Appendix 18-A

Murray River Coal Project: 2012 Country Foods Baseline Report

MURRAY RIVER COAL PROJECT

Application for an Environmental Assessment Certificate / Environmental Impact Statement

HD Mining International Ltd.

MURRAY RIVER COAL PROJECT
2012 Country Foods Baseline Report

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July 2013

MURRAY RIVER COAL PROJECT
2012 COUNTRY FOODS BASELINE REPORT

July 2013
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Prepared for:

HD Mining International Ltd.

Prepared by:

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia

Executive Summary

Executive Summary

HD Mining International Ltd. (HD Mining) proposes to develop the Murray River Coal Project (the Project) as a 6 million tonne per annum (6 Mtpa) underground metallurgical coal mine. The property is located approximately 12.5 km south of Tumbler Ridge, British Columbia. The Project is located within the Peace River Coalfield (PRC), an area with a long history of metallurgical grade coal mining, mainly from open pit mining. HD Mining is proposing to access deeper zones of the coal field (600 to 1,000 m below surface) through underground mining techniques.

To support HD Mining's planning and development of the Project, and to contribute to the environmental assessment process, environmental and socio-economic baseline studies were initiated by Rescan Environmental Services Ltd. (Rescan). Project-specific studies began in 2010 and have continued through 2012. As appropriate and available, historical data from government sources and neighbouring projects, as well as traditional use/knowledge information, have been compiled and incorporated into this report.

This report presents a cumulative assessment of all country foods information compiled for the Project to date. The report assesses the exposure of people to contaminants of potential concern (COPCs) from the consumption of country foods from the country foods local study area (LSA) under pre-development conditions. Country foods are plants and animals that are collected, hunted, or fished for nutrition and/or medicinal purposes. An understanding of the baseline exposure of humans to COPCs in country foods is necessary in order to conduct a sound assessment of potential future Project-related effects on human health.

The main objectives of the country foods baseline program were to:

- summarize the quality of environmental media and screen-in relevant COPCs;
- characterize current levels of country food consumption and provide an exposure assessment to country food-derived COPCs for human consumers of country foods;
- identify acceptable daily exposure levels to COPCs (toxicity reference values or reference doses) 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 a country foods screening level risk assessment within the human health effects assessment of the future environmental assessment.

Animal and plant species were selected for evaluation based on current harvesting and consumption patterns by local First Nations (FN) residents. The Project is located within Treaty 8 territory. The West Moberly First Nations (WMFN), Saulteau First Nations (SFN) and McLeod Lake Indian Band (MLIB) are the nearest Treaty 8 First Nations to the Project and rely on country foods for subsistence and cultural and traditional uses. Therefore, these three FN were selected as study groups for this assessment. The country foods evaluated were moose (*Alces alces*), snowshoe hare (*Lepus americanus*), grouse (*Dendragapus sp.)*, bull trout (*Salvelinus confluentus*), eastern brook trout (*Salvelinus fontinalis*), mountain whitefish (*Prosopium williamsoni*), and berries (*Viburnum edule* and *Ribes sp.*). Physical environmental media (water, soil, sediments) were used for the screening of COPCs. A variety of sedges, lichen, and berries (fruit and leafs; *Carex* sp., *Cladina rangiferina, Stereocaulon paschale, Peltigera scabrosa*, *Viburnum edule, Ribes* sp., respectively) were used to predict wildlife tissue concentrations (Appendix A).

In order to avoid destructive sampling to obtain bird and mammalian wildlife tissue metal concentrations, evaluations of bird and mammalian wildlife species were conducted using a food chain model. This model used metal concentration data from three media (i.e., soil, water, vegetation [lichen, sedges, and berry leaves]), in conjunction with consumption and biotransfer factors to provide a conservative estimate of metal concentrations in consumable bird and wildlife tissues. All vegetation metal concentration data were pooled and served as an input, together with soil and water metal concentrations, to the wildlife food chain model to estimate bird and mammalian wildlife tissue metal concentrations.

Metal concentration data from berries were also used to estimate risks to human health from consumption of berries. Tissue samples for metal analysis were collected from mountain whitefish in 2005, Eastern brook trout in 2011, and bull trout in 2011 and 2012 as part of the Fish and Fish Habitat baseline program and were used in modelling the human exposure ratio.

Consumption quantities of country foods were based on information collected from BC on-reserve FN communities between 2008 and 2010 (Chan et al. 2011). Human health risks from the consumption of country foods were estimated using exposure ratios and RMWIs were calculated for each country food evaluated.

The results from this assessment indicate there is no unacceptable risk to human receptors for both toddler and adults from the consumption of moose, snowshoe hare, grouse, trout, and berries, except in one case: exposure ratios for mercury from the consumption of moose by toddlers were twice as high (0.48) than the Health Canada-recommended exposure level of 0.2; however, based on the highly conservative assumptions made for the wildlife model in this screening level risk assessment this is likely an overestimation of risk. Measurement of mercury in pooled moose meat samples collected from BC FN communities during the 2008-2010 *First Nations Food, Nutrition & Environment Study* resulted in non-detectable levels (< 0.01 ppm on a dry weight basis). Specifically in the area relevant to this assessment, moose was not determined to be among the top ten contributors of mercury. Based on the predicted and measured levels of metals in the assessed country foods, the amounts currently consumed by country food harvesters are within the RMWIs and below recommended incremental lifetime cancer risk (ILCR) levels. Thus, people may safely continue to eat these foods at the quantities and rates they are accustomed to.

Despite the above conclusion, there are some uncertainties associated with the baseline assessment (i.e., consumption rates, measured and modeled tissue concentrations, exposure durations and frequencies, and biotransformation factors). Conservative assumptions were made to account for these uncertainties and will likely result in an over-estimation of health risks associated with the consumption of country foods from the study area.

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MURRAY RIVER COAL PROJECT
2012 COUNTRY FOODS BASELINE REPORT

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Acknowledgements

Acknowledgements

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Acronyms and Abbreviations

Acronyms 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.

ATSDR	Agency of Toxic Substances and Disease Registry
BTF	Biotransfer Factor
BW	Body Weight
CCME	Canadian Council of Ministers of the Environment
COPC	Contaminant of Potential Concern
EA	Environmental Assessment
EDI	Estimated Daily Intake
EIS	Environmental Impact Statement
FN	First Nations
INAC	Indian and Northern Affairs Canada
LOAEL	Lowest Observed Adverse Effects Level
ISQG	Interim Sediment Quality Guideline
IRIS	Integrated Risk Information Service
JECFA	Joint FAO/WHO Expert Committee on Food Additives and Contaminants
MLIB	McLeod Lake Indian Band
MRL	Minimal Risk Level
NOAEL	No Observed Adverse Effects Level
PAH	Polycyclic Aromatic Hydrocarbon
POP	Persistent Organic Pollutants
PRC	Peace River Coalfield
PTDI	Provisional Tolerable Daily Intake
PTWI	Provisional Tolerable Weekly Intake
RfD	Reference Dose
RMWI	Recommended Maximum Weekly Intake
SFN	Saulteau First Nations
T8TA	Treaty 8 Tribal Association
TDI	Tolerable Daily Intake
TRV	Toxicity Reference Value
US EPA	United States Environmental Protection Agency
WMFN	West Moberly First Nations
WMU	Wildlife Management Unit

1. Introduction

1. Introduction

HD Mining International Ltd. (HD Mining) proposes to develop the Murray River Coal Project (the Project) as a 6 million tonne per annum (6 Mtpa) underground metallurgical coal mine. The property is located approximately 12.5 km south of Tumbler Ridge, British Columbia (Figure 1-1), and consists of 57 coal licences covering an area of 16,024 hectares. The Project is located within the Peace River Coalfield (PRC), an area with a long history of metallurgical grade coal mining, mainly from open pit mining. HD Mining is proposing to access deeper zones of the coal field (600 to 1,000 m below surface) through underground mining techniques.

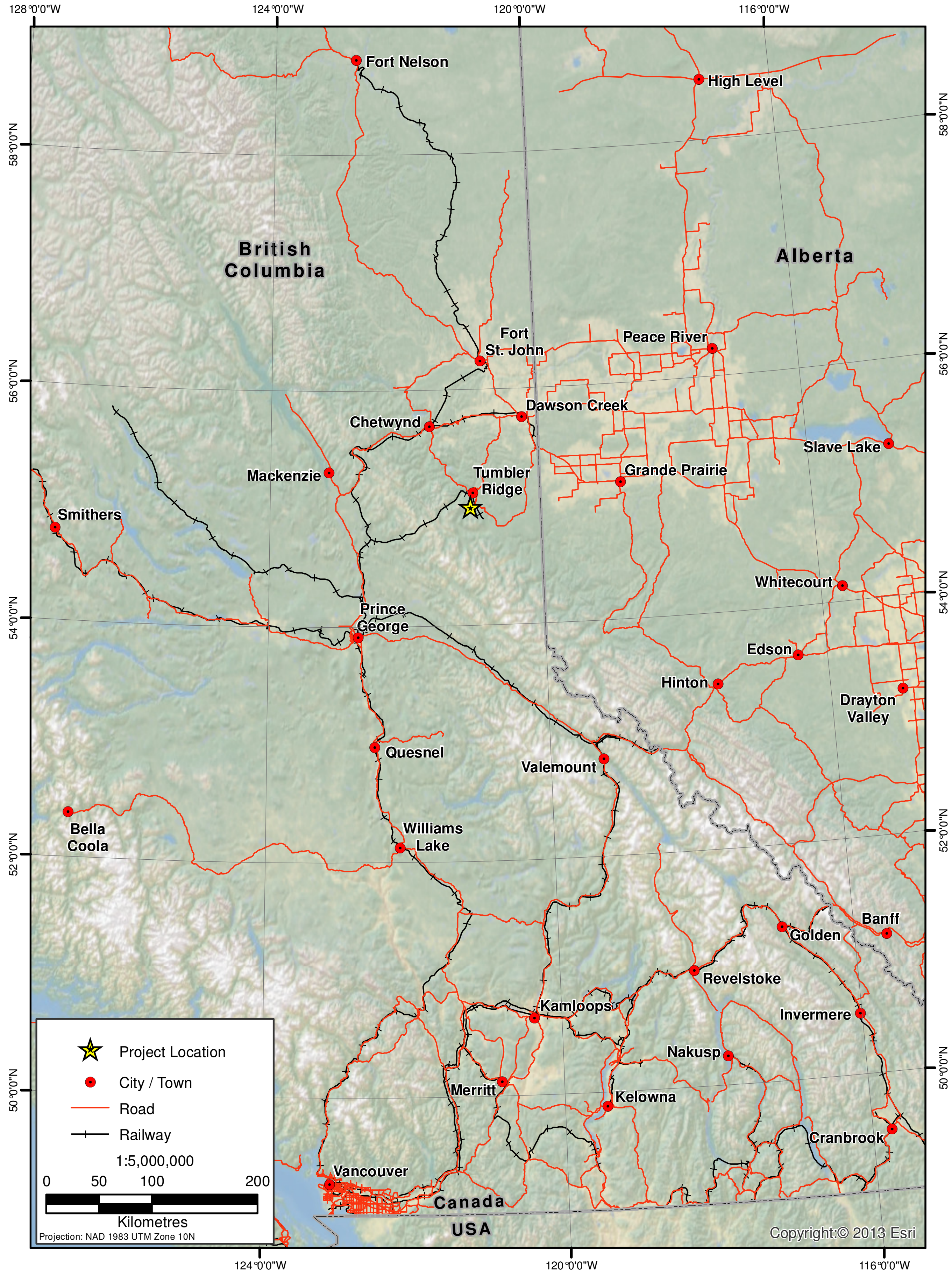
In October 2011, HD Mining submitted an application to the BC Ministry of Energy and Mines and Ministry of Environment seeking permission to complete a bulk sampling program as part of exploration of the property. In March 2012, HD Mining received approval to conduct a 100,000 tonne bulk sample for the purpose of conducting testing to assist in developing markets for the coal.

Beyond the bulk sample program, in order to develop a full mine at the proposed 6 Mtpa, the Project is subject to both the BC and Canadian environmental assessment processes. Development of any infrastructure for the full mine is not permitted before the requirements of these processes are met.

To support HD Mining's planning and development of the Project, and to contribute to the environmental assessment process, environmental and socio-economic baseline studies were initiated by Rescan Environmental Services Ltd. (Rescan). Project-specific studies began in 2010 and have continued through 2012. As appropriate and available, historical data from government sources and neighbouring projects, as well as traditional use/knowledge information, have been compiled and incorporated into analysis.

In order to help guide the scope of baseline studies, regional and local study areas (RSA and LSA, respectively) have been developed (Figures 1-2 and 1-3). The RSA is intended to encompass an area beyond which effects of the Project would not be expected. It is also intended to be ecologically relevant based on the home range of key wildlife species known to inhabit the region. The LSA encompasses an area surrounding the proposed Project infrastructure within which direct effects from the Project may be anticipated. Its boundary has also been developed following natural terrain and drainage boundaries in order to be ecologically relevant. For consistency, the same RSA and LSA are used for all environmental studies.

This report presents a cumulative assessment of all country foods information compiled for the Project to date. Country foods are plants and animals that are collected, hunted, or fished for nutrition and/or medicinal purposes. An understanding of the baseline exposure of humans to contaminants of potential concern (COPCs) in country foods is necessary in order to conduct a sound assessment of potential future Project-related effects on human health. Country foods were assessed at a local scale within the LSA boundaries (Figure 1-2) because any potential project-related effects to country foods will be highest in the LSA and the assessment will therefore be most conservative within the LSA. The baseline report assesses the exposure of people to COPCs from the consumption of country foods from the LSA under pre-development conditions.



