as the entire animal including bones, hair, and organs which tend to sequester metals to a greater extent than muscle tissue (Vijver et al. 2004). Thus it would be expected that whole-body tissue metal concentrations would be higher than muscle tissue metal concentrations.

9.4 RECOMMENDED MAXIMUM WEEKLY INTAKE

RMWIs were calculated as described by (Health Canada 2010b), using the following equation:

$$RMWI = \frac{TRV \times BW \times 7}{C_{food}}$$

where:

RMWI = recommended maximum weekly intake of food (kg/week)
TRV = toxicological reference value (mg/kg BW/day)
BW = receptor body weight (kg BW)
7 = days/week
C_{food} = mean metal concentration in food (mg/kg)

This equation was applied to each metal and receptor scenario. For these calculations, the yearly averaged serving size from Chan et al. (2011) was not used as averaged yearly serving sizes are very small resulting in an overestimation of the actual RMWI. Thus, more realistic serving sizes provided by Richardson (1997) were used in the calculation instead (Table 9.4-1). The Rainbow/Bull Trout serving sizes used were the arithmetic mean of "fish" for Canadian First Nations "eaters only", both sexes combined for adults (20 to 59 years), and toddlers (seven months to four years). Moose, hare, and grouse serving sizes used were the arithmetic mean of "wild game" for Canadian First Nations "eaters only", both sexes combined for adults (20 to 59 years) and toddlers (seven months to four years). Huckleberry serving sizes used were the arithmetic mean of "fruits and juices" for the Canadian population, both sexes combined for adults (20 to 59 years) and toddlers (seven months to four years).

Table 9.4-1. Recommended Maximum Weekly Intake and Number of Servings of Country Food

		Lowest Metal RMWI	Serving Size	Recommended Maximum Number of Servings
Human Receptor	Country Food	kg/week	kg/day [a]	# servings/week
Adult (general public)	Moose	74.2	0.280	265
	Snowshoe Hare	690	0.280	2465
	Ruffed Grouse	9.44	0.280	34
	Huckleberries	46.5	0.247	188
	Rainbow/Bull Trout	3.98	0.220	18
Adult (sensitive group)	Rainbow/Bull Trout	8.13	0.220	37
Toddler	Moose	17.3	0.0850	204
	Snowshoe Hare	161	0.0850	1895
	Ruffed Grouse	2.20	0.0850	26
	Huckleberries	7.00	0.234	30
	Rainbow/Bull Trout	0.929	0.0950	10

Notes:
RMWI = recommended maximum weekly intake.
[a] *based on serving sizes from Richardson (1997).*

The metal that had the lowest RMWI for each receptor was selected as the overall RMWI for each country food (Appendix E). By using the lowest RMWI for each food type, it is protective for all metals in that particular food. Table 9.4-1 presents the RMWIs that would be protective against potential effects to human health due to naturally occurring metals present in the foods. RMWIs have been also converted to the recommended maximum number of servings per week of moose, snowshoe hare, ruffed grouse, huckleberries, and Rainbow/Bull Trout by dividing the RMWI by the serving size (Richardson 1997).

As noted in Section 9.3-1 conservative assumptions in the assessment results in an overestimation of the true risk. Based on the amount of COPCs present in the country foods, the recommended maximum number of servings per week for adults, toddlers, and sensitive adults (women of child-bearing age) indicated in Table 9.4-1 would not be expected to cause human health effects. For example, it is recommended that toddlers eat a maximum of 10 servings of Rainbow/Bull Trout per week and a maximum of 204 servings of moose per week. Thus, country foods harvesters are not expected to experience health risks related to country food consumption based on consumption rates and frequencies used in this assessment.

9.4.1 Recommended Maximum Weekly Intake for Voles, Mice, and Shrews

The small mammal (red-backed voles, Western jumping mice, and masked shrews) RMWIs for adults and toddlers are presented in Table F-4. The lowest recommended number of weekly servings for small mammals was used to calculate the recommended number of servings per week (Table F-5). This calculation used the serving size for "wild game" for Canadian First Nations, "eaters only", both sexes combined for adults (20 to 59 years) and toddlers (seven months to four years; Richardson 1997). Based on the amount of COPCs present in the small mammals (voles, mice, and shrews), the recommended number of servings per week for adults and toddlers indicated in Table F-5 would not be expected to cause human health effects. Thus, country food harvesters are not expected to experience health risks related to small mammal consumption based on consumption rates and frequencies used in this assessment.

10. UNCERTAINTY ANALYSIS

10.1 INTRODUCTION

The process of evaluating human health risks from exposure to environmental media involves multiple steps, each containing inherent uncertainties that ultimately affect the final risk estimates. These uncertainties exist in numerous areas, including the collection of samples, laboratory analysis, estimation of potential exposures, and derivation of toxicity reference values, resulting in either an over- or under-estimation of risk. However, for the present study, where uncertainties existed, a conservative approach was taken to overestimate rather than underestimate potential risks.

Some of the uncertainties have been mentioned in the preceding report sections. The following uncertainty analysis is a qualitative discussion of the key sources of uncertainty in this study. There may be sources of uncertainty other than those evaluated here; however, their effect on the calculation of ERs, ILCRs, and RMWIs are considered to be less significant.

10.2 CONTAMINANTS OF POTENTIAL CONCERN

The COPCs selected for this assessment were metals, since the proposed Project involves development of a metal mine. Metals naturally occur in environmental media (i.e., soil, water, and plant and animal tissue) and have been monitored during baseline studies to support Project planning and processes. By screening measured baseline metal concentrations against environmental quality guidelines it is likely that all relevant metal COPCs have been selected for inclusion in the country foods baseline assessment.

However, there exists a possibility that other COPCs (e.g., other metals, organic chemicals, etc.) could be associated with Project activities in the future, but do not occur or were not measured under baseline conditions.

10.3 TISSUE CONCENTRATIONS

10.3.1 Terrestrial Species

Concentrations of metals in the tissue of moose, snowshoe hare, and ruffed grouse were predicted using a food chain model. As with all modelled data, the results are highly dependent on the accuracy of literature-based input parameters and the quality of the model itself. Standard methodologies for application of models have been used and clearly described throughout this report and in Appendix B.

The main uncertainty in the food chain model was in the selection of BTFs. For all animal exposure routes, BTFs from food-to-tissue were used. However, it is unlikely that the BTFs from soil-to-tissue and water-to-tissue are the same as food-to-tissue. In addition, the moose and snowshoe hare BTFs were based on values for beef, as BTFs are not available specifically for moose or snowshoe hare. Similarly, values for the ruffed grouse were based on available avian species information (chickens).

This is the accepted method to model the uptake of COPCs into animals when empirical data are not available or samples sizes are too small to make conclusions about population tissue concentrations.

The moose, snowshoe hare, and ruffed grouse ingestion rates that were used for food, soil, and water were based on guidance for estimating wildlife exposure characteristics provided by the US EPA (1993). Wherever possible, conservative assumptions have been made to ensure that potential risks are not underestimated. For example, most soil ingestion by moose occurs incidentally from grazing on grasses or foraging for vegetation on the ground. Moose and other ungulates occasionally intentionally consume soils directly to obtain minerals and salts to supplement their nutrient-poor vegetative diet, but this amount is small relative to the amount of soils consumed with vegetation. The food chain model assumed that moose would consume soil at the combined intentional and incidental ingestion rate. The same approach was used for ruffed grouse because they may consume small rocky material to aid in physically breaking down food in their gizzards and crops. Overall, it is anticipated that the soil and plant ingestion rates by moose, snowshoe hare, and ruffed grouse have been overestimated, which would result in conservatism in the risk estimates.

The exposure time that moose spend in the country foods RSA was conservatively assumed to be 25% (i.e., three months of the year). Moose may spend most of their time within one watershed and can therefore be representative of potential exposure from COPCs from an area within the RSA. Therefore, the exposure time factor used in the wildlife model is likely realistic for moose. The exposure time that ruffed grouse and snowshoe hare would spend within the country foods RSA was conservatively assumed to be 100%. Snowshoe hare and ruffed grouse have much smaller home ranges and their home range could plausibly be located entirely within the country foods LSA. Therefore, the exposure time was assumed to be 100%. This assumption results in human health risks being overestimated rather than underestimated, particularly if residence times are less than 100%.

Other uncertainties associated with the predicted animal tissue concentrations include the assumption that the diet of moose, snowshoe hare, and ruffed grouse include solely the plants and huckleberries that were collected in the field during baseline studies. Although selected for their prevalence, the plants and huckleberries may not have been representative of the actual foods consumed by the evaluated terrestrial mammals and birds. However, the model is expected to overestimate tissue residues (Golder and Associates 2005), which helps to compensate for any uncertainties.

10.3.2 Aquatic Species

Rainbow Trout and Bull Trout were collected from creeks within the country foods RSA in 2011 and 2012 (Figure 6.2-2) and were analyzed for tissue metal residues. The current EDI is based on 50 tissue samples (Table 7.5-1). Rainbow and Bull Trout, although included in the assessment, may migrate long distances and may therefore consume prey and be exposed to COPC concentrations outside the RSA. Therefore, changes in COPC loads could result from effects or environmental changes unrelated to the Project.

Many tissue concentrations were below the MDL in the food fish and values of half the MDL were used to calculate 95% UCLM metal tissue concentrations. This may over- or under-estimate the actual concentrations of metals in the tissues (depending on what the actual concentration is compared to the MDL) and result in uncertainties in the statistical summaries used as inputs for the modeling of ERs and ILCR. However, arsenic, cadmium, mercury, and selenium concentrations were above MDLs in most samples and methylmercury was the metal responsible for the lowest recommended weekly servings of Rainbow/Bull Trout. None of the edible fish samples exceeded the Health Canada mercury guideline of 0.5 mg/kg (Health Canada 2013).

The cancer slope factor was used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of arsenic. Upper-bound estimates conservatively exaggerate the risk to ensure that the risk is not underestimated if the underlying model is incorrect. The slope factor is based on one affected population in Taiwan concerning non-fatal skin cancer incidence, age, and level of exposure to arsenic via drinking water (not food; US EPA 2000b). The confidence in the oral slope factor is considered to be low overall. Animal studies have not associated arsenic exposure via ingestion with cancer, the mechanism of action in causing human cancers is not known, and studies on arsenic mutagenicity are inconclusive (US EPA 2000b).

10.3.3 Vegetation Species

All the soil and vegetation samples were collected from the Project Site and may not be representative of all soil and vegetation throughout the LSA/RSA. However, these sites were selected since they likely have the highest metal concentrations (given that they are located in the footprint of a proposed mine which would be expected to be mineral-rich) and likely over-estimates the metal concentrations in more distant, less mineralized areas. A total number of 67 plant samples were collected for analysis of tissue metal concentrations in 2011 and 2012. It is likely that the number of species and samples are a good representation of the plant species consumed by wildlife. There is a high degree of variation in metal concentrations between the plant species, likely due to species-specific physiological characteristics. Therefore, it is important to collect different plant species and not rely on surrogates.

Overall, plants are unlikely to be harvested in substantial quantities from within the country foods LSA by people because the LSA is at high elevation and only accessible via Forest Service Roads. The contribution of vegetation, especially berries, on total consumed metals by people is likely to be insignificant compared to animal consumption due to the lower rates of berry consumption.

10.3.4 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) procedures were followed during the sampling of the soil, water, vegetation, and fish for metal analysis. All persons collecting the water, soil, sediment, and tissue samples were trained on appropriate sampling techniques. This minimized the potential for cross contamination and ensured that the sample sizes were adequate for chemical analyses. Additional details on the QA/QC of the environmental media sampling are presented in the respective soil, vegetation, water quality, and fish baseline reports (Keystone Wildlife Research Ltd. 2013; Knight Piésold Ltd. 2013b; Sharpe 2013).

10.4 Locations of Country Foods Harvested

For all of the country foods evaluated it was assumed that 100% of the country foods consumed by people each year came from the country foods study area. This is an overestimate, given the vast area available for harvesting and the general inaccessibility of portions of the country foods RSA under baseline conditions. The overestimation provides conservatism in the risk predictions.

10.5 Country Foods Consumption Quantity and Frequency

The Simpcw First Nation and the Lakes Division Secwepemc asserted traditional territories overlap with the country foods RSA.

Estimated daily intake amounts of major traditional foods used for human characteristics were reported as the 95th percentile of serving sizes obtained from 24-hour recall surveys (Chan et al. 2011). The exposure frequencies for consumption were obtained by calculating the number of meals during the past four seasons divided by the number of days in a year. This methodology integrates COPC intake over longer periods of time and particularly assesses country foods that are seasonally or infrequently consumed, but with infrequently consumed foods reported as very low daily serving sizes. This can underestimate the risk for seasonally consumed foods during the season of highest consumption since the EDI is averaged out over the entire year. However, the recommended maximum weekly number of serving sizes provides a recommended maximum intake during seasons of high country food consumption.

Responses to food consumption surveys are known to vary considerably depending on when foods are assessed. For example, blueberry harvesting occurs during the summer months. A 24-hour recall interview in the summer, during blueberry harvesting could yield higher reported consumption frequencies compared to the same interview during winter months. Therefore, a 24-hour recall study should be conducted multiple times throughout the year, because the consumption data represent a single point in time (Coad 1994).

Literature data from the First Nations Food, Nutrition, and Environment Study (Chan et al. 2011) were used for the exposure calculations. Data were obtained from Ecozone 3, which incorporated survey data from the Lower Nicola and Splatsin (Spallumcheen) First Nations. Consumption data for the Simpcw First Nation and the Lakes Division Secwepemc were not available at the time of writing. This leads to some uncertainty as to whether the consumption quantity and frequency used in this report accurately reflects First Nations in closest proximity to the Project Site. Therefore, to be conservative the high (95th percentile) consumption amounts supplied by the Chan et al. (2011) study, rather than the mean consumption amounts, were incorporated into this report. Other studies, however, have indicated that food consumption surveys often lead to overestimations of actual intake (Institute for Risk Research 1999). Therefore, it is likely that any uncertainties associated with consumption quantities and frequencies provide a level of conservatism in the risk evaluation and RMWIs.

Consumption amounts and frequencies for toddlers also carry some uncertainty. As a conservative approach, it was assumed that toddlers ranging from six months to four years old consumed food at a rate of 43% of an adult consumption frequency based on recommendations made by Richardson (1997). It is unlikely that toddlers consume roughly half the amount of food that an adult would. It is probable that actual exposure to COPCs from ingestion of country foods is lower for toddlers.

This assessment does not consider seasonal differences in the way that food is prepared (it is based on fresh, wet weight and not dried or preserved weight), nor does it consider variability in a person's diet over time, because consumption data for different age groups (19 to 71+ years) were pooled.

10.6 TOXICITY REFERENCE VALUES

There is uncertainty associated with estimating TRVs by extrapolating potential effects on humans from animal studies in the laboratory. For human health risk assessments, it is a standard practice to assume that people are more sensitive to the toxic effects of a substance than laboratory animals. Therefore, the toxicity benchmarks for human health are set at much lower levels than the animal benchmarks (typically 100 to 1,000 times lower due to the application of safety factors). This large margin ensures that doses less than the TRV are safe and that minor exceedances of these benchmarks are unlikely to cause adverse health effects.

TRVs are derived for individual contaminants. However, it is recognized that multiple chemicals may be present within a food item and interactions between compounds may result in additivity (overall effect is the sum of the individual effects), antagonism (overall effect less than the sum of the individual effects), synergism (overall effect is greater than the sum of the individual effects), or potentiation (presence of one chemical results in toxicity of another chemical that otherwise would have been safe). Many of these interactions are poorly understood or remain unknown by modern science. Furthermore, in natural systems numerous physical variables (e.g., media temperature, pH, salinity, hardness, etc.) can accelerate or impede these chemical interactions. Because of these environmental variables, as well as poorly understood interactions among different compounds, assessments were only conducted for the individuals COPC levels and not for overall health effects.

10.7 DEFINITION OF HEALTH

This country foods assessment is a science-based approach recommended by Health Canada to protect human receptors from adverse health effects caused by exposure to the selected COPCs (metals). Community health and well-being is being addressed as part of the Socio-economic Baseline Report for the Project (ERM Rescan 2014b). However, it is recognized that health is defined by more than just physical well-being, as social, cultural, nutritional, and economic factors can also play a role in a person's overall health status.

The First Nation perspectives on food and health are strongly integrated. The social, cultural, spiritual, nutritional, and economic benefits of country foods together play a role in how the Aboriginal groups in general perceive country foods. The hunting, fishing, and gathering of country foods, and subsequent sharing of these foods with others throughout the community are social activities that bring individuals and families together (Chan et al. 2011).

11. CONCLUSIONS

This country foods baseline assessment integrated the results of the environmental media baseline data, human receptor characteristics, and regulatory-based TRVs. The potential for adverse human health effects as a result of consumption of five representative country foods (i.e., moose, snowshoe hare, ruffed grouse, Rainbow/Bull Trout, and huckleberries) was assessed. The country foods baseline assessment methodology was based on Health Canada's guidelines (Health Canada 2004a).

Rather than the mean concentrations, the 95% UCLM of metal concentrations were used to estimate the tissue metal concentrations in all country foods, ERs, RMWIs, and ILCRs. The duration for which the animals were assumed to be present within the country foods RSA, consumption frequencies of country foods, and portion size of country foods consumed were conservative. In addition, it was assumed that all country foods consumed were collected from within the country foods RSA. It is likely that the potential risk to human health due to country foods consumption from within the country foods RSA is overestimated.

Even using many conservative assumptions, this assessment found no unacceptable risks to human health from metal COPCs due to consumption of moose, snowshoe hare, ruffed grouse, Rainbow/Bull Trout, and huckleberries under baseline conditions at the consumption rates and frequencies used in the assessment.

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Appendix A

Summary of Measured Metal Concentrations in Physical Environmental Media and Biota

Table A-1. Summary of Measured Metal Concentration in Soil Samples

Total Metals	Minimum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% UCLM (mg/kg)	95th Percentile (mg/kg)	Maximum (mg/kg)
Aluminum	3460	17716	8908	19922	32950	43000
Antimony	<0.10	0.230	0.294	0.303	0.608	1.82
Arsenic	<0.50	15.5	18.3	20.1	51.2	76.5
Barium	11.2	57.4	30.9	65.0	110	157
Beryllium	<0.20	0.330	0.213	0.382	0.735	0.930
Bismuth	<0.10	0.505	0.425	0.611	1.28	2.19
Cadmium	0.0530	0.389	0.525	0.519	1.02	3.32
Calcium	125	1371	1129	1651	3655	4840
Chromium	2.60	19.6	21.8	25.0	49.0	136
Cobalt	0.640	10.9	17.7	15.3	22.7	118
Copper	4.58	197	756	384	446	5150
Iron	2150	31498	20679	36619	57050	120000
Lead	4.74	24.3	25.5	30.7	51.5	159
Lithium	<5.0	9.16	5.15	10.4	16.9	22.5
Magnesium	305	4314	3478	5175	10400	17400
Manganese	7.46	607	875	823	2360	4690
Mercury	0.0147	0.0442	0.0278	0.0511	0.100	0.140
Molybdenum	<0.10	1.23	0.817	1.43	2.26	4.19
Nickel	1.33	15.8	17.9	20.3	38.8	93.9
Phosphorus	175	576	500	700	1058	3290
Potassium	110	518	428	624	1435	2060
Selenium	<0.20	0.604	0.648	0.765	2.05	3.35
Silver	<0.10	0.389	0.315	0.467	0.863	1.71
Sodium	<100	109	121	139	328	727
Strontium	2.24	8.38	4.72	9.55	18.1	19.7
Thallium	<0.050	0.0700	0.0353	0.0787	0.124	0.157
Tin	0.130	0.698	0.308	0.774	1.00	1.26
Titanium	20.0	354	270	421	872	1390
Uranium	0.211	1.02	0.965	1.26	2.38	5.31
Vanadium	6.20	32.4	14.9	36.1	58.7	62.2
Zinc	5.30	76.2	55.5	89.9	172	232
Zirconium	<0.50	1.74	1.80	2.29	6.18	7.28

Notes:

UCLM = upper confidence limit of the mean.

< = concentrations were below the method detection limit, which is the value indicated. For calculation purposes, half the detection limit was substituted for values that were below the method detection limit.

n = 46 (except for zirconium, where n = 31).

All values expressed in mg/kg dry weight.