MURRAY RIVER COAL PROJECT

Project Location

Figure 1-1

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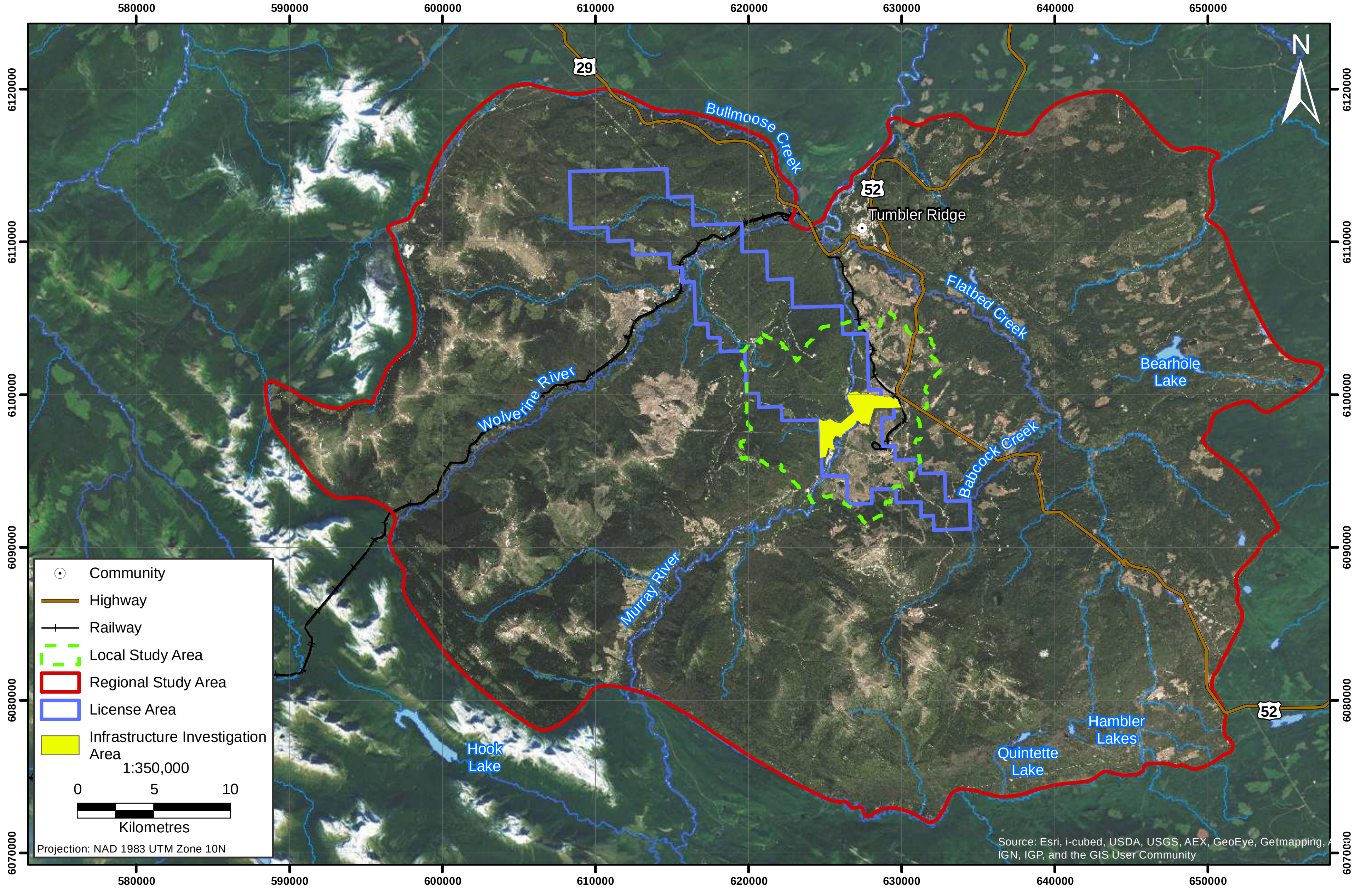

Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, IGN, IGP, and the GIS User Community

Figure 1-2

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MURRAY RIVER COAL PROJECT

Project Study Boundaries

Figure 1-2

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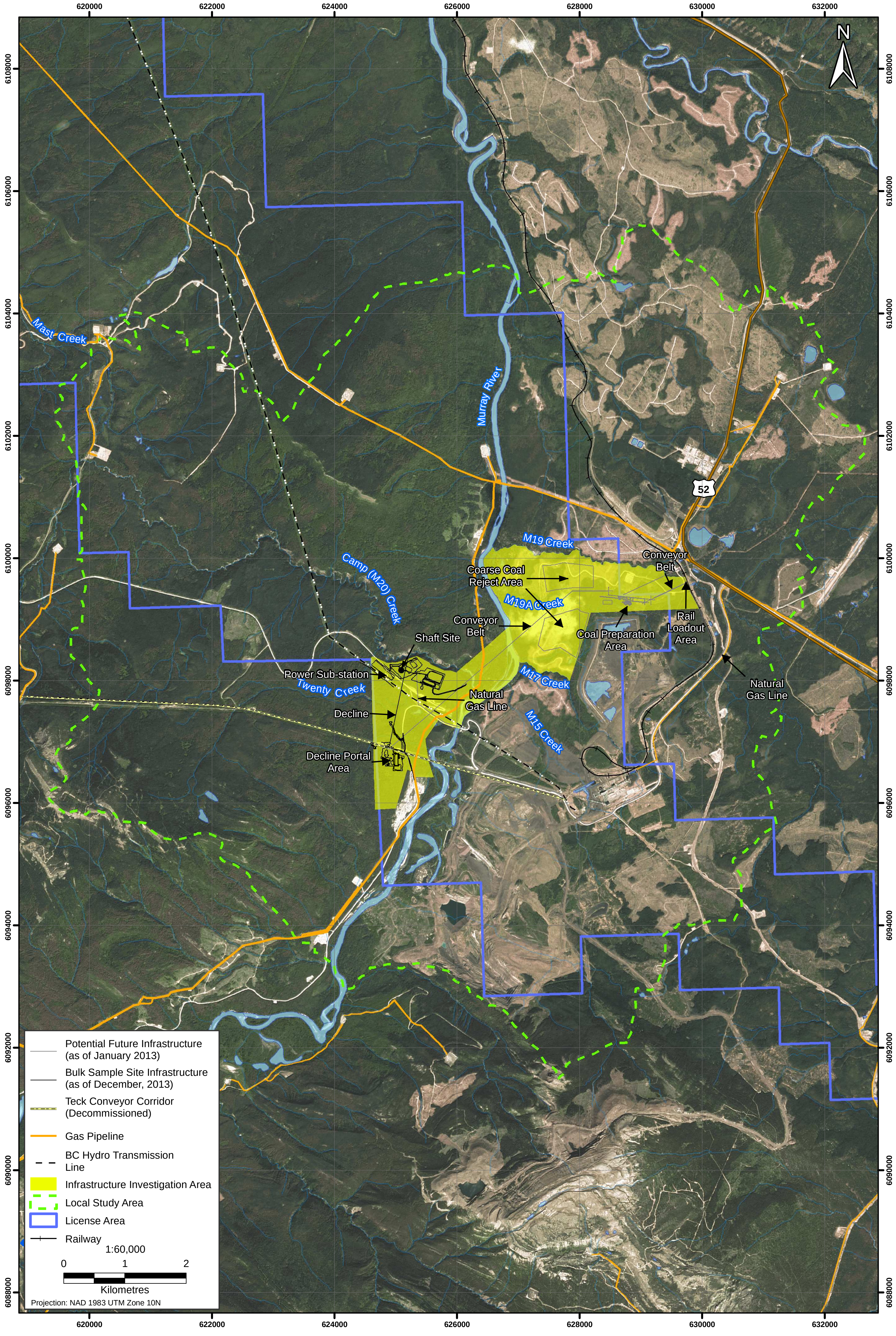
The concentration of metals in country foods can be directly related to the surrounding environmental media such as soil, water and vegetation. The country food risk assessment evaluates the metal concentration in these media to identify any COPCs. This report evaluates the current levels of metals in country foods and estimates the current consumption of metals by country food harvesters. It also presents the baseline recommended maximum weekly intakes (RMWI) of country foods, following Health Canada's guidance on health impact assessments (Health Canada 2010d). The main objectives of the country foods baseline program were to:

- summarize the quality of environmental media and screen-in relevant COPCs;
- characterize current levels of country food consumption and provide an exposure assessment to country food-derived COPCs for human consumers of country foods;
- identify acceptable daily exposure levels to COPCs (toxicity reference values or reference doses) 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 a country foods screening level risk assessment within the human health effects assessment of the future environmental assessment.

PROJECT # 0791-007-01 *GIS #* MUR-15-071 *VERSION #* T0.10 February 18 2013



MURRAY RIVER COAL PROJECT

Figure 1-3

Preliminary Site Layout

2. Background Information

2. Background Information

2.1 BACKGROUND INFORMATION

The quality of country foods has been of increasing concern over the last decade (INAC 2003). This concern is primarily due to studies showing the presence of persistent organic pollutants (POPs) and heavy metals in tissues of wildlife in undeveloped areas across Northern Canada and the Arctic. Increasing awareness about environmental effects on human health and the expansion of resource extraction in northeastern BC has led to public concern about the quality of country foods and has resulted in the commencement of a comprehensive human health risk assessment for northeastern BC led by the BC Ministry of Health (Fraser Basin Council 2012).

Indian and Northern Affairs Canada (INAC) developed the Northern Contaminants program to determine levels, geographic extent, and source of contaminants in the north (INAC 1991). Research has also included evaluating the health benefits and risks of consuming country foods. The potential benefits and risks have led Health Canada to provide guidance on the methodology of evaluating the quality of country foods (Health Canada 2010d). One of the main objectives of the studies is to provide information that assists individuals and communities in making informed decisions about their food consumption.

POPs are organic compounds that are resistant to environmental degradation, can bioaccumulate in an organism, and can biomagnify in the food chain. POPs are usually human generated chemicals (although some natural sources such as forest fires and volcanoes exist), whereas metals are naturally present in water and soil. Natural metal concentrations in water and soil vary based on geography and geology. In highly mineralized areas the water and soil can have naturally elevated concentrations of metals.

Many metals, such as copper, zinc, selenium, and manganese, are essential (or trace) minerals at low doses and are required to maintain proper health. However, doses that exceed nutritional requirements of these metals can cause adverse human health effects. Other metals, such as cadmium and lead, have no known beneficial biological function.

Metals were selected for evaluation because metals are present in the environment naturally and can co-occur at coal seams. This baseline study is required in order to distinguish naturally occurring metal concentrations from any potential future increase in metals from mining and transportation activities.

Although organic compounds, such as polycyclic aromatic hydrocarbons (PAHs) are tightly bound to coal and not generally released into the environment (Achten et al. 2011), PAHs were measured in baseline sediment and water samples.

2.2 APPLICABLE LEGISLATION (FEDERAL AND PROVINCIAL)

The inclusion of human health in environmental assessment (EA) in Canada has been recognized by the federal government and by the Province of BC under various legislation and requirements (Health Canada 2004, 2010e).

- BC's *Environmental Assessment Act* (2002): "Effects" are defined as including human health, and the purpose of the Act includes the assessment of "health effects"; and
- *Canadian Environmental Assessment Act* (2013): The definition of an "environmental effect" includes any changes in health or socio-economic conditions that are caused by the project's environmental effects.

Country food intake is an important pathway by which potential contaminants can affect human health. Country foods are therefore assessed using Health Canada's guidance document (Health Canada 2010d), which outlines the steps that need to be undertaken to characterize potential risks from the consumption of country foods.

2.3 LITERATURE REVIEW

First Nations (FN) are the people who are the traditional harvesters of country foods and rely on country foods for subsistence. The culture of hunting and of sharing food within the community increases the likelihood of exposure of sensitive populations (e.g., toddlers and elders) to COPCs and therefore focussing on FN is considered a conservative approach and inclusive of non-FN risks. Information about First Nations and their use of country foods was reviewed from reports and published literature. Rescan reviewed publicly available ethnographies and information on contemporary and traditional use and knowledge (Morice 1895, 1905; Goddard 1916; Jenness 1937; Ridington 1968, 1981, 1988; Weinstein 1979; Lanoue 1983, 1991; Denniston 1981; Lanoue and Ferrara 2004). Further information can be found in the socio-economic baseline (Rescan 2013g) and in recent applications for environmental certification by the BC Environmental Assessment office (TMW 2009; PRCI 2010; Finavera 2011). Further traditional use studies may be conducted by the individual FNs themselves and results will be incorporated in the environmental assessment if available.

The Project lies within Treaty 8 lands. The Treaty 8 signatory nations closest to the Project, and the Aboriginal study communities for this Project, are the McLeod Lake Indian Band (MLIB), West Moberly First Nations (WMFN), and Saulteau First Nations (SFN). These First Nations are members of the Treaty 8 Tribal Association (T8TA), which provides representation and coordination for member First Nations in a number of areas of common interest.

First Nations people maintain a subsistence economy based primarily on hunting, fishing, and plant gathering (Kuhnlein and Turner 2009), activities that benefit the health and social and cultural well-being of Aboriginal communities today. Aboriginal peoples have undergone a significant nutritional transition whereby traditional diets and associated activities have been replaced to some extent with patterns of consumption that increase the risk of chronic disease (Earle 2011). It is therefore important to examine the benefits and any potential risks associated with the consumption of country foods.

The intake of country foods varies by local geography, seasonality, and cultural group. Recent data for country food intake amounts, frequencies and country food species for the Treaty 8 First Nations was obtained from the *First Nations Food Nutrition & Environment Study* (Chan et al. 2011). It is recognized that each nation will have somewhat different country food intake characteristics, but the data provided in the report for the SFN (in aggregation with the Doig River First Nation within "ecozone 2") are the most recent and relevant for the purpose of this country foods baseline assessment. HD Mining is engaging all three First Nations to develop plans for TK/TU studies, but results were not available at the time of writing this baseline report.

All three First Nations were contacted to verify the information from the *First Nations Food Nutrition & Environment Study*. Initial response from SFN indicated that the values may under-estimate their current country food intake. However, this report represents the best available information. Exposure estimates may require updates if newer data from FN internal surveys are made available.

2.4 STUDY AREA AND LAND USE

The LSA is used for hunting, trapping, and fishing by resident and non-resident hunters and fishermen (Rescan 2013f). However, First Nations hunting and trapping is not captured in the Big Game Harvest Database or the trapline harvest data bases. Published summary maps (Brody 1981; Harris 1984) indicate the extent of some Aboriginal land use activities within the region, but those activities may not apply specifically to the country food LSA (Figure 2.4-1). The map indicates that the northwest corner of the license area was used by the WMFN and that the SFN land use borders the northwest corner of the license area. Review of secondary sources also indicates that Aboriginal trails pass through the LSA (Ballantyne 1978; Stryd 1982; Petro Canada 1983; Helm 2000, 2008).

A study of the Heritage Resources in the Northeast Coal Study Area, conducted by Ball (1978), identified 16 cabins (for resource acquisition activities) in their study area. None of these cabins were located within the footprint of the country foods LSA (Figure 2.4-2).

Although traditional use areas for the First Nation communities located closest to the Project are not overlapping with the LSA, existing highways (Highways 29 and 52) and a network of logging roads provide relatively easy access to the LSA for all FN and non-FN communities.

2.5 COUNTRY FOODS HARVESTERS

The Project is located within Treaty 8. The West Moberly First Nations (WMFN), Saulteau First Nations (SFN) and McLeod Lake Indian Band (MLIB) are the nearest Treaty 8 First Nations to the Project. A brief description of the study communities is provided below and was based on the *Murray River Coal Project Description* (Rescan 2013h), the *Murray River Coal Project: Socioeconomic Baseline* (Rescan 2013g), as well as derived from publicly available sources. Figure 2.5-1 shows the locations of the study communities.

McLeod Indian Band

The MLIB (Tsek'hene) community is located on Highway 97, approximately 140 km north of Prince George. MLIB is part of the Tsek'ehne ethno-linguistic group situated in the Rocky Mountain Trench (MLIB 2012). MLIB retain 21 reserves for their use and benefit totalling 20,053 ha; however the main community is still situated on McLeod Lake IR 1 (815.2 ha). This reserve is located on Highway 97, adjacent to the non-Aboriginal unincorporated Village of McLeod Lake (MLIB 2012). The MLIB is a community of approximately 490 members, with approximately 95 members living on McLeod Lake IR 1.

The MLIB continue to hunt and trap along the rivers and lakes that drain to the east into the Parsnip River, including Carp Lake and the Nation River and Lakes (Ridington 2008). Nation Lakes and Carp Lake are noted as productive hunting areas, and were the location of numerous MLIB traplines, while Carp Lake is also a well-known berry-picking area. Elk are harvested around Summit Lake and north of Hoglund Lake (Terrane 2008). Fish are harvested in the spring and summer at a number of locales, but primarily at the head of the Parsnip River and at Tabor Lake, Philip Lakes, Nation Lakes, Summit Lake, and McLeod Lake. Birds were harvested along the Crooked and Pack rivers (Terrane 2008). MLIB harvested bears in the past, but bears are not actively harvested anymore. They continue to harvest groundhogs and rabbits occasionally. Beavers and hare are still trapped for their pelts and their meat. Porcupines are occasionally harvested for their quills. People also continue to harvest grouse, geese and ducks (Terrane 2008).