Table A-2. Summary of Measured Metal Concentration in Surface Water Samples

Total Metals	Minimum (mg/L)	Mean (mg/L)	Standard Deviation (mg/L)	95% UCLM (mg/L)	95th Percentile (mg/L)	Maximum (mg/L)	n -
Aluminum	<0.0010	0.149	0.334	0.171	0.776	2.87	655
Antimony	<0.000020	0.000129	0.000103	0.000136	0.000250	0.000375	655
Arsenic	<0.000020	0.000382	0.000921	0.000441	0.00110	0.0107	655
Barium	0.00360	0.0104	0.00586	0.0108	0.0237	0.0383	655
Beryllium	<0.000010	0.000227	0.000167	0.000124	<0.0010	<0.0010	655
Bismuth	<0.0000050	<0.000537	<0.000357	<0.000562	<0.0010	<0.00150	553
Boron	<0.010	<0.0409	<0.0331	<0.0430	<0.10	<0.30	655
Cadmium	<0.0000050	0.0000112	0.0000162	0.0000123	0.0000393	0.000200	655
Calcium	2.55	17.1	13.1	18.0	42.8	55.2	655
Chromium	<0.0000080	0.000467	0.000678	0.000511	0.00200	0.00556	655
Cobalt	<0.0000050	0.000205	0.000311	0.000225	0.000890	0.00260	655
Copper	0.0000900	0.00158	0.00909	0.00216	0.00370	0.229	655
Iron	<0.0010	0.227	0.540	0.262	1.43	4.57	655
Lead	<0.0000050	0.000224	0.000508	0.000257	0.000700	0.00669	655
Lithium	<0.00010	0.00148	0.00107	0.00155	0.00250	0.00548	655
Magnesium	0.360	3.04	2.92	3.23	9.50	15.4	655
Manganese	<0.000050	0.00733	0.0145	0.00827	0.0319	0.165	655
Mercury	<0.0000020	0.0000113	0.0000537	0.0000148	0.0000250	0.00130	644
Molybdenum	<0.000050	0.000707	0.000689	0.000751	0.00223	0.00408	651
Nickel	<0.000040	0.000730	0.00123	0.000809	0.00291	0.0200	655
Phosphorus	<0.030	0.135	0.0416	0.140	0.150	<0.30	274
Potassium	0.136	0.657	0.357	0.680	1.34	2.04	655
Selenium	<0.000040	0.000155	0.000165	0.000166	0.000500	0.000700	655
Silicon	2.19	3.45	0.648	3.50	4.54	6.79	553
Silver	<0.0000050	0.00000897	0.0000096	0.0000096	0.0000250	0.000160	655
Sodium	0.326	1.05	0.411	1.07	1.83	2.71	655
Strontium	0.00910	0.0719	0.0568	0.0759	0.198	0.249	553
Sulfur	<3.0	6.71	58.3	12.6	5.00	961	270
Tellurium	<0.00020	<0.00020	0	<0.00020	<0.00020	<0.00020	30
Thallium	<0.0000020	0.0000256	0.0000335	0.0000278	0.000100	<0.00020	655
Thorium	<0.00010	0.0000583	0.0000456	0.0000725	0.0000500	0.000300	30
Tin	<0.000020	0.000898	0.00462	0.00120	0.00250	0.116	655
Titanium	<0.00020	0.0107	0.0285	0.0126	0.0497	0.239	655
Uranium	0.0000120	0.000651	0.000779	0.000701	0.00232	0.00460	655
Vanadium	<0.000050	0.00157	0.00286	0.00175	0.00326	0.0150	655
Zinc	<0.00010	0.00268	0.00730	0.00315	0.00610	0.181	654
Zirconium	<0.00010	0.000285	0.000290	0.000312	0.00100	<0.0020	309

Notes:

UCLM = upper confidence limit of the mean.

< = *concentrations were below the method detection limit, which is the value indicated. For calculation purposes, half the detection limit was substituted for values that were below the method detection limit.*

Table A-3. Summary of Measured Metal Concentration in Vegetation Samples

	Huckleberry (*Vaccinium membranaceum*) Metal Concentrations						Huckleberry Leaf (*Vaccinium membranaceum*) Metal Concentrations						Sitka Valerian (*Valeriana sitchensis*) Metal Concentrations					
Total Metals	**Minimum**	**Mean**	**SD**	**95% UCLM**	**95th Percentile**	**Maximum**	**Minimum**	**Mean**	**SD**	**95% UCLM**	**95th Percentile**	**Maximum**	**Minimum**	**Mean**	**SD**	**95% UCLM**	**95th Percentile**	**Maximum**
Aluminum	3.85	6.31	1.45	7.28	8.32	8.94	50.4	83.4	19.3	92.2	108	111	3.99	7.74	2.82	9.07	12.0	13.1
Antimony	<0.0020	<0.0020	-	<0.0020	0.00100	<0.0020	<0.0020	0.00123	0.000904	0.00164	0.00205	0.00450	<0.0020	0.00110	0.000374	0.00128	0.00149	0.00240
Arsenic	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	0.00590	0.0133	0.00924	0.0175	0.0322	0.0338	<0.0040	0.00469	0.00254	0.00589	0.00897	0.00910
Barium	1.85	2.60	0.797	3.13	3.72	3.91	10.8	20.6	7.63	24.0	35.2	40.9	4.42	9.64	3.48	11.3	15.3	15.7
Beryllium	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020
Bismuth	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020
Boron	0.630	1.39	0.470	1.71	1.94	2.04	5.04	8.20	3.07	9.60	12.6	17.6	2.63	5.57	2.03	6.53	8.41	8.71
Cadmium	<0.0020	0.00524	0.00397	0.00790	0.00993	0.0100	<0.0020	0.0145	0.0186	0.0230	0.0503	0.0716	<0.0020	0.00960	0.0104	0.0145	0.0258	0.0392
Calcium	125	288	113	363	426	454	1520	2151	442	2352	2983	3060	779	1198	269	1326	1570	1700
Cesium	0.00370	0.0327	0.0405	0.0598	0.0983	0.102	0.00790	0.0795	0.0958	0.123	0.231	0.386	0.00250	0.0351	0.0759	0.0710	0.139	0.295
Chromium	<0.010	0.00588	0.00247	0.00753	0.00955	0.0120	0.0200	0.0344	0.0238	0.0452	0.0691	0.116	0.0110	0.0198	0.00720	0.0232	0.0308	0.0360
Cobalt	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	0.00630	0.0188	0.0136	0.0250	0.0458	0.0510	<0.0040	0.0108	0.00520	0.0133	0.02	0.02
Copper	0.676	1.27	0.342	1.50	1.63	1.63	1.59	2.21	0.406	2.39	2.79	2.96	0.436	0.642	0.119	0.698	0.794	0.798
Gallium	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	<0.0040	0.00274	0.00197	0.00364	0.00729	0.00820	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040
Iron	3.52	4.85	0.938	5.48	6.19	6.69	16.8	33.1	15.0	39.9	65.6	72.5	5.83	12.3	6.44	15.3	24.2	29.5
Lead	<0.0040	0.00398	0.00176	0.00515	0.00608	0.00650	0.0113	0.0298	0.0163	0.0372	0.0569	0.0569	0.00850	0.0179	0.00889	0.0221	0.0336	0.0411
Lithium	<0.020	<0.020	-	<0.020	<0.020	<0.020	<0.020	0.0171	0.0128	0.0230	0.0403	0.0480	<0.020	<0.020	-	<0.020	<0.020	<0.020
Magnesium	79.8	155	43.3	184	210	220	562	876	215	974	1224	1280	152	280	83.0	320	395	457
Manganese	26.7	40.6	13.3	49.5	61.5	69.8	166	400	187	485	680	910	3.70	10.8	7.14	14.2	23.0	23.1
Mercury	<0.0010	<0.0010	-	<0.0010	<0.0010	<0.0010	0.00160	0.00229	0.000426	0.00248	0.00292	0.00320	<0.0010	0.000957	0.000454	0.00117	0.00164	0.00170
Molybdenum	0.00490	0.0282	0.00992	0.0348	0.0357	0.0371	0.00740	0.0360	0.0268	0.0482	0.0871	0.0951	<0.0040	0.0218	0.0163	0.0295	0.0448	0.0481
Nickel	0.0610	0.0931	0.0323	0.115	0.144	0.158	<0.090	0.362	0.238	0.471	0.791	0.961	<0.060	0.534	0.620	0.828	1.41	2.48
Phosphorus	191	309	68.1	355	398	410	411	522	112	573	717	727	175	314	110	366	518	595
Potassium	977	1597	357	1836	2053	2060	2200	3309	931	3732	4868	5400	2540	4405	1073	4913	5872	6210
Rhenium	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020
Rubidium	2.54	5.08	2.18	6.55	8.34	8.98	2.89	6.92	2.23	7.93	9.63	10.3	3.26	5.89	2.16	6.92	9.62	11.00
Selenium	<0.020	<0.020	-	<0.020	<0.020	<0.020	<0.020	0.0107	0.00258	0.0118	0.0130	0.0200	<0.020	<0.020	-	<0.020	<0.020	<0.020
Sodium	<20	<20	-	<20	<20	<20	<20	11.3	5.16	13.7	16.0	30.0	<20	<20	-	<20	<20	<20
Strontium	0.206	0.321	0.0678	0.366	0.407	0.413	1.15	3.36	2.36	4.44	8.37	9.64	1.93	4.16	1.47	4.86	6.83	6.94
Tellurium	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040
Thallium	<0.00040	<0.00040	-	<0.00040	<0.00040	<0.00040	<0.00040	0.000607	0.000496	0.000832	0.00129	0.00191	<0.00040	0.000855	0.00102	0.00134	0.00236	0.00402
Thorium	<0.0020	0.00124	0.000672	0.00169	0.00224	0.00290	<0.0020	0.00623	0.00915	0.0104	0.0226	0.0356	<0.0020	0.00236	0.00187	0.00325	0.00587	0.00600
Tin	<0.0040	0.0219	0.0226	0.0371	0.0520	0.0536	<0.0040	0.00644	0.00203	0.00736	0.00925	0.00960	<0.0040	0.00491	0.00387	0.00675	0.0105	0.0173
Titanium	0.0220	0.0465	0.0189	0.0592	0.0738	0.0790	0.260	0.490	0.185	0.575	0.762	0.945	0.175	0.267	0.0701	0.300	0.369	0.400
Uranium	<0.00040	0.000239	0.000110	0.000312	0.000402	0.000510	<0.00040	0.000697	0.000708	0.00102	0.00195	0.00296	<0.00040	0.000426	0.000355	0.000594	0.00104	0.00142
Vanadium	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	0.0144	0.0243	0.00868	0.0283	0.0402	0.0438	0.00780	0.0126	0.00356	0.0142	0.0182	0.0187
Yttrium	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	0.00290	0.00673	0.00535	0.00916	0.0145	0.0246	<0.0020	0.00221	0.00105	0.00271	0.00358	0.00410
Zinc	0.950	2.41	0.931	3.03	3.62	3.76	4.54	6.98	1.74	7.77	9.47	11.1	1.95	3.11	0.931	3.55	4.31	4.36
Zirconium	<0.040	<0.040	-	<0.040	<0.040	<0.040	<0.040	<0.040	-	<0.040	<0.040	<0.040	<0.040	<0.040	-	<0.040	<0.040	<0.040

Notes:

UCLM = upper confidence limit of the mean.