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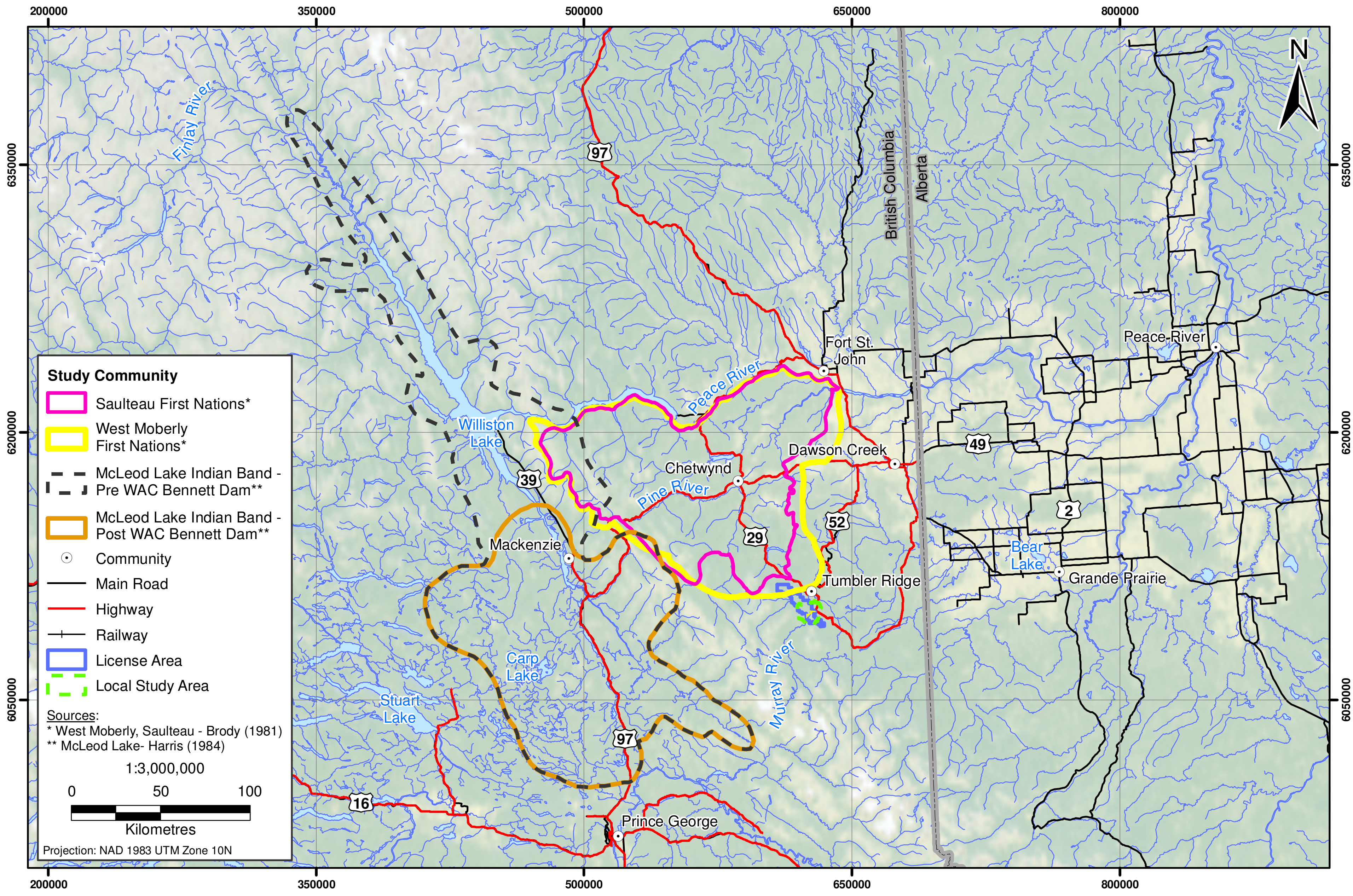

Figure 2.4-1

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Traditional Use of the LSA by the Study Communities

Figure 2.4-1

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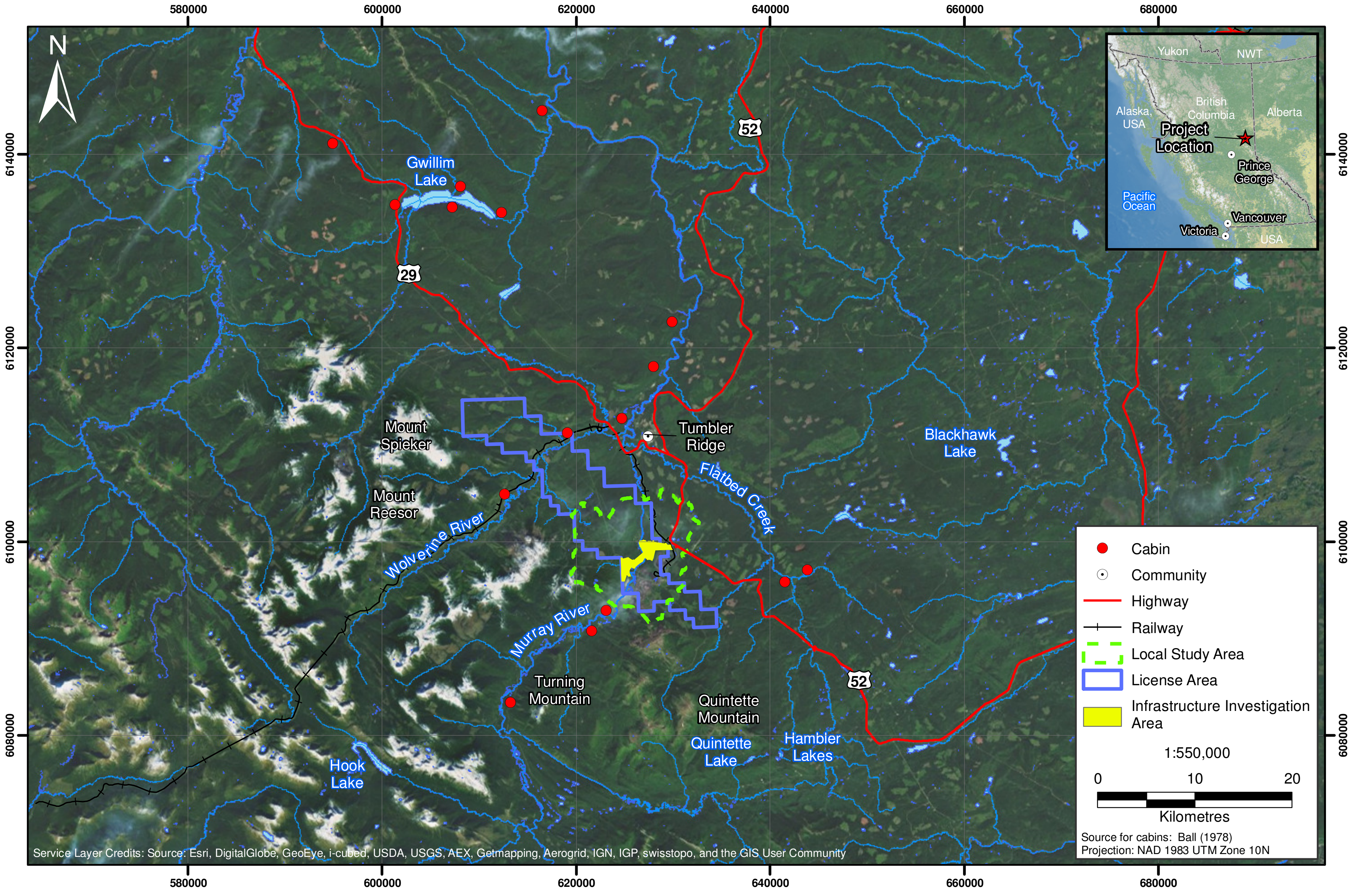

Source for cabins: Ball (1978)

Projection: NAD 1983 UTM Zone 10N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 2.4-2

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Cabins near the LSA ca. 1978

Figure 2.4-2

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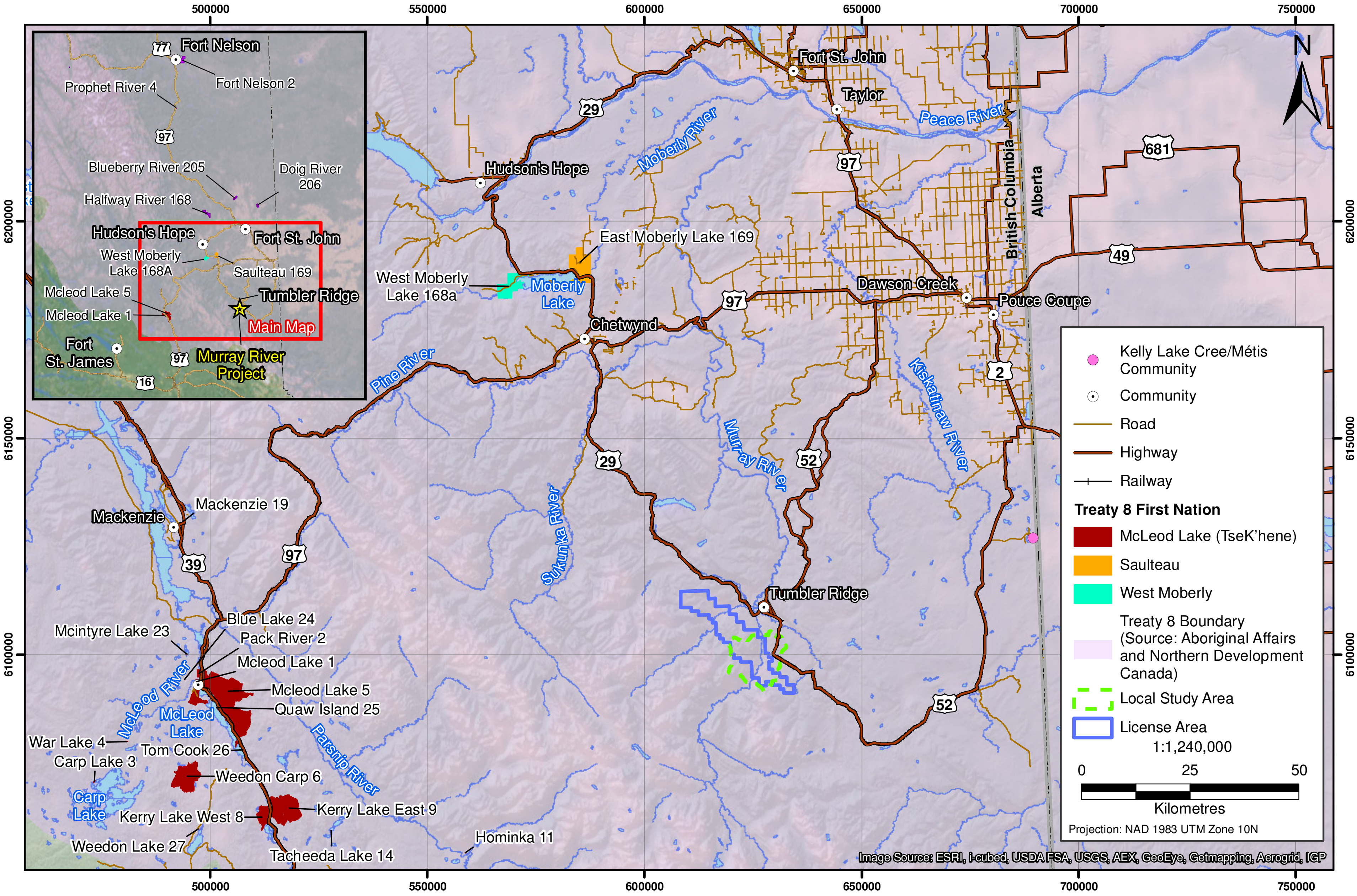

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MURRAY RIVER COAL PROJECT

Figure 2.5-1

Communities and Treaty 8 First Nations Located Near the Project

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West Moberly First Nation

The WMFN community is located on one 2,033ha reserve, West Moberly Lake 168A, at the west end of Moberly Lake, approximately 90 km southwest of Fort St. John and 30 km north of Chetwynd. The population of West Moberly First Nations is approximately 230 members, with about 85 members living on reserve. Hunting, trapping and fishing remain culturally and economically significant activities for the WMFN (PMT SRMP 2006). The traditional hunting and trapping territories of the WMFN are the foothills and mountains of the Rockies. Hunting and trapping occurred as far westward as the Ospika River, located on the western slope of the Rockies in the Rocky Mountain Trench. The Peace Moberly Tract, an area of land between Moberly Lake and the Peace River, is a key supply area for traditional foods for the WMFN. The area provides medicinal plants, as well as products used in cultural ceremonies, crafts, and the fabrication of items such as canoes, drums and snowshoes (PMT SRMP 2006).

Saulteau First Nations

The SFN community is located in the northern foothills of the Rocky Mountains, along the east end of Moberly Lake and near the Peace River Plateau, approximately 100 km southwest of Fort St. John and 25 km north of Chetwynd, along Highway 29. SFN is situated on one reserve, East Moberly Lake 169, with 3,025.8 hectares of land base. SFN is a Dunne-Zaa, Anishnaubemowin (Saulteau), and Nēhiyawēwi (Cree) speaking community with an approximate population of 840 members (T8TA 2012). According to the 2011 Census, there were 325 people living on the East Moberly Lake Reserve (Stats Can 2012).

Hunting, trapping and fishing remain culturally and economically significant activities for the SFN (PMT SRMP 2006). A vigorous hunting economy currently exists within the Saulteau community (PMT SRMP 2006; Finavera 2011). Moose is the mainstay of the hunting economy, although deer, mountain goat and caribou are also hunted. The SFN have historically hunted and trapped the lands south of the Peace River, and east of the Rocky Mountains since their arrival in the region in the late 19th century (Leonard 1995). This area includes lands within the Murray and Sukunka River watersheds, as well as northward within the Kiskatinaw River watershed to the Peace River (TMW 2009). Presently, the core of SFN hunting territory is located north of the present-day reserve, centered around the Moberly and Pine rivers, as well as Cameron and Boucher Lakes.

Historically, hunting, trapping, fishing, and gathering were central to the economic life of groups inhabiting northeast BC. Though the most important animal to the subsistence economy was moose, other large game, such as bison, caribou, deer, and bear, were also prized. Other animals were hunted or trapped by Tsek'ehne, Dane-zaa, Cree and Saulteaux groups, including mountain sheep and mountain goats, beaver, marmots, hares, porcupines, elk, grouse, ducks, and geese (Denniston 1981; Ridington 1981).

Resident and Non-Resident Harvest

In addition to Aboriginal use of country foods, resident and non-resident hunting takes place near the Project and is described in the *Murray River Coal Project - Non-traditional Land and Resource Use Baseline* (Rescan 2013f). No commercial angling guides are located within the Land Use RSA. No popular fishing destinations exist within the Land Use RSA. However, the Murray River, which runs through the LSA, provides some fishing opportunities with grayling, bulltrout, Eastern brook trout, and whitefish as targets. Target species for resident and non-resident hunting include black bear, caribou, cougar, elk, grizzly bear, moose, mountain goat, mountain sheep, mule deer, white-tailed deer and wolf. Resident hunters tend to target animals that provide meat for consumption (such as moose, elk and deer), while non-residents tend to target trophy animals (such as black bear and grizzly bear). Two guide outfitting licenses and three trap lines overlap the LSA and the LSA lies within one wildlife management units (WMU 7-12, Rescan 2013f). Harvest data for Wildlife Management Unit WMU 7-21 indicate that an average of 157 moose, 45 elk, 45 mule deer, and 43 white tail deer are killed per year by resident hunters and an average of 4 black bears, 3 moose, 2 elk and 2 grizzly bears were killed per year by non-resident hunters (Rescan 2013f). No harvest data are available for aboriginal hunting.

Although it is evident that non-aboriginal hunting and trapping takes place within the LSA, the study communities are the First Nations, because they are resident near the Project and rely on country foods for subsistence to a much greater extent than other consumers, and for cultural and traditional uses. Thus, the calculation of exposure to COPCs among FNs is the most conservative estimate (worst-case exposure scenario) that could be produced and is therefore inclusive of resident and non-resident exposures.

3. Methodology

3. Methodology

The methodology for this baseline country foods risk assessment was based on Health Canada's guidelines for health impact assessment (Health Canada 2010d).

The country foods assessment was divided into the following five stages:

1. **Problem Formulation**
   The Problem Formulation stage included the identification of the country foods requiring assessment, COPCs, and human receptors characteristics. A conceptual model, which is a pictorial representation of exposure pathways and routes associated with this specific assessment, is one of the major outcomes of the Problem Formulation.
2. **Exposure Assessment**
   The extent to which human receptors might be exposed to the COPCs was assessed. This included identifying the receptor specific characteristics (i.e., consumption amounts and consumption frequencies) and calculating the estimated daily intakes (EDIs).
3. **Effects Assessment (Toxicity Reference Value Assessment)**
   The tolerable daily intakes (TDIs), or doses of a chemical that can be taken into the body on a daily basis without appreciable health risk, were identified. These are referred to as Toxicity Reference Values (TRVs) by some regulatory agencies. These are the standards to which exposure estimates from the Exposure Assessment are compared to, in order to evaluate risk.
4. **Risk Characterization**
   The exposure and effects assessments were integrated to produce quantitative risk estimates (exposure ratios) and RMWIs. The RMWI is a recommended intake rate of country food items below which no risk to human health exists, and is compared to actual or assumed consumption rates used in the assessment.
5. **Uncertainty Analysis**
   The assumptions and uncertainties made throughout the assessment and their effects on the conclusions were evaluated.

The baseline assessment will describe the current quality of country foods, and will be used as a basis for comparison for a reassessment with predicted concentrations in support of an Environmental Assessment. It will also identify the need (if any) for future monitoring programs.

4. Problem Formulation

4. Problem Formulation

4.1 INTRODUCTION

The purpose of the problem formulation stage is to create a conceptual model for the country food assessment. This requires the identification of the most relevant country foods, COPCs, and human receptors that harvest foods from the LSA.

4.2 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 are currently collected in the LSA;
- how the country food is used (i.e., food, medicine, or both); and
- what part of the country food is consumed (i.e., specific organs, plant leaves or roots).

For FNs communities where a considerable amount of food is from country food harvesting, it is not always feasible to assess all country foods. This is due to the large number of species that are harvested and also seasonal availability due to migration patterns of the harvested populations or accessibility to hunting grounds. For FN groups, the foods selected for evaluation are those that result in the highest exposure to the COPCs (i.e., foods that are eaten most frequently and in the largest amounts). For instance, foods that are consumed every day are generally selected. Country foods that are consumed seasonally or infrequently may not be selected as they may not be a major exposure source of COPCs. Country foods are also selected based on their potential for chemical accumulation due to food chain position; for instance, top predator foods, which have a higher propensity for accumulating biomagnitive or bioaccumulative chemicals are selected for inclusion. These factors were considered when selecting the most relevant country food to evaluate.

For the country foods evaluation, First Nation consumption rates were estimated by evaluating data from the *First Nations Food Nutrition & Environment Study* (Chan et al. 2011). The data provided in the report for the SFN (in aggregation with the Doig River First Nation) from Ecozone 2 Boreal Plains/Subarctic are the most recent (2009 survey) and relevant for the purpose of this country foods baseline assessment. A total of 122 people, 93 people from the SFN and 29 people from the Doig River FN, participated in the surveys. Table 4.2-1 shows the percent of on-reserve study participants in Ecozone 2 who harvest traditional foods.

Table 4.2-1. Traditional Food Harvest Practices by On-reserve First Nations in Ecozone 2

Harvest Practice	Percent of Participants (%)
Hunted or set snares for food	66
Fished	37
Collected seafood	7
Collected wild plant food	46
Planted a garden	31

The following sections present the country foods that are harvested from the LSA and the foods that were selected for evaluation.

4.2.1 Aquatic Species

Fishing may have been a major food source to some First Nation groups within the Subarctic, but in general fish provided basic food only at certain times of the year when large game was difficult to secure. Fish were eaten fresh, dried for winter use, and used to feed sled dogs during the winter in recent years (Terrane 2008).

There are 19 freshwater fish species that are harvested and consumed by country food harvesters (Table 4.2-2; Chan et al. 2011). Various salmon and trout are the fish that are consumed most frequently by the FN in Ecozone 2. Salmon species are consumed by 63% of the people involved in the survey, while any type of trout was consumed by 34% of people. Marine fish or shellfish species are also consumed but were not included in this report because the LSA does not include a marine area.

Table 4.2-2. Percent of On-reserve BC First Nations from Ecozone 2 that Consumed Fish in the Year Prior to Survey

Traditional Food (Common Name)	Species Name	Percent of People Consuming Food (%)
Salmon (any type)	-	63
Sockeye	*Oncorhynchus nerka*	34
Trout (any type)**	-	33
Pink salmon	*Oncorhynchus gorbuscha*	30
Rainbow trout	*Oncorhynchus mykiss*	22
Trout, Dolly Varden	*Salvelinus malma malma*	19
Northern pike	*Esox lucius*	17
Lake trout	*Salvelinus namaycush*	14
Chinook	*Oncorhynchus tshawytscha*	9
Coho	*Oncorhynchus kisutch*	8
Trout, Bull**	*Salvelinus confluentus*	6
Chum	*Oncorhynchus keta*	5
Brook trout	*Salvelinus fontinalis*	3
Whitefish**	*Coregonus* spp.	2
Arctic grayling	*Thymallus arcticus*	2
Walleye (Pickerel)	*Sander vitreus*	2
Sucker (longnose, largescaled)	*Catostomus catostomus / macrocheilus*	1
Eulachon	*Thaleichthys pacificus*	1
Burbot	*Lota lota*	1
Yellow perch	*Perca flavescens*	1
Bass (any type)	-	1

*** Denotes this country food species was selected for evaluation.*
Adapted from Chan et al. (2011).

Northeastern BC has a range of lakes and rivers that support a variety of fish species including lake trout, Arctic grayling, northern pike, walleye, mountain whitefish, and bull trout. As such, fishing and angling are popular local activities in the region. The Murray River contains relatively high fisheries values and supports several regionally important sport-fish populations. The most significant feature defining fish distribution within the Murray mainstem is Kinuseo Falls, located 38 km upstream of the Project. This 60 m high waterfall represents the upper limit of distribution for most fish species. Native species present downstream of the falls include mountain whitefish (*Prosopium williamsoni*), Arctic grayling (*Thymallus arcticus*), bull trout (*Salvelinus confluentus*), northern pike (*Esox lucius*), burbot *(Lota lota*), longnose sucker (*Catostomus catostomus*), slimy sculpin (*Cottus cognatus*), longnose dace (*Rhinichthys cataractae*), finescale dace (*Phoxinus neogaeus*) and lake chub (*Couesius plumbeus*).

Three non-native sport-fish species have been introduced to the Murray River system in recent decades, including rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), and westslope cutthroat trout (Oncorhynchus clarkii lewisi; Diversified Environmental Services 2011; Rescan 2013e).

No specific fishing areas were indicated within the LSA by the land use baseline study (Rescan 2013f). However, the Murray River provides some fishing opportunities. Whitefish, bulltrout and grayling are reported as targets (Rescan 2013f).

Mountain whitefish are the most numerous sportsfish in the Murray River and are abundant throughout the Peace region. They are predominately mainstem spawners, but some of the yearlings and juveniles migrate into tributaries for feeding through the summer. Overwintering fish are found in congregations in large pools of the mainstem of the Murray River.

Bull trout are a blue listed char species that is generally thought to be in a state of decline throughout its global and BC range (MoE 2013). Young bull trout feed on zooplankton and zoobenthos, especially chironomids. As they grow larger, they begin to feed heavily upon other fish and fish eggs. Murray River bull trout move upstream to spawn in Fellers creek, a tributary to the Murray River approximately 27 km upstream of the Project. Bull trout have exacting habitat demands and can be impacted by resource extraction activities. Bull trout populations are also in danger from hybridization with non-native brook trout.

Eastern brook trout is a non-native introduced sports-fish species in the salmon family. Commencing in 1980, brook trout were introduced to five non fish-bearing lakes thought to be closed systems to provide ice-fishing opportunities for recreational anglers. These included Moose Lake, Quality Lake and three small lakes in the “Kinuseo Lakes” group. By 1990, it had become apparent that brook trout were escaping and colonizing downstream drainages within the middle Murray River watershed. Concerns about potential brook trout colonization of bull trout habitat prompted the discontinuation of brook trout stocking in the 1990s. Brook trout are now commonly found in several Murray River tributaries in the vicinity of the Project (Diversified Environmental Services 2011).

Other fish species were also considered for assessment as country foods. Tissue metals were not analyzed for grayling during the baseline fish and fish habitat assessments. Therefore, grayling was not included in the country food baseline assessment. Grayling and salmon are anadromous fish and reside primarily in marine waters except during early juvenile life stages and spawning migrations. Although salmon are reported as frequent food fish, the Murray River does not support salmon. Therefore, salmon were not included in the baseline assessment. While slimy sculpin and finescale dace were sampled for tissue metal analysis, they are not considered food fish and fish tissue metal data were therefore not included in the country foods assessment.

Based on the fish samples collected for tissue metal analysis and the frequency of use as food, trout (bull trout and Eastern brook trout) and mountain whitefish were included in this baseline country food assessment.

4.2.2 Terrestrial Species

Terrestrial species include large and small mammalian species and avian species. Table 4.2-3 presents a list of food, including food from terrestrial animals and berries, that have been reported for the LSA (Rescan 2013d) and are consumed by country foods harvesters (Chan et al. 2011).

Table 4.2-3. Seasonal Frequency of Top Ten Consumed Traditional Food Items for Consumers and Non-consumers Combined, Based on Average Days per Year, Ecozone 2, BC FN Living On-reserve

Traditional Food	Average Days per Season (SE) for Ecozone 2 Participants (n=122)				Average Days per Year (SE)
	Summer	Spring	Winter	Fall	
Moose meat	29 (5)	29 (5)	25 (1)	29 (5)	112 (17)
Elk meat	6 (0)	3 (1)	3 (1)	6 (1)	18 (1)
Blueberries (alaska, oval leaved, bog)	6 (1)	4 (1)	1 (1)	2 (1)	13 (1)
Salmon (any type)	4 (1)	2 (0)	2 (0)	3 (1)	11 (3)
Moose kidney	5 (4)	1 (1)	1 (1)	1 (1)	9 (7)
Wild strawberry	4 (0)	2 (1)	1 (0)	1 (0)	7 (0)
Labrador tea leaves	2 (1)	2 (1)	2 (1)	2 (1)	7 (5)
Saskatoon berry	4 (2)	1 (1)	1 (0)	1 (1)	7 (3)
Deer meat	2 (0)	1 (0)	2 (0)	2 (0)	7 (1)
Grouse (blue, ruffed)	1 (1)	1 (1)	1 (0)	1 (1)	5 (3)

Notes:
SE = Standard error
Adapted from Chan et al. (2011).

Moose, elk, and deer are large mammals commonly consumed by the FN study communities. Moose is the most frequently consumed large terrestrial mammal by the FN communities (112 days per year), and is a food item they rely on throughout the year (Table 4.2-3). The muscle tissue (meat) is most frequently consumed (97% of survey participants, see Table 4.2-6); however, moose kidney (49%) and liver (24%, data not shown) are also consumed on a more infrequent basis. A representative of the WMFN on April 2011 indicated in an interview with Rescan (WMFN Member, pers. comm) that all parts of the moose, except the lungs, are eaten by First Nations peoples, and that moose is consumed about 4 days per week throughout the year. However, a moose consumption rate of 112 days per year was chosen for this report to be consistent with consumption rates for other food sources provided by the *First Nations Food Nutrition & Environment Study*.

Moose are non-migratory large mammals with a variable size home range. Generally, animals may spend most of their time within one watershed and can therefore be representative of potential exposure from COPCs from an area within the LSA, which took natural terrain and drainage boundaries into consideration. It is also assumed that animals distribute the time they spend throughout their home range area equally.

There are no small mammals listed in the top ten consumed traditional food items for Ecozone 2 based on day per year consumed. However, 46% of surveyed people reported eating snowshoe hare (Table 4.2-4) and hares are distributed widely. Because hares are small herbivorous mammals and because they are eaten by FN study communities, hares were included in this report. In addition to snowshoe hare, beaver and muskrat are also reported as eaten by WMFN members, but only 3 and 6 times per year (WMFN Member, pers. comm).

Table 4.2-4. Percent of On-reserve BC First Nations from Ecozone 2 that Consumed Food from Terrestrial Species in the Year Prior to the Survey

Traditional Food (Common Name)	Species Name	Percent of People Consuming Food (%)
Mammals (non-specific)		100
Large Mammals		
Moose meat **	*Alces alces*	97
Elk meat	*Cervus canadensis*	67
Moose kidney	*Alces alces*	49
Deer meat	*Cervidae* sp.	40
Moose liver	*Alces alces*	24
other land mammals	-	10
Deer liver	*Cervidae* sp.	7
Caribou meat	*Rangifer tarandus*	7
Elk liver	*Cervus canadensis*	7
Elk kidney	*Cervus canadensis*	7
Sheep meat (bighorn, stone)	*Ovis canadensis / Ovis dalli stonei*	6
Black bear fat	*Ursus americanus*	5
Black bear meat	*Ursus americanus*	4
Mountain goat meat	*Oreamnos americanus*	3
Caribou liver	*Rangifer tarandus*	3
Caribou kidney	*Rangifer tarandus*	3
Dear kidney	*Cervidae* sp.	2
Small Mammals		
Rabbit (snowshoe hare)**	*Lepus americanus*	46
Beaver meat	*Castor canadensis*	22
Porcupine meat	*Erethizon dorsatum*	3
Birds (non-specific)		49
Grouse (blue, ruffed)**	*Dendragapus sp.*	45
Geese (Canada, brant, snow, greater white fronted)	*Branta* sp., *Anser* sp., *Chen* sp.	18
Ducks (non-fish eating, all combined)	-	15
Mallard	*Anas platyrhynchos*	9
Wood duck	*Aix sponsa*	2
American wigeon	*Anas americana*	2
Merganser (common, hooded)	*Mergus merganser*	2
Ptarmigan (willow, white tailed, rock)	*Lagopus* sp.	1
Swan (mute, trumpeter)	*Cygnus olor / Lagopus lagopus*	1
other birds	-	1

*** Denotes the country food species selected for evaluation.*
Adapted from Chan et al. (2011).

The harvested birds include various species of ducks, geese, grouse, ptarmigans, and occasionally swans (Chan et al. 2011; Anonymous, pers. comm.). Grouse are non-migratory birds with a small home range and are the most frequently consumed bird species among the top ten consumed traditional food items (5 days/year). Forty-five percent of survey participants reported eating grouse. Therefore, moose, snowshoe hare, and grouse were the three terrestrial country food species assessed in this report.