< = concentrations were below the method detection limit, which is the value indicated. For calculation purposes, half the detection limit was substituted for values that were below the method detection limit.

SD = standard deviation of the mean.

Since there were only two samples of Sorbus, maximum concentrations were used in calculations rather than 95% UCLM.

All concentrations are in mg/kg wet weight.

n = 8 for huckleberry; n = 15 for huckleberry leaves; n = 14 for Sitka valerian; n = 13 for willow; n = 15 for fireweed; n = 2 for sorbus.

Table A-3. Summary of Measured Metal Concentration in Vegetation Samples

	Willow (*Salix barclayi* and *Salix drummondiana*) Metal Concentrations						Fireweed (*Epilobium angustifolium*) Metal Concentrations						Sorbus (*Sorbus sitchensis* and *Sorbus scopulina*) Metal Concentrations				
Total Metals	**Minimum**	**Mean**	**SD**	**95% UCLM**	**95th Percentile**	**Maximum**	**Minimum**	**Mean**	**SD**	**95% UCLM**	**95th Percentile**	**Maximum**	**Minimum**	**Mean**	**SD**	**95th Percentile**	**Maximum**
Aluminum	6.27	63.0	71.1	98.1	185	258	3.20	8.09	4.35	10.1	14.1	21.6	5.61	17.9	17.4	29.0	30.2
Antimony	<0.0020	0.00188	0.00163	0.00269	0.00440	0.0068	<0.0020	0.00114	0.000542	0.00139	0.00163	0.00310	<0.0020	0.00180	0.00113	0.00252	0.00260
Arsenic	<0.0040	0.0432	0.0421	0.0640	0.112	0.149	<0.0040	0.00557	0.00737	0.00892	0.0223	0.0259	0.00480	0.0112	0.00898	0.0169	0.0175
Barium	1.69	10.4	8.75	14.7	24.5	31.3	1.89	8.20	8.50	12.1	20.9	36.4	21.4	22.0	0.849	22.5	22.6
Beryllium	<0.0020	0.00328	0.00378	0.00514	0.0114	0.0115	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020
Bismuth	<0.0020	0.00257	0.00265	0.00388	0.00648	0.0102	<0.0020	<0.0020	-	0.00100	<0.0020	<0.0020	0.00100	0.00100	-	0.00100	0.00100
Boron	4.24	9.03	3.92	11.0	15.8	16.0	2.45	5.21	1.72	5.99	7.22	7.97	10.3	10.3	-	10.3	10.3
Cadmium	0.163	0.595	0.413	0.799	1.32	1.34	<0.0020	0.0337	0.110	0.0838	0.140	0.432	0.0357	0.123	0.123	0.201	0.210
Calcium	1230	3755	1592	4542	6070	6940	1320	2119	605	2394	3092	3400	3650	3725	106	3793	3800
Cesium	0.00770	0.0364	0.0292	0.0508	0.0907	0.102	0.00150	0.0156	0.0198	0.0246	0.0563	0.0672	0.0228	0.0366	0.0195	0.0490	0.0504
Chromium	0.0140	0.0936	0.0776	0.132	0.231	0.251	<0.010	0.0586	0.145	0.125	0.260	0.572	0.0150	0.0245	0.0134	0.0331	0.0340
Cobalt	0.0334	0.299	0.195	0.395	0.542	0.605	<0.0040	0.00801	0.00565	0.0106	0.0177	0.0241	0.0183	0.0184	0.0000707	0.0184	0.0184
Copper	0.907	2.35	1.15	2.92	4.32	4.81	0.617	1.10	0.374	1.27	1.77	1.94	1.72	2.22	0.707	2.67	2.72
Gallium	<0.0040	0.0160	0.0192	0.0255	0.0478	0.0676	<0.0040	0.00217	0.000645	0.00246	0.00275	0.00450	<0.0040	0.00430	0.00325	0.00637	0.00660
Iron	21.0	114	112	169	291	402	7.65	14.9	9.35	19.2	27.3	46.4	26.1	42.9	23.7	57.9	59.6
Lead	0.00920	0.0782	0.0671	0.111	0.193	0.194	0.00720	0.0177	0.0141	0.0241	0.0430	0.0600	0.0299	0.0363	0.00898	0.0420	0.0426
Lithium	<0.020	0.0311	0.0357	0.0487	0.103	0.118	0.0100	0.0100	-	0.0100	0.0100	0.0100	0.0220	0.0720	0.0707	0.117	0.122
Magnesium	422	817	341	985	1376	1580	299	564	107	613	676	696	806	1083	392	1332	1360
Manganese	22.6	101	81.5	142	246	302	10.7	37.2	26.4	49.2	80.4	121	146	458	441	738	769
Mercury	<0.0010	0.00228	0.000896	0.00272	0.00342	0.00390	<0.0010	0.00138	0.000575	0.00164	0.00207	0.00270	0.00300	0.00335	0.000495	0.00367	0.00370
Molybdenum	0.0170	0.0523	0.0363	0.0703	0.116	0.130	0.00530	0.111	0.167	0.187	0.403	0.636	0.0677	0.0716	0.00544	0.0750	0.0754
Nickel	0.0990	1.73	1.34	2.40	3.59	5.08	<0.040	0.288	0.200	0.379	0.640	0.676	0.287	0.319	0.0445	0.347	0.350
Phosphorus	481	705	217	813	1124	1250	268	534	210	630	834	1090	742	776	48.1	807	810
Potassium	3360	4850	1287	5486	7016	7430	1300	3089	1243	3654	5200	5200	7120	8515	1973	9771	9910
Rhenium	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020
Rubidium	1.31	7.45	3.18	9.02	12.2	13.6	0.496	2.38	1.22	2.93	4.07	4.34	11.0	13.1	2.97	15.0	15.2
Selenium	<0.020	0.0156	0.0122	0.0216	0.0386	0.0500	<0.020	0.0127	0.00799	0.0163	0.0260	0.0400	<0.020	<0.020	-	<0.020	<0.020
Sodium	<20	<20	-	<20	<20	<20	<20	<20	-	<20	<20	<20	<20	<20	-	<20	<20
Strontium	2.13	13.3	9.98	18.2	30.1	42.2	2.28	5.87	2.49	7.00	8.95	13.0	5.64	6.12	0.672	6.54	6.59
Tellurium	<0.0040	0.00218	0.000666	0.00251	0.00296	0.00440	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	-	<0.0040	<0.0040
Thallium	<0.00040	0.000859	0.00101	0.00136	0.00293	0.00310	<0.00040	0.000453	0.000321	0.000599	0.000992	0.00116	0.000470	0.000585	0.000163	0.000689	0.000700
Thorium	<0.0020	0.0330	0.0379	0.0517	0.105	0.108	<0.0020	0.00280	0.00513	0.00513	0.00896	0.0210	<0.0020	0.00375	0.00389	0.00623	0.00650
Tin	0.00410	0.00662	0.00247	0.00784	0.0108	0.0126	<0.0040	0.00361	0.00217	0.00459	0.00752	0.00780	0.00990	0.0103	0.000495	0.0106	0.0106
Titanium	0.395	1.57	1.53	2.32	4.36	5.40	0.0750	0.218	0.121	0.273	0.479	0.485	0.284	0.625	0.482	0.932	0.966
Uranium	<0.00040	0.00323	0.00354	0.00498	0.00931	0.0118	<0.00040	0.000473	0.000764	0.000821	0.00157	0.00313	<0.00040	0.000705	0.000714	0.00116	0.00121
Vanadium	0.0132	0.0971	0.107	0.150	0.284	0.376	<0.0040	0.0105	0.00854	0.0144	0.0276	0.0354	0.00680	0.0296	0.0322	0.0501	0.0524
Yttrium	0.00280	0.0390	0.0447	0.0611	0.113	0.154	<0.0020	0.00647	0.00918	0.0106	0.0268	0.0323	0.0113	0.0123	0.00141	0.0132	0.0133
Zinc	17.5	49.1	28.4	63.2	94.7	115	3.61	6.49	2.18	7.48	10.9	11.7	9.27	13.3	5.68	16.9	17.3
Zirconium	<0.040	0.0684	0.157	0.146	0.268	0.589	<0.040	<0.040	-	<0.040	<0.040	<0.040	<0.040	<0.040	-	<0.040	<0.040

Notes:

UCLM = upper confidence limit of the mean.

< = concentrations were below the method detection limit, which is the value indicated. For calculation purposes, half the detection limit was substituted for values that were below the method detection limit.

SD = standard deviation of the mean.

Since there were only two samples of Sorbus, maximum concentrations were used in calculations rather than 95% UCLM.

All concentrations are in mg/kg wet weight.

n = 8 for huckleberry; n = 15 for huckleberry leaves; n = 14 for Sitka valerian; n = 13 for willow; n = 15 for fireweed; n = 2 for sorbus.