4.2.3 Vegetation Species

The LSA at Murray River is composed primarily of mesic forests and moderately dry forests (Rescan 2013b). There are also some bogs, wetlands, riparian and floodplain ecosystems. Anthropogenically modified areas, including existing mines, seismic lines, roads, transmission lines, oil, gas and hydro power developments, are interspersed throughout the LSA and are particularly common in the south eastern section. History of natural disturbances such as wildfires, windthrow, insect epidemics (notably pine beetle (*Dendroctonus ponderosae*)), and tree disease are widespread. The 2010-2012 Ecosystem and Vegetation Baseline Study Report (Rescan 2013b) provides further information (including scientific names) on plant species found in the LSA and RSA.

Berries were selected for sampling because they are common within the LSA and are a food source for wildlife and humans. Lichens were selected as they are known bioaccumalators of contaminants and can be used to monitor the movement and deposition of atmospheric particles and to detect metal effects on vegetation. Lichens, leaves of berries, and sedges were chosen as species consumed frequently by wildlife.

Northern communities still harvest a number of food plant resources, including highbush cranberry, Saskatoon berry, chokecherry, Indian-potato, and avalanche lily. Pine and spruce trees were used as sources of firewood and bark, while cottonwood trees were used for making dugout canoes. The cambium of lodgepole pine trees was also accessed as a food resource, although the use of cambium does not appear to be as widespread or intensive in the northeast as is was in the central interior of BC. Various hardwoods were used to smoke meat and fish (Terrane 2008).

First Nations study communities from ecozone 2 collect a variety of plant species for food or medicine (Table 4.2-5; Chan et al. 2011). Overall, berries are consumed more frequently than any other part of plants (roots, shoots, greens, inner bark, or mushrooms) and continue to be an important part of the MLIBs traditional resource consumption (Terrane 2008); however, they are not consumed to the extent they were in the past. The most commonly consumed berry species are Alaska, oval leaved and bog blueberry and are consumed by 82 % of the people surveyed in ecozone 2. Other commonly consumed berries include wild strawberries (72%), Saskatoon berry (70%), raspberries (63%). Blueberries, strawberries and Saskatoon berries are listed in the top ten consumed traditional food items (13, 7, and 7 days per year, respectively; Table 4.2-3) and are consumed predominately in the spring and summer. These berries are typically found throughout the areas used by the MLIB for traditional activities (Terrane 2008). For this study, cranberries (*Viburnum edule*) and currants (*Ribes* sp.) were collected from 15 sites throughout the LSA (Rescan 2013c), which are eaten by 25 and 6% of the surveyed population, respectively. While medicinal plants are highly important to the Aboriginal groups in this area, little has been written on the medicinal uses of specific plants. The MLIB provided a list of 43 plant species which were harvested traditionally in their TK study for the Roman Mountain Coal Project (Golder Associates 2009). MLIB is part of the Tsek'ehne and people from other bands of the Tsek'ehne have also discussed using Labrador tea, red-osier dogwood, devil's club, cow parsnip, and other plants for medicine (Littlefield, Dorricott, and Cullon 2007). An ethnobotany study of the Prophet River Band of Dane-zaa in the North Peace River area listed species such as trembling aspen, balsam fir, white spruce, jack pine, and other plants that had medicinal applications (Bannister 2006).

Table 4.2-5. Percent of On-reserve BC First Nations from Ecozone 2 that Consume Plant Species in the Year Prior to the Survey

Traditional Food (Common Name)	Species Name	Percent Consumption (%)
Wild Berries	Various	98
Blueberries (alaska, oval leaved, bog)	*Vaccinium alaskensis, V. ovalifolium, V. uliginosum*	82
Wild Strawberry	*Fragaria virginiana*	72
Saskatoon berry	*Amelanchier alnifolia*	70
Raspberry (wild, creeping)	*Rubus idaeus*	63
Blue huckleberry	*Vaccinium deliciosum*	27
Cranberry (low-bush/lingonberry, bog)**	*Viburnum edule*	25
Red huckleberry	*Vaccinium parvifolium*	15
Rose hips	*Rosa acicularis*	14
Crabapple	*Malus* sp.	10
Blackberry, trailing	*Rubus ursinus*	9
Blackberry, large (himalyan)	*Rubus armeniacus*	6
Gooseberry/currant**	*Ribes* sp.	6
Soapberries	*Sapindus*	5
Black caps (black raspberry)	*Rubus occidentalis*	3
Cloudberries	*Rubus chamaemorus*	3
Salal berries	*Gaultheria shallon*	2
Bunchberries	*Cornus canadensis*	2
Other plants	Various	29
Rat root	*Acorus calamus*	23
Labrador Tea - leaves	*Rhododendron* sp.	22
Onion (nodding, hooker’s)	*Allium cernuum, A. acuminatum*	4
Stinging nettle - leaves	*Urtica dioica*	3
Bitter root	*Lewisia rediviva*	3
Cow-parsnip - shoots	*Heracleum maximum*	3
Giant horsetail - shoots	*Equisetum* sp.	1

*** Denotes the country food species selected for evaluation*
Adapted from Chan et al. (2011).

It is important to note that berries and plants are usually collected closer to peoples’ homes and therefore not likely collected in the LSA (WMFN Member, pers. comm.). However, in order to estimate the potential exposure from COPCs in berries, it was assumed that 100% of consumed berries originate in the LSA. Highbush cranberries (*Viburnum edule*) and currants (*Ribes* sp.) were used in this assessment. *V. edule* is known under many different common names and therefore can be called lowbush as well as highbush cranberry.

4.2.4 Summary

A summary of the country foods selected for assessment is presented in Table 4.2-6.

Table 4.2-6. Country Foods Selected for Evaluation

Category	Country Food	Species Name	Parts Consumed
Wildlife	Moose	*Alces alces*	Muscle
	Snowshoe hare	*Lepus americanus*	Muscle
	Grouse	*Dendragapus* sp.	Muscle
Aquatic	Bull trout	*Salvelinus confluentus*	Muscle
	Eastern brook trout	*Salvelinus fontinalis*	Muscle
	Mountain whitefish	*Prosopium williamsoni*	Muscle
Plants	Highbush cranberry	*Viburnum edule*	Fruit
	Currants	*Ribes* sp.	Fruit

4.3 CONTAMINANTS OF POTENTIAL CONCERN SELECTED FOR EVALUATION

4.3.1 Chemicals Scoped Out as Chemicals of Potential Concern

Some chemicals that may be associated with Project development (i.e., petroleum hydrocarbons) were considered for evaluation in the baseline assessment. PAHs were analyzed in a subset of water and sediment samples inside the LSA. Water quality data showed that naphthalene was above detection limit (0.000043 mg/L) in one out of a total of three samples taken in June, August and October of 2010, but was below BC and CCME freshwater quality guidelines (Rescan 2013a). Analysis of sediment samples showed PAH concentrations above detection limit and above guidelines for several PAHs. Hydrocarbons that are associated with coal, although a significant source of PAHs in sediments, are not toxic to aquatic life since they are often not bioavailable (Chapman et al. 1996). This is in contrast to PAHs from other sources such as oil, which, although they contain many of the same constituents, are bioavailable and could result in adverse effects to the exposed biota (Chapman et al. 1996).

A study looking at the bioavailability of PAHs from sediments demonstrated that PAH associated with coal-derived materials are not bioavailable and do not result in bioaccumulation of PAHs in earthworms (Talley et al. 2002). In a recent study, PAH compounds were incubated with different types of soil and types of coal particles for 29 weeks under aerobic conditions. No significant decrease in soil or coal PAH was observed, indicating that PAHs strongly sorbed to the coal or coal-derived particles and were not bioavailable to the microbial communities (Achten et al. 2011).

A site-specific study conducted at Pine River and its tributaries including Murray River (its largest tributary) showed that “coal was a major contributor of PAHs to the Pine River watershed” and that benthic invertebrates were not affected by the PAHs from the coal (Pennart et al. 2004). In the current baseline assessment, PAH measurements in the freshwater were below the detection limit and elevated PAH levels were only detected in the sediments. As shown in the study by Pennart et al. (2004), the majority of these PAHs in the sediments are tightly bound to coal particles. This would result in these compounds being insoluble (resulting in measurements in water below the detection limit) and not bioavailable, resulting in no significant effects on the biota exposed to these sediments. Sediment quality guidelines will not be applicable in cases where hydrocarbons are not readily bioavailable (Chapman et al. 1996). Since these PAHs are not bioavailable, no data on PAH concentrations in fish tissues was collected and PAHs were not included in further consideration as contaminants of potential concern for country foods quality.

4.3.2 Inclusion of Metals as Contaminants of Potential Concern

The COPCs selected for this assessment were metals, which naturally occur in environmental media (i.e., soil, water and plant and animal tissue) under baseline conditions and where changes in their concentrations may be associated with future Project activities.

4.3.3 Screening Criteria for Contaminants of Potential Concern

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

- The 95th percentile of concentrations for a metal in surface waters measured during freshwater baseline studies (data included from 2010 to 2012) exceeded the Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of freshwater aquatic life or the BC maximum criteria for freshwater quality (CCME 2012c; Rescan 2013a; see Figure 4.3-1 for sampling locations and Table 4.3-1).
- The 95th percentile of concentrations for a metal in freshwater sediments collected in 2010 to 2012 exceeded the Canadian CCME interim sediment quality guidelines (ISQGs) for the protection of aquatic life and the BC sediment quality guidelines (BC MOE 2006b; CCME 2012a; Rescan 2013a). Figure 4.3-1 represents sediment sampling locations. The ISQG, rather than the probable effects level (PEL), lowest effects level (LEL, BC screening level concentration), or severe effects level (SEL, BC screening level concentration) was used for screening, because the ISQG is more conservative and used for evaluating the potential for biological effects (CCME 2012a). If no ISQG was available, the next lowest guideline was used (Table 4.3-2).
- The 95th percentile of the concentrations for a metal in surface soils collected from 2010 to 2012 exceeded the CCME soil quality guidelines for the protection of agricultural or parkland/residential soil or the lifestock or industrial criteria of the BC Contaminated Site Regulation (BC Reg. 375/96; BC CSR 2011; CCME 2012b; Rescan 2013c; see Figure 5.3-2 for sampling locations and Table 5.3-3).

Table 4.3-1. Summary Statistics for Total Metal Concentrations in Water Collected between 2010 and 2012

		Total Metal Concentrations in Water Samples Collected in the LSA (mg/L)				
Parameter	**Number of Samples**	**Mean**	**95th Percentile**	**Maximum**	**CCME Water Quality Guideline[1] (mg/L)**	**BC Maximum Criteria[2] (mg/L)**
Aluminum	293	**0.930**	**4.07**	**22.1**	0.1	0.1
Antimony	293	0.0000999	0.000336	0.000580		
Arsenic	293	0.000597	0.00250	**0.0192**	0.005	0.005
Barium	293	0.129	0.243	1.74		
Beryllium	293	0.000134	0.000328	0.00158		
Bismuth	284	<0.0005	<0.0005	<0.0005		
Boron	293	0.0109	0.0200	0.0550	1.5	1.2
Cadmium	293	**0.0000632**	**0.000235**	**0.00158**	0.000046	
Calcium	293	42.4	60.6	246		
Chromium	293	**0.00160**	**0.00657**	**0.0351**	0.001	
Cobalt	293	0.000564	0.00186	0.0202		0.11
Copper	293	0.00194	**0.00680**	**0.0501**	0.0033	0.016
Iron	293	**1.26**	**4.20**	**43.4**	0.3	1
Lead	293	0.000709	0.00240	**0.0284**	0.0052	0.134
Lithium	293	0.00550	0.0115	0.0541		

(continued)

Table 4.3-1. Summary Statistics for Total Metal Concentrations in Water Collected between 2010 and 2012 (completed)

Parameter	Number of Samples	Total Metal Concentrations in Water Samples Collected in the LSA (mg/L)			CCME Water Quality Guideline[1] (mg/L)	BC Maximum Criteria[2] (mg/L)
		Mean	95th Percentile	Maximum		
Magnesium	293	12.4	18.7	138		
Manganese	293	0.0299	0.0964	0.660		2.16
Mercury	293	0.0000119	**0.0000372**	**0.000250**	0.000026	0.0001
Molybdenum	293	0.000615	0.000959	0.00221	0.073	2
Nickel	293	0.00243	0.00777	0.0618	0.128	
Phosphorus	284	<0.3	<0.3	2.12		
Potassium	284	0.758	1.96	6.68		
Selenium	293	0.000678	**0.00250**	**0.00507**	0.001	0.002
Silicon	284	3.74	11.3	45.4		
Silver	292	0.0000269	**0.000186**	**0.000675**	0.0001	0.003
Sodium	284	4.23	12.8	34.5		
Strontium	288	**0.328**	0.230	**14.1**		
Tellurium	5	<0.002	<0.002	<0.002		
Thallium	287	0.00545	0.000316	0.193	0.0008	
Thorium	14	0.000211	0.000500	0.000500		
Tin	284	<0.0001	0.000139	0.00100		
Titanium	293	0.0308	0.133	0.685		
Uranium	293	0.000404	0.000682	0.00754	0.015	
Vanadium	293	0.00340	0.0137	0.0753		
Zinc	293	0.00805	0.0233	**0.227**	0.03	0.076

Notes:

For calculation purposes, half the detection limit was substituted for values that were below the detection method limit.

[1] Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment (CCME 2012b)

[2] British Columbia Maximum Criteria from British Columbia Ministry of Environment guidelines for the protection of freshwater aquatic life (BC MOE 2006a)

Shaded cells indicate concentrations greater than CCME (2012b) or BC maximum ambient water quality criteria (BC MOE 2006a). BC maximum criteria for cadmium, copper, lead, manganese, nickel, silver and zinc are hardness-dependent while aluminum maximum criteria is pH-dependent.