Table A-4. Summary of Measured Metal Concentration in Small Mammal Tissue (Voles, Mice, and Shrews)

Total Metals	Minimum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% UCLM (mg/kg)	95th Percentile (mg/kg)	Maximum (mg/kg)	n -
Aluminum	3.02	9.28	6.77	11.8	22.4	32.1	21
Antimony	<0.0020	<0.0020	-	0.00100	<0.0020	<0.0020	21
Arsenic	0.0072	0.0446	0.0560	0.0657	0.100	0.263	21
Barium	1.01	4.31	2.33	5.18	6.98	11.4	21
Beryllium	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	21
Bismuth	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	21
Boron	<0.20	0.383	0.140	0.436	0.550	0.740	21
Cadmium	0.00870	0.155	0.124	0.201	0.323	0.568	21
Calcium	4540	7341	1552	7925	9460	11100	21
Cesium	0.0333	2.32	3.60	3.68	6.52	16.8	21
Chromium	0.0120	0.0298	0.0147	0.0354	0.0440	0.0840	21
Cobalt	0.0107	0.0496	0.0254	0.0591	0.0848	0.113	21
Copper	2.21	3.04	1.04	3.43	3.68	7.22	21
Gallium	<0.0040	0.00262	0.00163	0.00323	0.00590	0.00810	21
Iron	58.2	75.1	14.8	80.6	98.7	118	21
Lead	0.0473	0.140	0.127	0.188	0.486	0.513	21
Lithium	<0.020	0.0160	0.0102	0.0199	0.0340	0.0410	21
Magnesium	329	378	36.9	392	447	450	21
Manganese	1.61	5.76	3.21	6.97	13.5	13.5	21
Mercury	<0.0010	0.0532	0.0371	0.0671	0.111	0.143	21
Molybdenum	0.0573	0.118	0.0299	0.129	0.164	0.168	21
Nickel	0.0800	0.145	0.0614	0.168	0.256	0.311	21
Phosphorus	4020	5606	922	5953	6910	7570	21
Potassium	2660	3110	190	3181	3400	3420	21
Rhenium	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	21
Rubidium	8.07	32.4	13.1	37.3	51.6	54.6	21
Selenium	0.0730	0.304	0.168	0.367	0.538	0.821	21
Sodium	1100	1239	90.2	1273	1370	1400	21
Strontium	1.79	3.26	1.10	3.67	4.21	6.85	21
Tellurium	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	21
Thallium	0.000600	0.00373	0.00232	0.00461	0.00787	0.00828	21
Thorium	<0.0020	0.00209	0.00275	0.00312	0.00590	0.0129	21
Tin	0.0275	0.0633	0.0357	0.0768	0.139	0.161	21
Titanium	1.38	2.78	1.11	3.20	4.71	5.83	21
Uranium	<0.00040	0.000555	0.000542	0.000759	0.00118	0.00244	21
Vanadium	0.00500	0.0168	0.0103	0.0207	0.0347	0.0462	21
Yttrium	<0.0020	0.00276	0.00238	0.00365	0.00770	0.00920	21
Zinc	22.5	26.8	2.92	27.9	32.1	33.0	21
Zirconium	<0.040	<0.040	-	<0.040	<0.040	<0.040	21

Notes:

UCLM = upper confidence limit of the mean.

< = concentrations were below the method detection limit, which is the value indicated. For calculation purposes, half the detection limit was substituted for values that were below the method detection limit.

All concentrations in wet weight.

Mice species included Western jumping mice (Zapus princeps) and deer mice (Peromyscus maniculatus).

Vole species was Red-backed voles (Myodes rutilus).

Shrew species was masked shrew (Sorex cinereus).

Table A-5. Summary of Measured Metal Concentration in Bull Trout (*Salvelinus confluentus*) and Rainbow Trout Tissue (*Oncorhynchus mykiss*)

Total Metals	Minimum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% UCLM (mg/kg)	95th Percentile (mg/kg)	Maximum (mg/kg)	n -
Aluminum	<0.40	0.419	0.327	0.496	1.10	1.23	50
Antimony	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	50
Arsenic	0.0155	0.0785	0.0674	0.0945	0.177	0.374	50
Barium	<0.010	0.0413	0.0594	0.0562	0.128	0.363	45
Beryllium	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	50
Bismuth	<0.0020	0.00167	0.00308	0.00240	0.00200	0.0180	50
Boron	<0.20	0.297	0.533	0.423	1.11	3.25	50
Cadmium	<0.0020	0.0102	0.0106	0.0127	0.0262	0.0594	50
Calcium	126	390	437	493	1082	2720	50
Cesium	0.00880	0.0291	0.0128	0.0322	0.0508	0.0620	50
Chromium	<0.010	0.00936	0.00505	0.0106	0.0196	0.0240	50
Cobalt	0.00550	0.0413	0.0353	0.0496	0.103	0.204	50
Copper	0.197	0.393	0.141	0.426	0.713	0.815	50
Gallium	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	50
Iron	2.25	4.35	1.64	4.73	7.64	8.99	50
Lead	<0.0040	0.0110	0.0294	0.0180	0.0317	0.198	50
Lithium	<0.020	0.0162	0.0149	0.0198	0.0437	0.0930	50
Magnesium	162	262	34.0	270	313	335	50
Manganese	0.0708	0.271	0.405	0.367	0.840	2.55	50
Mercury	0.0120	0.0260	0.0108	0.0286	0.0452	0.0512	50
Molybdenum	<0.0040	0.00430	0.00328	0.00508	0.00913	0.0194	50
Nickel	<0.010	0.0210	0.0544	0.0339	0.0450	0.389	50
Phosphorus	1480	2303	348	2386	2940	3390	50
Potassium	2540	4105	490	4221	4861	4930	50
Rhenium	<0.0020	<0.0020	-	<0.0020	<0.0020	<0.0020	50
Rubidium	1.24	3.80	1.77	4.22	6.78	7.91	50
Selenium	0.167	0.458	0.168	0.498	0.787	0.862	50
Sodium	<500	672	107	698	806	870	50
Strontium	0.0480	0.480	0.929	0.700	1.93	4.83	50
Tellurium	<0.0040	<0.0040	-	<0.0040	<0.0040	<0.0040	50
Thallium	0.00123	0.00292	0.00115	0.00319	0.00523	0.00594	50
Thorium	<0.0020	0.00177	0.00393	0.00270	0.00331	0.0278	50
Tin	<0.0040	0.0120	0.0124	0.0150	0.0300	0.0558	50
Titanium	<0.010	0.0185	0.0354	0.0270	0.0436	0.220	49
Uranium	<0.00040	0.0003254	0.000426	0.000427	0.000796	0.00284	50
Vanadium	<0.0040	0.00284	0.00277	0.00350	0.00891	0.0155	50
Yttrium	<0.0020	0.00103	0.000184	0.00107	0.00100	0.00230	50
Zinc	3.22	7.48	1.93	7.94	11.1	13.4	50
Zirconium	<0.040	<0.040	-	<0.040	<0.040	<0.040	50

Notes:

UCLM = upper confidence limit of the mean.

< = *concentrations were below the method detection limit, which is the value indicated. For calculation purposes, half the detection limit was substituted for values that were below the method detection limit.*

All concentrations in wet weight.

Appendix B

Food Chain Model and Predicted Moose, Snowshoe Hare, and Grouse Tissue Metal Concentrations

HARPER CREEK PROJECT

Appendix B. Food Chain Model and Predicted Moose, Snowshoe Hare, and Grouse Tissue Metal Concentrations

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1. INTRODUCTION

Tissue concentrations for moose, snowshoe hare, and ruffed grouse were estimated using a food chain model. The food chain model predicts metal concentrations in animal tissue by estimating the fraction of metals that are retained in the tissues when wildlife ingests environmental media such as vegetation, soil, and surface water. The food chain model followed the methodology described in Golder Associates Ltd. (2005), which is recommended by Health Canada (2010). The modelled metal concentrations were used in the country foods baseline study to assess the potential for these foods to affect human health.

2. METHOD

The following equation was used to predict terrestrial animal tissue concentrations:

$$C_{meat}\ (mg/kg) = C_{m[soil]} + C_{m[water]} + C_{m[veg]}$$

where:
$C_{m[soil]}$ = *Concentration in meat from the animals exposure to metals in soil*
$C_{m[water]}$ = *Concentration in meat from the animals exposure to metals in water*
$C_{m[veg]}$ = *Concentration in meat from the animals exposure to metals in vegetation*

The terrestrial wildlife uptake equations used to estimate the concentrations in animal tissue (meat) from exposure to soil, vegetation, and water are presented in Table B-1.

Table B-1. Terrestrial Wildlife Metal Uptake Equations

Pathway	Equation and Parameters
Generic Equation	$C_{m[media]} = BTF \times C \times IR \times ET \times fw$
Baseline Ingestion Equations	
Soil Ingestion	$C_{m[soil]} = BTF_{tissue\text{-}food} \times C_{soil} \times IR_{soil} \times ET \times fw$
Vegetation Ingestion	$C_{m[veg]} = BTF_{tissue\text{-}food} \times C_{veg} \times IR_{veg} \times ET \times fw$
Water Ingestion	$C_{m[water]} = BTF_{tissue\text{-}food} \times C_{water} \times IR_{water} \times ET \times fw$

Notes:
$C_{m[media]}$ = *Concentration of metals in animal tissue from media (e.g., soil, veg, water) ingestion (mg/kg).*
$BTF_{tissue\text{-}food}$ = *Biotransfer factor for the animal species and metal (day/kg).*
$C_{[media]}$ = *Metal concentration in soil, veg, or water (mg/kg or mg/L).*
$IR_{soil/veg/water}$ = *Daily ingestion rate of media for moose, hare, and grouse (kg/day or L/day).*
ET = Exposure time spent in the area for moose, hare, and grouse (unitless).
fw = Fraction of daily consumption for moose, hare, and grouse (assumed 1; unitless).

2.1 BIOTRANSFER FACTORS

The tissue uptake calculations were based on metal specific biotransfer factors (BTF), which are rates at which metals are taken up and absorbed into wildlife tissue from their food. Food-to-tissue BTFs are used for water and soil transfer calculations in the absence of BTFs for these media, as recommended by Golder (2005). No species-specific BTFs on moose and snowshoe hare were available, therefore beef BTFs were used (Table B-2; US EPA 2005; RAIS 2010). The use of beef BTFs for wild mammals is considered to be a conservative approach (RAIS 2010). There were no BTFs specifically for ruffed grouse, and beef BTFs are inappropriate, therefore chicken BTFs were used (RAIS 2010). The chicken BTFs were obtained from the Pacific Northwest National Laboratory's (PNNL) report (Staven et al. 2003; US EPA 2005).