Table 4.3-2. Summary Statistics for Total Metal Concentrations in Sediments Collected between 2010 and 2012

Parameter	Number of Samples	Total Metal Concentrations in Sediment Samples Collected in the LSA (mg/kg)			CCME[1] and BC[2] Sediment Quality Guidelines (mg/kg)				
		Mean	95th Percentile	Maximum	ISQG[3]	PEL[4]	LEL[5]	SEL[6]	Other
Aluminum	38	7,122	12,675	14,100					
Antimony	38	0.490	0.800	0.900					
Arsenic	38	4.92	**7.35**	**7.60**	5.9	17			
Barium	38	278	482	544					
Beryllium	38	0.420	0.815	1.00					
Bismuth	38	<0.1	0.120	0.120					
Cadmium	38	**0.780**	**1.20**	**1.23**	0.6	3.5			

(continued)

Table 4.3-2. Summary Statistics for Total Metal Concentrations in Sediments Collected between 2010 and 2012 (completed)

Parameter	Number of Samples	Total Metal Concentrations in Sediment Samples Collected in the LSA (mg/kg)			CCME[1] and BC[2] Sediment Quality Guidelines (mg/kg)				
		Mean	95th Percentile	Maximum	ISQG[3]	PEL[4]	LEL[5]	SEL[6]	Other
Calcium	38	41,398	63,580	67,700					
Chromium	38	17.6	**41.6**	**61.9**	37.3	90			
Cobalt	38	6.70	10.8	11.4					
Copper	38	**20.0**	**28.8**	**29.6**	35.7	197			
Iron	38	15,790	**23,800**	**24,900**			21,200	43,766	
Lead	38	8.93	13.0	13.1	35	91.3			
Lithium	29	11.6	18.6	21.0					
Magnesium	38	14,666	19,330	21,300					
Manganese	38	282	428	443			460	1,100	
Mercury	38	<0.05	0.0732	0.0800	0.17	0.486			
Molybdenum	38	1.30	2.11	2.18					
Nickel	38	**26.7**	**42.1**	**54.7**			16	75	
Phosphorus	38	946	1,145	1,300					
Potassium	38	1,232	2,416	2,800					
Selenium	38	0.730	1.30	1.50					2
Silver	38	0.170	0.230	0.269					0.5[7]
Sodium	38	68.0	1221	140					
Strontium	38	56.4	90.1	92.8					
Sulfur	9	1,000	1,500	1,500					
Thallium	38	0.160	0.194	0.212					
Tin	38	1.20	5.80	10.9					
Titanium	38	20.5	42.0	51.8					
Uranium	38	0.810	1.07	1.10					
Vanadium	38	29.4	48.3	53.0					
Zinc	38	85.4	117	118	123	315			
Zirconium	29	1.26	3.30	3.60					

Notes:

For calculation purposes, half the detection limit was substituted for values that were below the detection method limit.

[1] Canadian sediment quality guideline for protection of freshwater aquatic life, Canadian Council of Ministers of the Environment (2012a)

[2] British Columbia working sediment guideline for the protection of freshwater aquatic life (BC MOE 2006b).

Shaded cells indicate concentrations greater than CCME (2012a) or BC sediment quality guidelines (BC MOE 2006b).

[3] ISQG = CCME interim sediment quality guideline

[4] PEL = CCME probable effects level

[5] LEL = BC lowest effect level based on the screening level concentration

[6] SEL = BC severe effect level based on the screening level concentration

[7] BC Working guideline based on Ontario sediment guideline

Table 4.3-3. Summary Statistics for Metal Concentrations in Soil

		Concentrations in Soil Samples Collected in the LSA (mg/kg dw)			BC CSR limits (mg/kg dw)		CCME limits (mg/kg dw)	
Parameters	Number of Samples	Mean	95th Percentile	Maximum	CSR-L Livestock Criteria[1]	CSR-I Industrial Criteria[2]	CCME Agricultural Criteria[3]	CCME Industrial Criteria[4]
pH	40	5.82	7.79	7.87				
Total Organic Carbon	23	3.94	13.0	39.0				
Metals								
Aluminum	17	7,249	10,640	11,600				
Antimony	40	2.10	5.00	5.00	20	40	20	40
Arsenic	40	4.67	8.53	**17.6**	25	100	12	12
Barium	40	211	**585**	**1,010**	400	1,500	750	2,000
Beryllium	40	0.310	0.631	0.660	4	8	4	8
Bismuth	17	0.100	0.100	0.100				
Cadmium	40	0.600	**1.87**	**2.16**	70	500	1.4	22
Calcium	17	8,206	23,900	54,700				
Chromium	40	10.8	15.9	20.8	50	700	64	87
Cobalt	40	4.50	8.56	10.2	40	300	40	300
Copper	40	10.0	21.7	30.5	150	250	63	91
Iron	17	16,082	25,120	36,800				
Lead	40	10.0	15.0	15.0	350	2,000	70	600
Lithium	17	8.30	13.4	13.5				
Magnesium	17	2,974	7,512	13,400				
Manganese	17	283	744	779				
Mercury	40	0.0380	0.100	0.114	0.6	150	6.6	50
Molybdenum	40	1.40	2.00	2.91	5	40	5	40
Nickel	40	14.0	29.8	32.7	150	500	50	50
Phosphorus	17	552	844	1,190				
Potassium	17	919	1,522	1,650				
Selenium	40	0.337	0.864	**1.66**	2	10	1	2.9
Silver	40	0.490	1.00	1.14	20	40	20	40
Sodium	17	50.0	50.0	50.0				
Strontium	17	19.0	51.2	51.2				
Thallium	40	0.258	0.500	0.500	2		1	1
Tin	40	1.69	2.50	**6.10**	5	300	5	300
Titanium	17	42.0	73.0	114				
Uranium	40	0.510	1.08	1.35			23	300
Vanadium	40	27.0	42.1	46.8	200		130	130
Zinc	40	52.0	91.7	120	200	600	200	360

Notes:

For calculation purposes, half the detection limit was substituted for values that were below the method detection limit.

Shaded cells indicate concentrations greater than CCME or BC CSR guideline levels.

[1] *CSR-L = Contaminated Site Regulation (BC Reg. 375/96), Livestock Criteria (BC CSR 2011).*

[2] *CSR-I = Contaminated Site Regulation (BC Reg. 375/96), Industrial Criteria (BC CSR 2011).*

[3] *CCME Canadian Soil Quality Guidelines for Protection for Environmental and Human Health, Agricultural Limits (CCME 2012b).*

[4] *CCME Canadian Soil Quality Guidelines for Protection for Environmental and Human Health, Industrial Limits (CCME 2012b).*

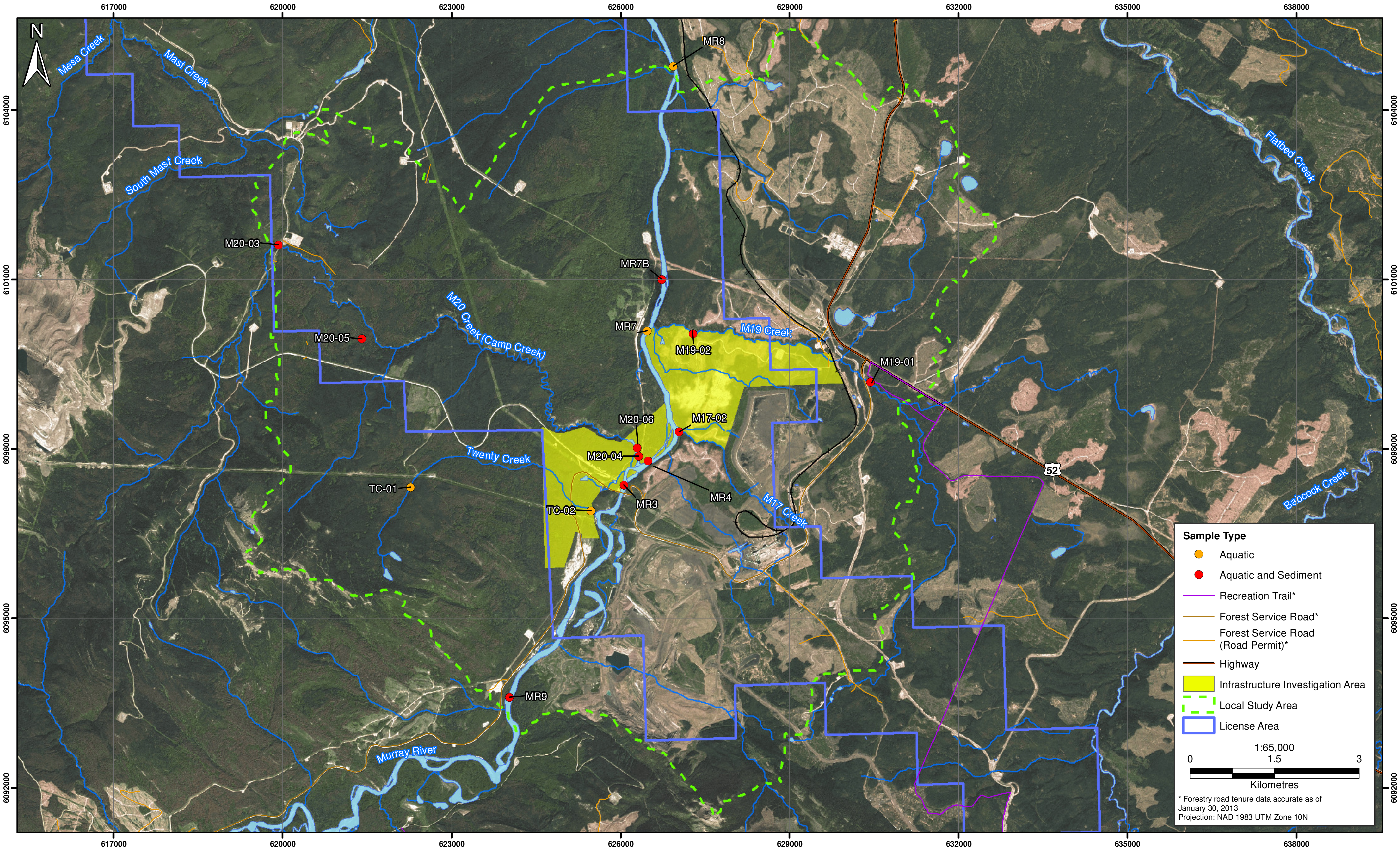

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Figure 4.3-1

Sample Locations of Stream Water and Sediment (2010-2012)

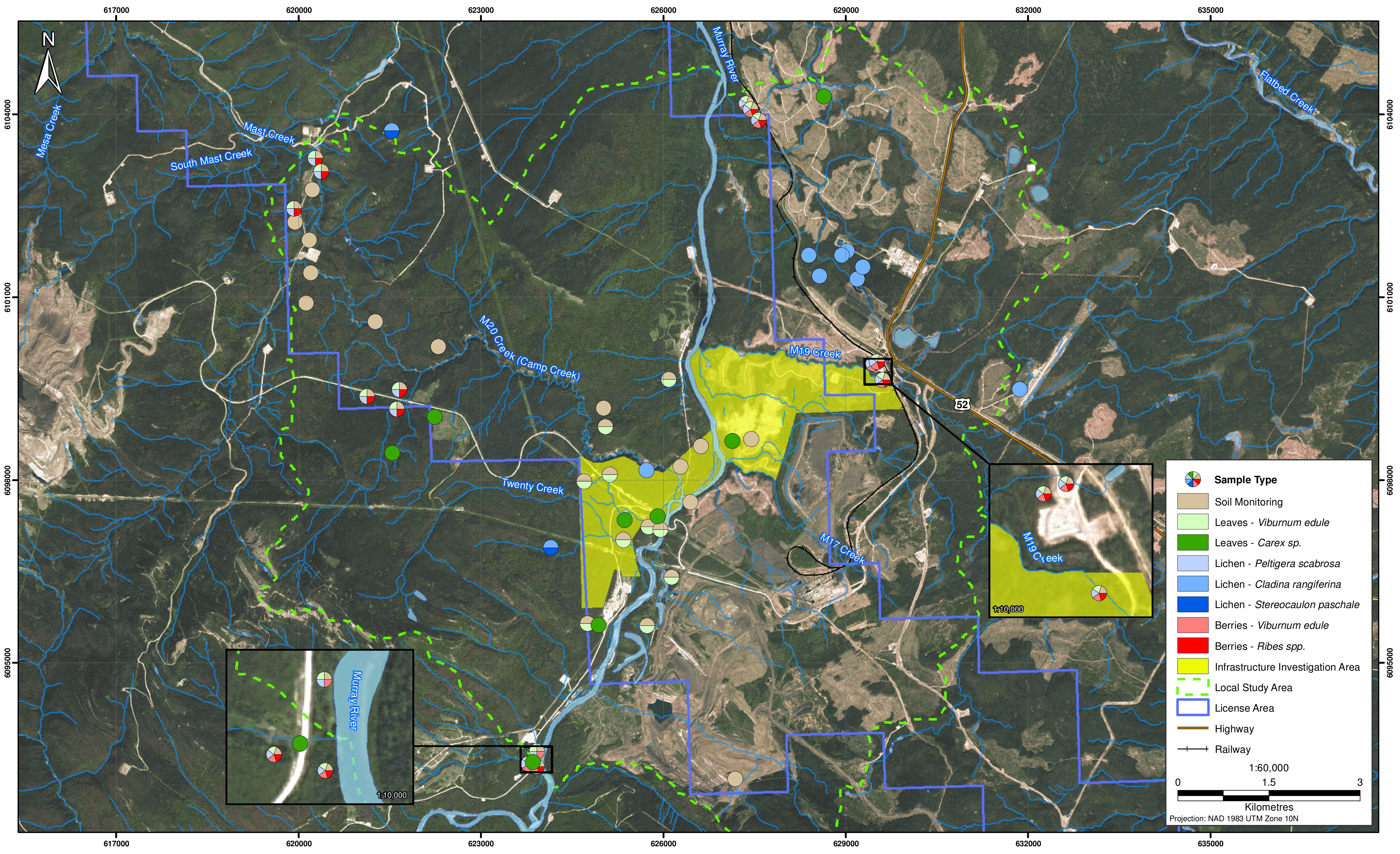

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Figure 4.3-2

Sample Locations for Soil, Lichen, and Plant Tissue (2010-2012)

The method detection limit (MDL) is the lowest detectable laboratory concentration. For the purpose of summarizing the data, when metal concentrations in water, sediment 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 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 (ie., with regards to human health; US EPA 2000a).

It is noted that the maximum and the mean concentrations of media, in addition to the 95th percentile, are presented to provide a measure of the maximum level and the central tendency to which a metal is distributed in the LSA and to provide an input to the wildlife food chain model.

Tables 4.3-1 to 4.3-3 present a summary of the results for the metal analysis in water, sediments and soils collected between 2010 and 2012, respectively. Samples were collected from six Murray River sites dissecting the LSA, tributaries TC, M17, M19, and M20, and wetlands (Figure 4.3-1). Analytical results for water and sediment concentrations of metals are provided in the *2010-2012 Aquatics Cumulative Baseline Report* (Rescan 2013a). Table 4.3-4 provides the screening of water, soil and sediment concentrations (95th percentile) against the CCME Environmental Guidelines and identifies the COPCs that were selected for evaluation. The following ten COPCs were selected: aluminum, arsenic, barium, cadmium, chromium, copper, mercury, nickel, selenium, and silver.