Table B-2. Biotransfer Factors Used to Predict Metal Uptake into Terrestrial Wildlife Tissue

	BTF_{beef}		$BTF_{chicken}$	
COPC	**day/kg**	**Reference**	**day/kg**	**Reference**
Aluminum	0.0015	1	0.8	3
Arsenic	0.002	1	0.83	2
Cadmium	0.00055	1	0.106	4
Chromium	0.0055	1	0.2	2
Cobalt	0.01	2	2	2
Copper	0.01	1	0.5	2
Lead	0.0003	2	0.8	2, 5
Mercury	0.25	1	0.03	2
Nickel	0.006	1	0.001	2
Selenium	0.00227	4	1.13	4
Silver	0.003	1	2	2
Thallium	0.04	4	10.8	2
Vanadium	0.0025	1	0.0003	4
Zinc	0.00009	4	0.00875	4

Notes:
COPC = contaminant of potential concern.
BTF_{beef} = biotransfer factor for beef.
$BTF_{chicken}$ = biotransfer factor for chicken.
References:
1 = RAIS (2010)
2 = Staven et al. (2003)
3 = $BTF_{chicken}$ for aluminum is based on $BTF_{chicken}$ for gallium
4 = US EPA (2005)
5 = Based on arsenic

When BTF values were not available for a specific metal, the BTF for a metal with similar physicochemical characteristics was substituted. Metals were considered similar in their physicochemical characteristics if they were immediately above or below each other on the periodic table of elements. For example, the $BTF_{chicken}$ for aluminum was not available; therefore, the $BTF_{chicken}$ value for gallium was substituted because gallium is below aluminum on the periodic table.

2.2 METAL CONCENTRATIONS IN ENVIRONMENTAL MEDIA

To support food chain modelling of wildlife species, samples of huckleberry fruit and leaves (*Vaccinium membranaceum*), Sitka valerian (*Valeriana sitchensis*), willow (*Salix barclayi* and some *Salix drummondiana*), fireweed (*Epilobium anugustifolium*), and sorbus (*Sorbus sitchensis and S. scopulina)* were collected from 15 sites within the country foods LSA in 2012 and analyzed for metal concentrations (Sharpe 2013). Overall, eight huckleberry fruit and 15 leaf samples, 14 Sitka valerian samples, 13 willow samples, 15 fireweed samples, and two sorbus samples were included in the food chain model. The metal concentrations for vegetation used in the wildlife food chain model were the 95% Upper Confident Limit of the Mean (UCLM) metal concentrations of all vegetation types collected except for sorbus which only had two samples collected thus the maximum concentration was used.

Moose are browsing herbivores (Azimuth 2012) and their diet was assumed to be 70% willow, 15% sorbus, 5% fireweed, 5% Sitka valerian, 4% huckleberry leaves, and 1% huckleberries (S. Sharpe, pers. comm.). Snowshoe hare are grazing herbivores (Azimuth 2012) and their diet was assumed to be 50% willow, 20% fireweed, 15% sorbus, 10% Sitka valerian, 4% huckleberry leaves, and 1% huckleberries (S. Sharpe, pers. comm.). Ruffed grouse are foliage and browsing omnivores (Azimuth 2012) and their diet was assumed to be 56% huckleberry leaves, 14% huckleberries, 15% sorbus, 5% fireweed, 5% willow, and 5% Sitka valerian (S. Sharpe, pers. comm.).

Data used from the soil sampling program included soil samples collected from depths ranging from 0 to 20 cm below ground surface (US EPA 2012). The data used from the surface water sampling program included samples from lakes and streams within the country foods RSA collected between 2009 to 2014. A summary of the data collected is presented in Table B-3. These concentrations were used to predict the tissue metal concentrations in moose, snowshoe hare, and grouse.

2.3 TERRESTRIAL WILDLIFE CHARACTERISTICS

Terrestrial wildlife characteristics are species-specific parameters that were used to estimate the amount of time an animal would spend in the country foods RSA and the amount of environmental media that each species would be exposed to during that time. Table B-4 presents the species-specific characteristics obtained from Azimuth (2012) and Beyer and Fries (2003) that were used to predict moose, snowshoe hare, and ruffed grouse tissue metal concentrations.

Generally, moose may spend most of their time within one watershed and can therefore be representative of potential exposure from COPCs from an area within the RSA. It is also assumed that animals distribute the time they spend throughout their home range area equally. Habitat suitability for moose in the country foods LSA and RSA has increased due to logging; however, moose are only occasional visitors the area and are likely only there during the summer for two to three months (August to October) with a conservative abundance of one moose per 4 km^2 (S. Sharpe, pers. comm.). Therefore, as a conservative measure, the exposure time for moose was assumed to be three months of the year.

For snowshoe hare, the home range is estimated to be between 0.057 and 0.1 km^2 (Adams 1959), and grouse may have a home range of 1.04 km^2 (Thompson III and Fritzell 1989); the country foods RSA is large enough that it could overlap with the entire home range of both snowshoe hare and ruffed grouse. Therefore, the exposure time for both snowshoe hare and ruffed grouse was assumed to be the entire year.

Table B-3. Summary of 95th Upper Confidence Level of the Mean Metal Concentrations in Vegetation Tissue, Soil, and Surface Water Samples

COPC	Measured Baseline Concentration (95th UCLM)										
	Vegetation (mg/kg ww)						Vegetation Mix (mg/kg ww) for:			Soil[d]	Water[e]
	Berries (n=8)	Willow (n=13)	Sorbus (n=2)	Fireweed (n=15)	Sitka Valerian (n=14)	Berry Leaves (n=15)	Moose[a]	Hare[b]	Grouse[c]	mg/kg dw	mg/L
							$C_{moose\text{-}veg}$	$C_{hare\text{-}veg}$	$C_{grouse\text{-}veg}$	C_{soil}	C_{water}
Aluminum	7.28	98.1	30.2	10.1	9.07	92.2	77.9	60.3	63.0	19922	0.171
Arsenic	0.002	0.064	0.0175	0.00892	0.00589	0.0175	0.0489	0.0377	0.0167	20.1	0.000441
Cadmium	0.0079	0.799	0.21	0.0838	0.0145	0.0230	0.597	0.45	0.0903	0.519	0.0000123
Chromium	0.00753	0.132	0.034	0.125	0.0232	0.0452	0.107	0.1	0.0455	25.0	0.000511
Cobalt	0.002	0.395	0.0184	0.0106	0.0133	0.025	0.282	0.205	0.038	15.3	0.000225
Copper	1.5	2.92	2.72	1.27	0.698	2.39	2.66	2.3	2.20	384	0.00216
Lead	0.00515	0.111	0.0426	0.0241	0.0221	0.0372	0.0882	0.0707	0.0358	30.7	0.000257
Mercury	0.0005	0.00272	0.0037	0.00164	0.00117	0.00248	0.0027	0.00246	0.00229	0.0511	0.0000148
Nickel	0.115	2.40	0.350	0.379	0.828	0.471	1.81	1.43	0.512	20.3	0.000809
Selenium	0.01	0.0216	0.0100	0.0163	0.0100	0.0118	0.0185	0.0171	0.0119	0.765	0.000166
Silver	NC	NC	NC	NC	NC	NC	NC	NC	NC	0.467	0.00000958
Thallium	0.0002	0.00136	0.0007	0.000599	0.00134	0.000832	0.00119	0.00107	0.000764	0.0787	0.0000278
Vanadium	0.002	0.150	0.0524	0.0144	0.0142	0.0283	0.115	0.0882	0.0329	36.1	0.00120
Zinc	3.03	63.2	17.3	7.48	3.55	7.77	47.7	36.4	11.1	89.9	0.0126

Notes:
ww = wet weight
NC = not calculated because that parameter was not measured in environmental media data
COPC = contaminant of potential concern
UCLM = upper confidence limit of the mean
[a] *Moose vegetation mix: 70% willow, 15% sorbus, 5% fireweed, 5% Sitka valerian, 4% vaccinium leaves, 1% vaccinum berries.*
[b] *Hare vegetation mix: 50% willow, 20% fireweed, 15% sorbus, 10% Sitka valerian, 4% vaccinium leaves, 1% vaccinium berries.*
[c] *Grouse vegetation mix: 56% vaccinium leaves, 14% vaccinum berries, 15% sorbus, 5% fireweed, 5% willow, 5% Sitka valerian.*
[d] *The total number of soil samples was n=46.*
[e] *The total number of water samples varies for the different COPCs (n=644 for mercury; n=654 for zinc; n=655 for all other COPCs).*

Table B-4. Terrestrial Wildlife Characteristics

Parameter	Unit	Symbol	Moose	Snowshoe Hare	Ruffed Grouse
Body weight	kg	BW	400	1.3	0.552
Food Ingestion Rate	kg-ww/day	IR	8.00	0.078	0.033
Vegetation Ingestion Rate	kg-ww/day	IR_{veg}	7.84	0.073	0.030
Soil Ingestion Rate	kg-dw/day	IR_{soil}	0.16	0.0049	0.0032
Water Ingestion Rate	L/day	IR_{water}	20.0	0.13	0.039
Exposure Time in Area	-	ET	0.25	1	1
Fraction of Daily Consumption	-	fw	1	1	1

Notes:
ww = wet weight
dw = dry weight
Moose, snowshoe hare, and grouse parameters from Azimuth (2012), except for the soil ingestion rate for ruffed grouse is based on the average for American woodcock and Wild turkey (9.65% of total diet) provided by Beyer and Fries (2003).

3. SAMPLE CALCULATION AND COMPLETE MODEL RESULTS

To calculate the amount of metals that each ingestion pathway contributes, an equation for all ingestion routes is presented in Table B-5, followed by media specific equations. Table B-5 also provides a sample calculation for the aluminum concentration in moose tissue resulting from ingesting soil, water, and vegetation during baseline.

Table B-5. Sample Calculation of Aluminum Concentration in Moose Tissue due to Uptake from Soil, Surface Water, and Vegetation

Overall Equation:

$C_{meat} = C_{m[veg]} + C_{m[soil]} + C_{m[water]}$

where:

$C_{m[veg]} = BTF_{tissue\text{-}food} \times C_{veg} \times IR_{veg} \times ET \times fw$

$C_{m[soil]} = BTF_{tissue\text{-}food} \times C_{soil} \text{ x } IR_{soil} \times ET \times fw$

$C_{m[water]} = BTF_{tissue\text{-}food} \times C_{water} \times IR_{water} \times ET \times fw$

Parameters:

C_{meat}	= Total concentration of COPC (aluminum) in animal tissue (moose) from all ingestion pathways (mg/kg)
$C_{m[veg]}$	= Total concentration of COPC (aluminum) in animal tissue (moose) from vegetation ingestion (mg/kg)
$C_{m[soil]}$	= Total concentration of metal (aluminum) in animal tissue (moose) from soil ingestion (mg/kg)
$C_{m[water]}$	= Total concentration of metal (aluminum) in animal tissue (moose) from water ingestion (mg/kg)
$BTF_{tissue\text{-}food}$	= Biotransfer factor from food consumption to tissues for a selected metal (mg/kg)
$C_{m[media]}$	= 95th upper confidence level of the mean metal concentration in media (mg/kg)
$IR_{soil/veg/water}$	= Ingestion rate of media (i.e., soil, vegetation, or water; kg/day)
ET	= Exposure time in the Project area (unitless)
fw	= Fraction of daily consumption for animal (assumed 1; unitless)

Sample Calculation:

$C_{m[veg]}$	= (0.0015 day/kg) × (77.9 mg/kg ww) × (7.84 kg/day) × 0.25 = 0.229 mg/kg
$C_{m[soil]}$	= (0.0015 day/kg) × (19,922 mg/kg dw) × (0.16 kg/day) × 0.25 = 1.20 mg/kg
$C_{m[water]}$	= (0.0015 mg/kg) × (0.17 mg/L) × (20 L/day) × 0.25 = 0.00128 mg/kg
C_{meat}	= (0.229 + 1.20 + 0.00128) mg/kg = 1.43 mg/kg wet weight

Notes:
COPC = contaminant of potential concern

Table B-6 presents the modelled moose, snowshoe hare, and ruffed grouse metal concentrations for this baseline country foods assessment. Each ingestion pathway (i.e., soil, water, and vegetation) contributes to the total concentration of metals in these country foods. These metal concentrations in moose, snowshoe hare, and ruffed grouse tissue were used in the country foods baseline assessment to calculate the estimated daily intake of metals for people who eat these foods from within the country foods RSA.

Table B-6. Modelled Metal Concentrations in Moose, Snowshoe Hare, and Grouse Tissue

COPC	Moose				Snowshoe Hare				Grouse			
	$C_{m[veg]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$	$C_{m[veg]}$	$C_{m[soil]}$	$C_{m[water]}$	$C_{m[total]}$
Aluminum	2.29×10^{-01}	1.20×10^{00}	1.28×10^{-03}	**1.43×10^{00}**	6.61×10^{-03}	1.47×10^{-01}	3.33×10^{-05}	**1.53×10^{-01}**	1.51×10^{00}	$5.09 \times 10^{+01}$	5.28×10^{-03}	**$5.25 \times 10^{+01}$**
Arsenic[a]	1.92×10^{-04}	1.60×10^{-03}	4.41×10^{-06}	**1.80×10^{-03}**	5.52×10^{-06}	1.97×10^{-04}	1.15×10^{-07}	**2.03×10^{-04}**	4.14×10^{-04}	5.32×10^{-02}	1.41×10^{-05}	**5.36×10^{-02}**
Cadmium	6.43×10^{-04}	1.14×10^{-05}	3.37×10^{-08}	**6.55×10^{-04}**	1.81×10^{-05}	1.40×10^{-06}	8.77×10^{-10}	**1.95×10^{-05}**	2.87×10^{-04}	1.76×10^{-04}	5.04×10^{-08}	**4.63×10^{-04}**
Chromium	1.15×10^{-03}	5.51×10^{-03}	1.41×10^{-05}	**6.67×10^{-03}**	4.03×10^{-05}	6.76×10^{-04}	3.65×10^{-07}	**7.17×10^{-04}**	2.72×10^{-04}	1.60×10^{-02}	3.95×10^{-06}	**1.63×10^{-02}**
Cobalt	5.52×10^{-03}	6.11×10^{-03}	1.13×10^{-05}	**1.16×10^{-02}**	1.50×10^{-04}	7.50×10^{-04}	2.93×10^{-07}	**9.00×10^{-04}**	2.27×10^{-03}	9.76×10^{-02}	1.74×10^{-05}	**9.99×10^{-02}**
Copper	5.21×10^{-02}	1.54×10^{-01}	1.08×10^{-04}	**2.06×10^{-01}**	1.68×10^{-03}	1.89×10^{-02}	2.81×10^{-06}	**2.05×10^{-02}**	3.30×10^{-02}	6.13×10^{-01}	4.18×10^{-05}	**6.46×10^{-01}**
Lead	5.19×10^{-05}	3.68×10^{-04}	3.86×10^{-07}	**4.20×10^{-04}**	1.55×10^{-06}	4.52×10^{-05}	1.00×10^{-08}	**4.68×10^{-05}**	8.58×10^{-04}	7.84×10^{-02}	7.95×10^{-06}	**7.93×10^{-02}**
Mercury	1.32×10^{-03}	5.11×10^{-04}	1.85×10^{-05}	**1.85×10^{-03}**	4.50×10^{-05}	6.28×10^{-05}	4.81×10^{-07}	**1.08×10^{-04}**	2.06×10^{-06}	4.90×10^{-06}	1.71×10^{-08}	**6.98×10^{-06}**
Nickel	2.13×10^{-02}	4.87×10^{-03}	2.43×10^{-05}	**2.62×10^{-02}**	6.27×10^{-04}	5.98×10^{-04}	6.31×10^{-07}	**1.22×10^{-03}**	1.53×10^{-05}	6.48×10^{-05}	3.12×10^{-08}	**8.01×10^{-05}**
Selenium	8.23×10^{-05}	6.93×10^{-05}	1.88×10^{-06}	**1.53×10^{-04}**	2.84×10^{-06}	8.51×10^{-06}	4.88×10^{-08}	**1.14×10^{-05}**	4.02×10^{-04}	2.75×10^{-03}	7.21×10^{-06}	**3.16×10^{-03}**
Silver	NC	5.61×10^{-05}	1.44×10^{-07}	**NC**	NC	6.89×10^{-06}	3.74×10^{-09}	**NC**	NC	2.99×10^{-03}	7.40×10^{-07}	**NC**
Thallium	9.31×10^{-05}	1.26×10^{-04}	5.56×10^{-06}	**2.25×10^{-04}**	3.14×10^{-06}	1.55×10^{-05}	1.44×10^{-07}	**1.88×10^{-05}**	2.47×10^{-04}	2.72×10^{-03}	1.16×10^{-05}	**2.98×10^{-03}**
Vanadium	5.65×10^{-04}	3.61×10^{-03}	1.49×10^{-05}	**4.19×10^{-03}**	1.61×10^{-05}	4.43×10^{-04}	3.89×10^{-07}	**4.60×10^{-04}**	2.95×10^{-07}	3.46×10^{-05}	1.39×10^{-08}	**3.49×10^{-05}**
Zinc	8.42×10^{-03}	3.24×10^{-04}	5.66×10^{-06}	**8.74×10^{-03}**	2.39×10^{-04}	3.98×10^{-05}	1.47×10^{-07}	**2.79×10^{-04}**	2.90×10^{-03}	2.51×10^{-03}	4.25×10^{-06}	**5.42×10^{-03}**

Notes:
NC = not calculated because that parameter was not measured in environmental media data.
COPC = contaminant of potential concern.
C_{mveg} *= concentration of COPC in meat tissue from vegetation consumption (mg/kg).*
C_{msoil} *= concentration of COPC in meat tissue from soil consumption (mg/kg).*
C_{mwater} *= concentration of COPC in meat tissue from water consumption (mg/kg).*
C_{mtotal} *= total concentration of COPC in meat tissue from soil, vegetation and water consumption (mg/kg).*
[a] Total arsenic concentration calculated in the moose meat was converted into inorganic arsenic concentration before being used in any of the risk calculations. Inorganic arsenic concentrations were estimated based on proportions of inorganic arsenic to total arsenic concentrations in Schoof et al. (1999) and were used in the country foods baseline assessments calculations. See Section 8.2.2 for further explanation.
All concentrations in mg/kg wet weight.

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Appendix C

Sample Calculation of the Estimated Daily Intake of Aluminum for Toddlers Consuming Moose Tissue

Appendix C. Sample Calculation of the Estimated Daily Intake of Aluminum for Toddlers Consuming Moose Tissue

$$EDI_{moose} = \frac{IR \times C_{moose} \times F_s}{BW}$$

$$EDI_{moose} = \frac{0.0452 \text{ kg/day} \times 1.43 \text{ mg/kg} \times 1.0}{16.5 \text{ kg BW}}$$

$$EDI_{moose} = 0.0039 \text{ mg/kg BW/day}$$

Parameter

EDI =	Estimated daily intake (mg/kg BW/day)
IR =	Ingestion rate (kg/day)
F_s =	Fraction of year consuming meat (unitless)
C_{moose} =	Predicted aluminum concentration in moose meat (95% UCLM, mg/kg)
BW =	Body weight of receptor (kg BW)

Parameter Value

IR =	0.0452
F_s =	1.00
C_{moose} =	1.43
BW =	16.5
EDI =	0.00390

Appendix D

Sample Calculation of Estimated Daily Lifetime Exposure to Arsenic for an Adult Consuming Rainbow/Bull Trout Tissue

Appendix D. Sample Calculation of Estimated Daily Lifetime Exposure to Arsenic for an Adult Consuming Rainbow/Bull Trout Tissue

$$ELDE_{\text{Rainbow/Bull Trout}} = \frac{IR \times Fs \times C_{\text{Rainbow/Bull Trout}} \times P_{as} \times YE}{BW \times LE}$$

$ELDE_{\text{Rainbow/Bull Trout}}$	= estimated lifetime daily intake of Rainbow/Bull Trout (mg/kg BW/day)
IR	= ingestion rate (kg/day)
$C_{\text{Rainbow/Bull Trout}}$	= metal concentration in Rainbow/Bull Trout (mg/kg wet weight)
$P_{\text{as (in Rainbow/Bull Trout)}}$	= proportion of inorganic arsenic relative to total arsenic concentration
Fs	= fraction of year consuming Rainbow Bull Trout (unitless)
YE	= years exposed (yr)
BW	= receptor body weight (kg BW)
LE	= life expectancy (yr)