Table 4.3-4. Metal Contaminants of Potential Concern Selected for Analysis Based on Screening using CCME and BC Guidelines for Water, Soil, and Sediment Quality

Parameter	95th Percentile Water Concentration Exceeds CCME or BC Guidelines	95th Percentile Sediment Concentration Exceeds CCME or BC Guidelines	95th Percentile Soil Concentration Exceeds CCME or BC Guidelines	Chosen as COPC
Aluminum	yes	no	no	yes
Antimony	no	no	no	no
Arsenic	no	yes	no	yes
Barium	no	no	yes	yes
Beryllium	no	no	no	no
Bismuth	no	no	no	no
Boron	no	-	-	no
Cadmium	yes	yes	yes	yes
Calcium	no	no	no	no
Chromium	yes	yes	no	yes
Cobalt	no	no	no	no
Copper	yes	yes	no	yes
Iron	yes	yes	no	no
Lead	no	no	no	no
Lithium	no	no	no	no
Magnesium	no	no	no	no
Manganese	no	no	no	no
Mercury	yes	no	no	yes
Molybdenum	no	no	no	no

(continued)

Table 4.3-4. Metal Contaminants of Potential Concern Selected for Analysis Based on Screening using CCME and BC Guidelines for Water, Soil, and Sediment Quality (completed)

Parameter	95th Percentile Water Concentration Exceeds CCME or BC Guidelines	95th Percentile Sediment Concentration Exceeds CCME or BC Guidelines	95th Percentile Soil Concentration Exceeds CCME or BC Guidelines	Chosen as COPC
Nickel	No	**yes**	no	**yes**
Phosphorus	no	no	no	no
Potassium	no	no	no	no
Selenium	**yes**	no	no	**yes**
Silicon	no	-	-	no
Silver	**yes**	no	no	**yes**
Sodium	no	no	no	no
Strontium	no	no	no	no
Tellurium	no	-	-	no
Thallium	no	no	no	no
Thorium	no	-	-	no
Tin	no	no	no	no
Titanium	no	no	no	no
Uranium	no	no	no	no
Vanadium	no	no	no	no
Zinc	no	no	no	no
Zirconium	-	no	-	no

Iron was not identified as a COPC despite measured concentrations in surface waters and sediment exceeding CCME guidelines for the protection of freshwater aquatic life. Iron is an essential element as it is a required component in the 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. Iron toxicity 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 (EVM 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 or the individual has an accompanying genetic defect (EVM 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 (EVM 2003). The US EPA has not calculated a reference dose (RfD) for iron, but the WHO has listed a provisional maximum tolerable daily intake (PMTDI) for iron (from all sources) of 56 mg/day (Goldhaber 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.

4.4 HUMAN RECEPTORS

Both adults (older than 19 years of age) and toddlers (six months to four years of age) were evaluated for their susceptibility to selected COPCs. Adults comprise the largest section of the population, and include pregnant women and breast-feeding mothers as a sensitive group. Adults are the people most likely to harvest, process and consume country foods. Country food consumption has also been determined to increase with age (Health Canada 2003). Toddlers are considered the most susceptible life stage for chemical exposures because of their higher relative ingestion rates per unit body weight and their rapid absorption and metabolic rates during this important growth period, compared to adults. Elderly people can also experience life stage sensitivity. Therefore, adults and toddlers were selected as the human receptors for this assessment.

The intake of some COPCs (e.g., copper, selenium) that are considered essential trace elements is evaluated against toxicity reference values (TRVs) that are specific for different age groups and reflect their tolerable upper intake levels (Health Canada 2010b, 2010c).

For carcinogenic risk, all life stages are susceptible. However, adults are used to evaluate carcinogenic risk because this is calculated over an adult lifespan, as recommended by Health Canada (2010b, 2010c).

4.5 HUMAN EXPOSURE PATHWAYS

The purpose of the exposure pathway screening process is to determine the primary route that people in the Project area may come into contact with metals. Some examples of exposure pathways are skin contact, inhalation of dust, and drinking water. However, these exposure pathways are not relevant to country food exposures. The exposure pathway that was selected for the country food assessment was the ingestion of:

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

The exposure pathways are shown in Figure 4.5-1. This figure presents the source of the metal, residency media (i.e., fish, plants and animals), exposure routes, and receptors. The conceptual model for this assessment is presented in Figure 4.5-2.

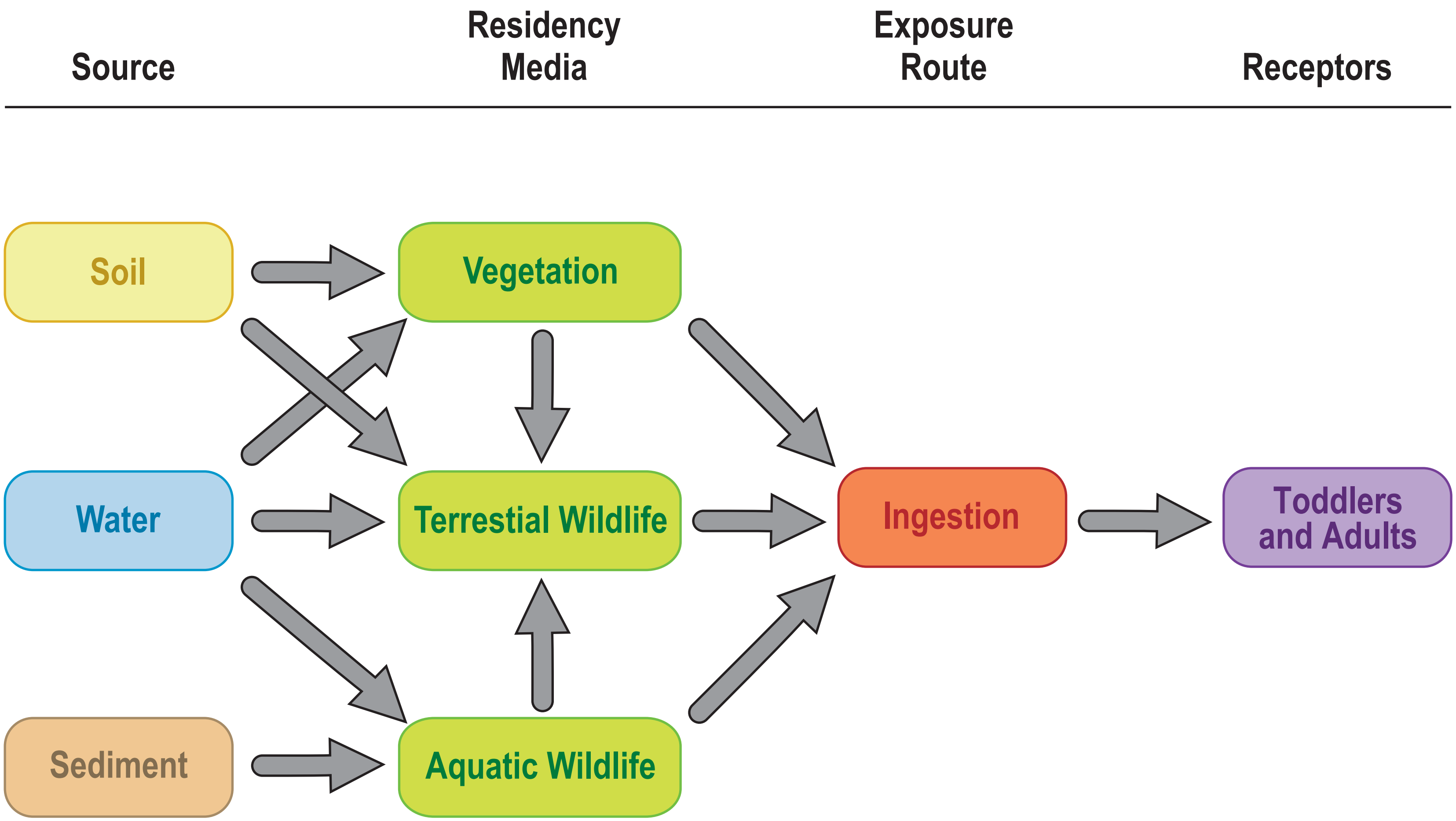

Figure 4.5-1

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Human Exposure Pathways

Figure 4.5-1

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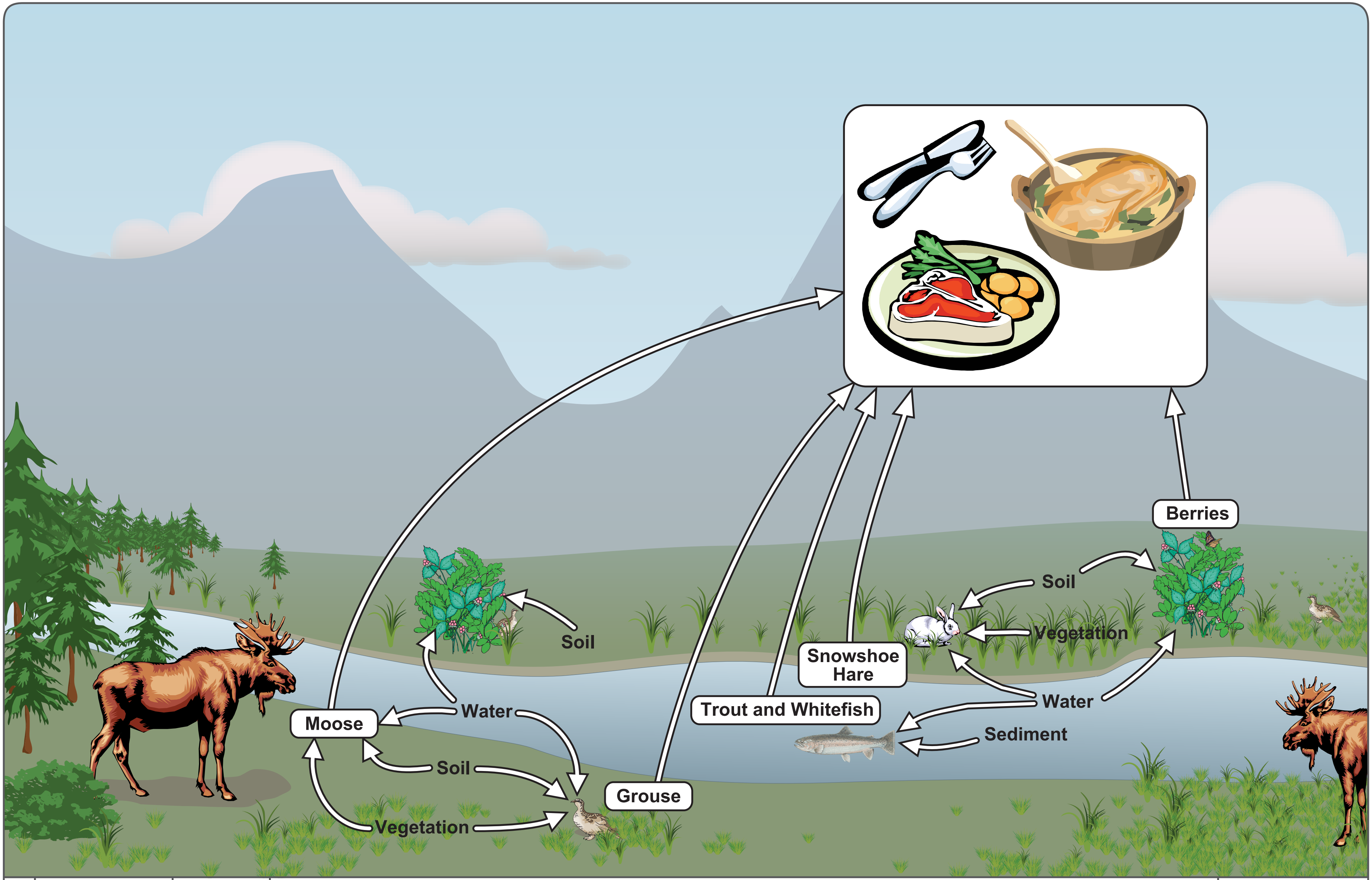

Figure 4.5-2

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Country Foods Conceptual Model of COPC Exposure

Figure 4.5-2

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5. Exposure Assessment

5. Exposure Assessment

5.1 INTRODUCTION

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

- the concentration of metals in aquatic species (trout) tissue resulting from their uptake of metals from the water, sediment, and diet;
- the concentration of metals in terrestrial wildlife (moose, snowshoe hare, grouse) tissue resulting from ingestion of environmental media (vegetation, water and soil);
- the concentration of metals in vegetation (highbush cranberry, currants) resulting from their uptake of metals in soil and water; and
- human receptor characteristics (i.e., consumption amount, frequency, body weight, age).

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

5.2 AQUATIC SPECIES TISSUE CONCENTRATIONS

Metal concentrations were analyzed from composite samples collected by EVS-Golder Associates in 2004, Ministry of Environment in 2005, Diversified Environmental Services in 2011, Stantec in 2011, and Rescan in 2011 (Rescan 2013e). Three mountain whitefish (*Prosopium williamsoni*), six bull trout (*Salvelinus confluentus*), three Eastern brook trout (*Salvelinus fontinalis*), and 72 slimy sculpins (*Cottus cognatus*) samples were collected between 2004 and 2012 from within the LSA (Figure 5.2-1). However, only bull trout, brook trout and mountain whitefish (one composite) were considered country food species, and were incorporated into the analysis for country foods (n=10), while slimy sculpins were excluded (see rationale in Section 4.2.1). The mean fork lengths for whitefish, bull trout and Eastern brook trout samples were 69 mm, 179 mm, and 154 mm, respectively. The mean tissue concentrations of the COPCs are presented in Table 5.2-1. The mean COPC concentration of all fish species and samples was used to calculate human exposure ratios. Detailed fish tissue metal concentrations are presented in appendices to (Rescan 2013e).

Older samples for mountain whitefish tissue metals from 2005 were based on dry weight and had a higher method detection limit (MDL) for chromium than samples obtained in 2011 and 2012. Metal concentrations with values below the detection limit were replaced with half the value of the detection limit for summary calculations of samples with different metal detection limits.

5.3 VEGETATION TISSUE CONCENTRATIONS

Plant species that were collected and analyzed for metal concentrations in 2010, 2011, and 2012 were: sedges (*Carex* sp.), lichen (*Cladina rangiferina, Stereocaulon paschale,* and *Peltigera scabrosa)*, berries (fruit and leafs; *Viburnum edule* and *Ribes* sp.). Sample locations for the different species are illustrated in Figure 4.3-2. Samples that were taken at or just outside the LSA boundary were included in the model, because they were collected as part of the baseline sampling program intended to sample throughout the LSA (Rescan 2013c). Detailed sampling methods and results are provided in Rescan (2013c). Only above-ground parts of plants (leafs, berries) are collected. Summary statistics (mean, 95th percentile and maximum) plant tissue concentrations of COPCs are presented in Table 5.3-1.