Parameter	**Value**
IR	0.0114
$C_{\text{Rainbow/Bull Trout}}$	0.0946
$P_{\text{as (in Rainbow/Bull Trout)}}$	0.1
Fs	1
YE = LE	80
BW	70.7

$$ELDE_{\text{Rainbow/Bull Trout}} = \frac{0.0114 \text{ kg/day} \times 0.0946 \text{ mg/kg ww} \times 0.1 \text{ x } 80 \text{ yr}}{70.7 \text{ kg BW} \times 80 \text{ yr}}$$

$$ELDE_{\text{Rainbow/Bull Trout}} = 0.00000153 \quad \text{mg/kg BW/day}$$

Appendix E

Recommended Maximum Weekly Intake Rates for Country Foods

Table E-1. Sample Calculation of RMWI in Toddlers Consuming Moose Tissue

$$RMWI_{metal} = \frac{TRV_{metal} \times BW_{toddler} \times 7}{C_{moose}}$$

$RMWI_{metal}$	= recommended maximum weekly intake of moose meat (kg/week)
TRV	= toxicological reference value (mg/kg BW/day)
BW	= receptor body weight (kg)
7	= days/week
C_{moose}	= metal concentration in moose meat (mg/kg)

COPC	TRV_{metal} mg/kg BW/day	$BW_{toddler}$ kg	C_{moose} mg/kg	$RMWI_{metal}$ kg/week
Aluminum	1	16.5	1.43	81.0
Arsenic*	0.0003	16.5	0.0000140	2,466
Cadmium	0.001	16.5	0.000655	176
Chromium	0.001	16.5	0.00667	17.3
Cobalt	0.01	16.5	0.0116	99.2
Copper	0.091	16.5	0.206	51.1
Lead	0.00357	16.5	0.000420	981
Mercury	0.0003	16.5	0.00185	18.7
Nickel	0.025	16.5	0.0262	110
Selenium	0.0062	16.5	0.000153	4,668
Silver	0.005	16.5	NC	NC
Thallium	0.00007	16.5	0.000225	36.0
Vanadium	0.009	16.5	0.00419	248
Zinc	0.48	16.5	0.00874	6,340

Notes:

Highlighted cell indicates the lowest (final) RMWI = 17.3 kg/week.

COPC = contaminant of potential concern.

NC = not calculated because that parameter was not measured in environmental media data.

** Arsenic RMWIs are based on inorganic arsenic concentrations.*

Table E-2. Summary of Recommended Maximum Weekly Intakes for Adults

COPC	RMWI (kg/week)				
	Moose	Hare	Grouse	Berries	Rainbow/Bull Trout
Aluminum	347	3,224	9.44	67.9	996
Arsenic*	10,568	93,860	266	155	15.7
Cadmium	756	25,385	1,068	62.7	39.0
Chromium	74.2	690	30.4	65.7	46.7
Cobalt	425	5,497	49.5	2475	99.6
Copper	339	3,396	108	46.5	163
Lead	4,205	37,790	22.3	343	98.2
Mercury	80.1	1,371	21,282	297	NA
Methylmercury	NA	NA	NA	NA	8.13
Nickel	473	10,101	154,371	108	365
Selenium	18,387	247,458	892	282	5.65
Silver	NC	NC	NC	NC	NC
Thallium	154	1,847	12	173	9.90
Vanadium	1,064	9,693	127,678	2,227	1,273
Zinc	32,259	1,010,528	52,047	93.0	35.5

Notes:

COPC = contaminant of potential concern.

NC = not calculated because that parameter was not measured in environmental media data.

NA = not applicable.

RMWI = recommended maximum weekly intake.

Highlighted cells indicate the lowest RMWI for each country food item.

** Arsenic RMWIs are based on inorganic arsenic concentrations.*

Table E-3. Summary of Recommended Maximum Weekly Intakes for Sensitive Adults (Women of Child-bearing Age)

COPC	RMWI (kg/week)				
	Moose	**Hare**	**Grouse**	**Berries**	**Rainbow/Bull Trout**
Methylmercury	NA	NA	NA	NA	3.98

Notes:

COPC = contaminant of potential concern.

NC = not calculated because that parameter was not measured in environmental media data.

NA = not applicable.

RMWI = recommended maximum weekly intake.

Highlighted cells indicate the lowest RMWI for each country food item.

Table E-4. Summary of Recommended Maximum Weekly Intakes for Toddlers

	RMWI (kg/week)				
COPC	Moose	Hare	Grouse	Berries	Rainbow/Bull Trout
Aluminum	81.0	753	2.20	15.9	232
Arsenic*	2,466	21,905	62.1	36.1	3.66
Cadmium	176	5,924	249	14.6	9.09
Chromium	17.3	161	7.10	15.3	10.9
Cobalt	99.2	1,283	11.6	578	23.2
Copper	51.1	512	16.3	7.00	24.6
Lead	981	8,819	5.20	80.0	22.9
Mercury	18.7	320	4,967	69.3	NA
Methylmercury	NA	NA	NA	NA	0.929
Nickel	110	2,357	36,027	25.2	85.2
Selenium	4,668	62,818	226	71.6	1.44
Silver	NC	NC	NC	NC	NC
Thallium	36.0	431	2.72	40.4	2.31
Vanadium	248	2,262	29,798	520	297
Zinc	6,340	198,600	10,229	18.3	6.98

Notes:

COPC = contaminant of potential concern.

NC = not calculated because that parameter was not measured in environmental media data.

NA = not applicable.

RMWI = recommended maximum weekly intake.

Highlighted cells indicate the lowest RMWI for each country food item.

** Arsenic RMWIs are based on inorganic arsenic concentrations.*

Appendix F

Exposure Assessment and Risk Characterization Calculations based on Measured COPCs in Small Mammals

Table F-1. Estimated Daily Intake of Contaminants of Potential Concern by Human Receptors from Consuming Small Mammals (Voles, Mice, and Shrews)

COPC	Estimated Daily Intake of COPC by Adult Receptor mg/kg BW/day	Estimated Daily Intake of COPC by Toddler Receptor mg/kg BW/day
Aluminum	1.07×10^{-5}	1.98×10^{-5}
Arsenic*	$4.65 \text{ x } 10^{-10}$	8.57×10^{-10}
Cadmium	1.83×10^{-7}	3.37×10^{-7}
Chromium	3.21×10^{-8}	5.92×10^{-8}
Cobalt	5.37×10^{-8}	9.90×10^{-8}
Copper	3.12×10^{-6}	5.74×10^{-6}
Lead	1.71×10^{-7}	3.14×10^{-07}
Mercury	6.10×10^{-8}	1.12×10^{-7}
Nickel	1.53×10^{-7}	2.81×10^{-7}
Selenium	3.33×10^{-7}	6.14×10^{-7}
Thallium	4.19×10^{-9}	7.71×10^{-9}
Vanadium	1.88×10^{-8}	3.46×10^{-8}
Zinc	2.54×10^{-5}	4.68×10^{-5}

Notes:

COPC = contaminant of potential concern.

Small mammals included Red-backed voles (Myodes rutilus; *n = 17), Western jumping mice* (Zapus princeps; *n = 3), and masked shrews* (Sorex cinereus; *n = 1).*

Silver was not included as a COPC because it was not analyzed in small mammal tissues.

** Arsenic EDIs are based on inorganic arsenic concentrations. See Section 8.2.2 for further explanation.*

Table F-2. Human Exposure Ratios Based on Measured Small Mammal Tissue Concentrations

COPC	Exposure Ratio for Adult Receptor	Exposure Ratio for Toddler Receptor
Aluminum	1.07×10^{-5}	1.98×10^{-5}
Arsenic*	1.55×10^{-6}	2.86×10^{-6}
Cadmium	1.83×10^{-4}	3.37×10^{-4}
Chromium	3.21×10^{-5}	5.92×10^{-5}
Cobalt	5.37×10^{-6}	9.90×10^{-6}
Copper	2.21×10^{-5}	6.31×10^{-5}
Lead	4.78×10^{-5}	8.81×10^{-5}
Mercury	2.03×10^{-4}	3.75×10^{-4}
Nickel	6.10×10^{-6}	1.12×10^{-5}
Selenium	5.85×10^{-5}	9.90×10^{-5}
Thallium	5.98×10^{-5}	1.10×10^{-4}
Vanadium	2.08×10^{-6}	3.84×10^{-6}
Zinc	4.45×10^{-5}	9.74×10^{-5}

Notes:

COPC = contaminant of potential concern.

** Arsenic exposure ratios are based on inorganic arsenic concentrations.*

Silver was not included as a COPC because it was not analyzed in small mammal tissues.

Table F-3. Estimated Daily Lifetime Exposure and Incremental Lifetime Cancer Risk for Adult Human Receptors Exposed to Arsenic in Small Mammals

Country Food	ELDE mg/kg/day	ILCR unitless
Small Mammal 95% UCLM Tissue Metal Concentration	1.07×10^{-5}	1.93×10^{-5}
Small Mammal Mean Tissue Metal Concentration	4.05×10^{-8}	7.29×10^{-8}

Notes:

ELDE = estimated lifetime daily exposure.

ILCR = incremental lifetime cancer risk.

Shaded cells indicate elevated incremental lifetime cancer risk.

An ILCR estimate less than 1 $\times 10^{-5}$ *is normally considered acceptable (Health Canada 2010b).*

Arsenic ELDEs and ILCRs are based on inorganic arsenic concentrations.

Table F-4. Summary of Recommended Maximum Weekly Intakes of Small Mammals for Adults and Toddlers

COPC	Adult RMWI kg/week	Toddler RMWI kg/week
Aluminum	41.8	9.76
Arsenic*	290	67.6
Cadmium	2.46	0.573
Chromium	14.0	3.27
Cobalt	83.7	19.5
Copper	20.3	3.06
Lead	9.40	2.19
Mercury	2.21	0.516
Nickel	73.7	17.2
Selenium	7.69	1.95
Thallium	7.52	1.75
Vanadium	216	50.3
Zinc	10.1	1.98

Notes:

COPC = contaminant of potential concern.

RMWI = recommended maximum weekly intake.

** Arsenic RMWIs are based on inorganic arsenic concentrations.*

Silver was not included as a COPC because it was not analyzed in small mammal tissues.

Highlighted cells indicate the lowest RMWI for adults and toddlers.

Table F-5. Recommended Maximum Weekly Servings of Small Mammals

Human Receptor	Lowest Metal RMWI kg/week	Serving Size kg/day[a]	Recommended Number of Servings # servings/week
Adult	2.21	0.280	8
Toddler	0.516	0.0850	6

Notes:

RMWI = recommended maximum weekly intake.

[a] *Based on serving sizes from Richardson (1997).*