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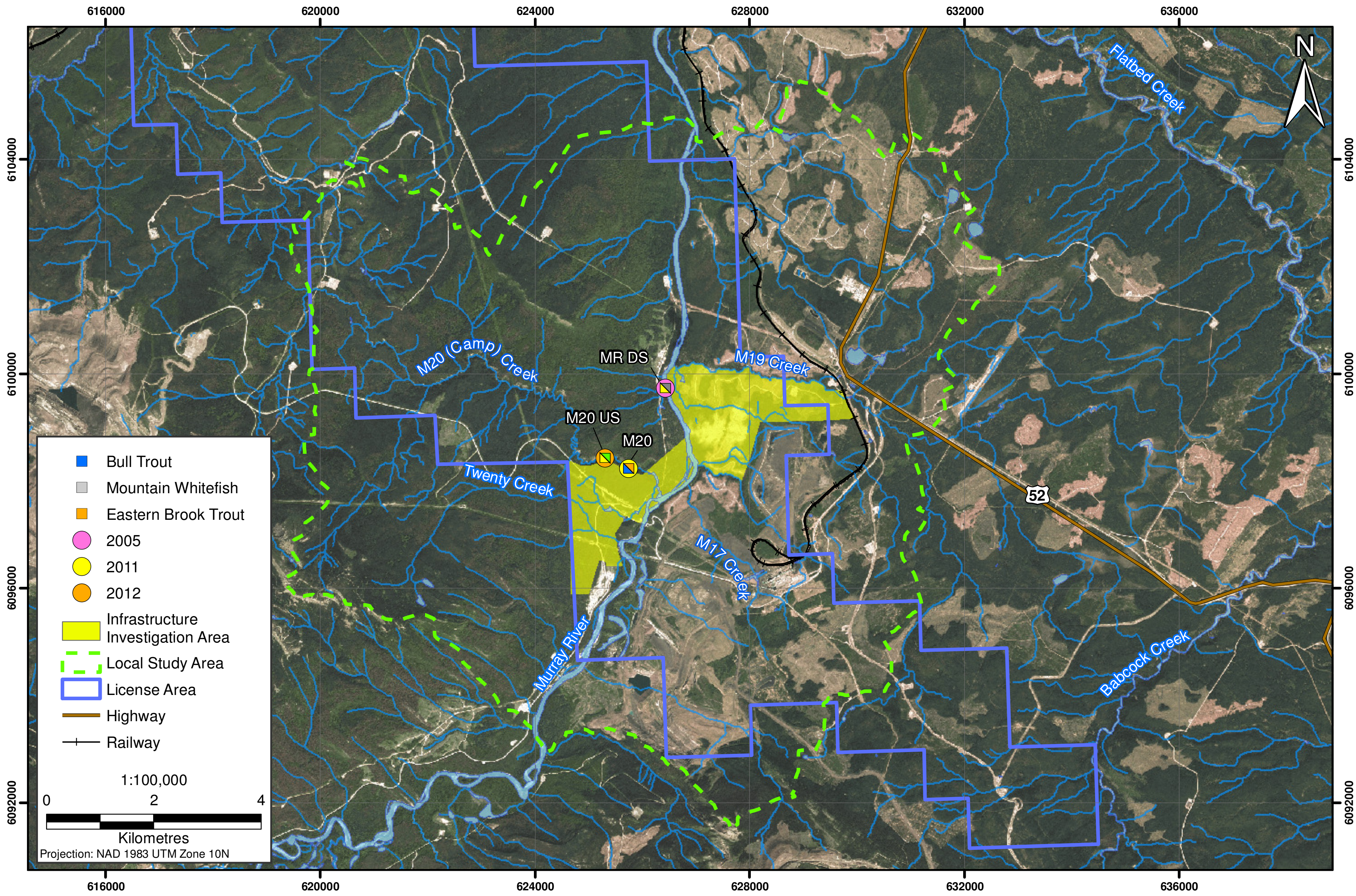

Figure 5.2-1

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Fish Tissue Metals Sample Sites Inside the Local Study Area (2004-2012)

Figure 5.2-1

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Table 5.2-1. Metal Concentrations in Food Fish from the Murray River LSA

COPC (Total Metal)	Bull Trout (2011, 2012)		Brook Trout (2011)		Mountain White Fish (2005)		Bull Trout + Brook Trout + Mountain Whitefish	
	n	mean	n	mean	n	mean	n	mean
Aluminum	6	12.9	3	25.3	1	22.3	10	17.6
Arsenic	6	0.0100	3	0.0200	1	0.0300	10	0.0200
Barium	6	1.15	3	2.03	1	0.930	10	1.39
Cadmium	6	0.050	3	0.0200	1	0.0600	10	0.0500
Chromium	6	0.100	3	0.120	1	0.0500	10	0.100
Copper	6	0.620	3	0.810	1	0.790	10	0.700
Mercury	6	0.0200	3	0.0200	0	ND	9	0.0200
Nickel	6	0.0700	3	0.0900	1	0.0500	10	0.0700
Selenium	6	0.880	3	0.690	1	1.08	10	0.840
Silver	0	ND	0	ND	0	ND	0	ND

Notes:
ND = Not determined
n = number of tissue samples
Tissue metal concentrations below method detection limit are calculated as half of the detection limit.
All concentrations are in mg/kg wet weight, except for samples from 2004 and 2005, where wet weight concentrations were derived from dry weight measurements and percent moisture content.
Wet weight concentrations were derived from dry weight measurements and percent moisture content:

$$Wet\ weight = dry\ weight \times \left(\frac{100-\%moisture}{100}\right)$$

Table 5.3-1. Metal Concentrations in Plants from the Murray River LSA

COPCs	Berries (fruit)				Lichen (tissues)				Sedges and Berry Plants (leafs)			
	n	mean	95th Percentile	Max	n	mean	95th Percentile	Max	n	mean	95th Percentile	Max
Aluminum	23	3	7	7	39	420	931	1,210	57	53.0	239	427
Arsenic	23	0.00400	0.0100	0.0100	39	0.240	0.640	0.750	57	0.0200	0.0600	0.180
Barium	23	4.00	10.0	10.0	39	31.0	83.0	159	57	50.0	141	526
Cadmium	23	0.0100	0.0200	0.0300	39	0.160	0.290	1.24	57	0.0900	0.300	0.640
Chromium	23	0.0200	0.0400	0.0800	39	2.05	6.00	8.66	57	0.370	1.08	1.35
Copper	23	0.840	1.59	1.61	39	2.18	4.25	5.55	57	1.69	3.68	4.37
Mercury	23	0.00060	0.00100	0.00150	37	0.0360	0.0850	0.130	57	0.00360	0.0105	0.0160
Nickel	23	0.100	0.190	0.230	39	1.61	4.24	5.82	57	0.540	1.51	2.45
Selenium	23	0.0100	0.0100	0.0300	39	0.0800	0.100	0.110	57	0.130	0.240	0.950
Silver	0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND

Notes:
ND = Not determined
All concentrations are in mg/kg wet weight.
n = sample size
Analytical results in Rescan (2013c).

5.4 TERRESTRIAL SPECIES TISSUE CONCENTRATIONS

Tissue COPC concentrations for terrestrial species (moose, snowshoe hare, grouse) were modeled using a wildlife food chain model (Health Canada 2010d; Appendix A). The model uses baseline mean concentrations of water, soil, and vegetation, animal specific ingestion rates, and metal-specific biotransfer factors (BTF). For the model, it is assumed that moose spent all year on site, which is considered a conservative approach, and that its diet consists of a mix of 75% leafs (sedges and berry plants), and 25% lichens (Appendix A, Timmermann and McNicol 1988; Sharnoff and Rosentreter 1998). Grouse and snowshoe hare tissue concentrations were also modeled, and it was assumed that both animals spend all year on site due to their small home ranges. The diets of hare and grouse were assumed to be 80% leafs (sedges and berries), 10% berries, and 10% lichen (Appendix A). The primary consumed terrestrial country food was moose. As a result, exposure to metals from the consumption of grouse and snowshoe hare would be small compared to the exposure to metals consumed from other food sources such as moose.

Table 5.4-1 presents the modeled mean moose, snowshoe hare, and grouse muscle tissue concentrations for COPCs. Appendix A provides additional detail about the food chain model used to predict animal muscle tissue concentrations.

Table 5.4-1. Predicted Mean Metal Concentrations in Wildlife Species from Uptake through Water, Soil, and Vegetation Ingestion

	Modeled Concentration of COPCs in Muscle Tissue (mg/kg wet weight)		
COPCs	Moose	Grouse	Hare
Aluminum	3.79	412	0.0523
Arsenic	0.00294	0.274	0.0000420
Barium	0.0961	0.166	0.00107
Cadmium	0.000628	0.0393	0.00000630
Chromium	0.0518	0.160	0.000510
Copper	0.193	0.416	0.00209
Mercury	0.0302	0.0000960	0.000210
Nickel	0.0603	0.00103	0.000680
Selenium	0.0184	0.0374	0.000200
Silver	0.281	0.592	0.000160

5.5 HUMAN RECEPTOR CHARACTERISTICS

Human receptor consumption characteristics (country food intake amounts, frequencies and country food species) for the Treaty 8 First Nations were obtained from the *First Nations Food Nutrition & Environment Study* (Chan et al. 2011) as well as general human characteristics outlined by Health Canada (2010d) and Richardson (1997).

Studies of energy intake through different foods show that traditional food seems to complement market food rather than substitute for it, since energy intakes are greater when traditional food is consumed (Chan et al. 2011). On days when traditional foods are consumed, diet quality is much improved for most parameters. Traditional foods are shown to be the major contributor to protein, vitamin D, iron, and zinc; and are among the 10 major contributors to energy, polyunsaturated fat, cholesterol, vitamin A, vitamin C and calcium.

The typical daily amount of traditional food consumed was based on a 24-hour recall study (Chan et al. 2011), where study participants are 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 biggest servings when compared to other age groups (19-50 and 71+ years; Table 5.5-1). Chan et al. (2011) multiplied the serving size by the frequency of consumption of each traditional food (Table 4.2-3) and obtained the estimated intake of major traditional foods in (g/person/day) averaged over one year. The 95th percentile 'high consumption' amount as calculated by Chan et al. (2011) is presented in Table 5.5-2 and was used as a conservative input for the modeling of exposure ratios.

Table 5.5-1. Mean Portion Size of Traditional Food Categories, by Gender and Age Group, as Reported from 24-hour Recalls for BC First Nations Living On-reserve (from Chan et al. 2011)

Traditional Food Category	Women Mean grams/serving			Men Mean grams/serving			Average Mean grams/serving	
	Age 19-50	Age 51-70	Age 71+	Age 19-50	Age 51-70	Age 71+	Women	Men
Land mammals	136	123	103	234	153	181	121	189
Fish	109	132	87	163	163	100	109	142
Wild berries	56	41	57	74	39	18	51	44
Wild birds	75	75*	75*	75*	75*	75*	75	75

Notes:
**imputed portion size from mean intake by total population (Chan et al. 2011)*

Overall, moose meat is the country food that is consumed in highest quantities (up to 234 g/serving; Table 6.5-1; Chan et al. 2011) and frequencies (112 days per year; Table 4.2-3). Other large ungulates (elk, deer, caribou) are also consumed in moderate quantities. As a result, the estimated high consumption (95th percentile) amounts for the other large herbivorous mammals (deer, elk, and caribou) were added to the consumption amounts for moose to provide a highly conservative estimate for exposure of an average adult person to COPCs from the consumption of large herbivorous mammal meat (142.5 g/person/day).

Fish are consumed in moderate quantities relative to the total consumption of country foods, with an average portion size of 142 g for men and 109 g for women (Table 6.5-1; Chan et al. 2011). The consumption frequency is provided for salmon for ecozone 2 as 11 times per year (Table 4.2-3). However, the total fish (not just salmon) consumption is likely higher, but is not provided in the table in the primary reference. The *First Nations Food Nutrition & Environment Study* provides an estimated high consumption (95th percentile) amount for several freshwater fish groups (e.g., salmon, trout, eulachon, whitefish, pike). Because this country foods assessment uses fish COPC concentrations predominately obtained from trout (bull trout and Eastern brook trout) and whitefish, and salmon are migratory and therefore do not reflect conditions in the LSA, the exposure assessment used the average intake for trout and whitefish combined (Chan et al. 2011; Table 5.5-2; 12.30 g/person/day).

Berries are consumed by FN in ecozone 2 seven to 13 times a year, depending on the species (Chan et al. 2011; Table 4.2-3). Notably, highbush cranberries and currants, collected during the vegetation baseline studies for tissue metal analysis, are not listed in the *First Nations Food Nutrition & Environment Study,* but will be used as substitutes for berry species listed as consumed by FN in ecozone 2 (Table 4.2-3). For the purpose of this country foods assessment, estimated high (95th percentile) consumption amounts for a number of berry species have been added to provide a conservative estimate of exposure to COPCs through the consumption of berries throughout the year (Table 5.5-2; 37.8 g/person/day).

Table 5.5-2. Estimated High Consumption (95th Percentile) Amount of Major Traditional Foods Using Traditional Food Frequency Results

Traditional Food	**Women**			**Men**			**Total Population Mean grams/person/day**
	Mean grams/person/day			**Mean grams/person/day**			
	Age 19-50	**Age 51-70**	**Age 71+**	**Age 19-50**	**Age 51-70**	**Age 71+**	
Moose meat	80.4	78.7	81.1	139	90.8	39.6	105
Deer meat	17.9	28.2	13.5	77.0	20.2	11.9	26.6
Elk meat	7.44	8.07	6.76	15.4	20.2	19.8	8.78
Caribou meat	1.49	3.36	1.13	1.28	3.36	9.90	1.67
Total large mammal							**142**
Trout, any	7.18	10.9	2.39	23.3	14.0	4.40	11.4
Whitefish	0.300	0.720	0.950	1.12	1.76	1.10	0.870
Total fish							**12.3**
Soapberries	7.33	5.45	7.50	9.71	2.54	0.200	6.64
Blue huckleberries	7.33	5.45	5.62	9.71	3.18	0.200	5.81
Blueberries	7.33	5.45	6.56	5.46	3.18	0.990	4.98
Blackberries, large	3.21	1.36	8.43	8.50	2.54	1.18	3.83
Raspberries	4.58	1.82	1.87	6.07	2.12	0.250	3.83
Wild Strawberry	3.66	1.36	1.87	4.86	2.54	0.390	3.32
Saskatoon berry	3.05	1.82	2.81	4.86	1.27	1.23	2.77
Red huckleberries	1.83	1.36	3.75	4.86	1.27	0.690	1.94
Blackberries, trailing	1.53	1.45	0.000	4.86	1.27	1.18	1.66
Black caps	0.920	0.680	0.310	4.86	0.420	0.200	1.11
Low bush cranberries	0.920	1.02	1.87	1.62	0.850	0.390	1.11
Salalberries	0.310	0.910	1.87	1.21	1.27	NA	0.830
Total berries							**37.8**
Rabbit meat	1.12	2.69	6.76	2.57	5.04	6.93	**2.93**
Grouse	1.64	0.910	1.23	1.64	3.29	1.64	**1.64**

Notes:
NA = not available
Bolded numbers are used in the assessment.

Rabbit (or snowshoe hare) is eaten by 46% of the population in ecozone 2 (Table 4.2-4); however, no consumption frequency is provided in the *First Nations Food Nutrition & Environment Study*. The estimated high (95th percentile) consumption rate for rabbit meat is 2.93 g/person/day throughout the year (Table 5.5-2). Grouse is eaten by 45% of the population (Table 4.2-4) at an average of 75 g serving size (Table 5.5-1) and at a frequency of 5 days per year (Table 4.2-3). The high (95th percentile) consumption amount is estimated by Chan et al. (2011) to be 1.64 g/person/day for grouse meat.

No data was collected on the serving sizes of toddlers. It was assumed that a toddler would eat the country foods at the same frequency as adults, with a serving size of 43% of the adult serving size as described by Richardson (1997). It is anticipated that this assumption overestimates the actual toddler serving size.

Human receptor characteristics for toddler and adult body weights are based on guidance provided by Health Canada (2010b, 2010d). Table 5.5-3 summarizes the human receptor characteristics for various country foods for the First Nation study group based on literature data.

Table 5.5-3. Human Receptor Body Weights and Consumption Rates of Specific Country Foods

Parameter	Toddler	Adult	Data Source
Body Weight (kg)	16.5	70.7	(Health Canada 2010d)
Consumption Rate (g /person/day)[1]			
Large mammal (moose, elk, deer, caribou)	61.3	142.5	(Chan et al. 2011)
Fish (trout and whitefish)	4.9	12.3	(Chan et al. 2011)
Berries	16.2	37.8	(Chan et al. 2011)
Snowshoe hare	1.26	2.93	(Chan et al. 2011)
Grouse	0.70	1.64	(Chan et al. 2011)

Notes:

[1] *Assumes consumption frequency of 365 days per year.*

5.6 ESTIMATED DAILY INTAKE

An EDI of each metal for the toddler and adult receptors was based on predicted (moose, grouse, and snowshoe hare) and measured (berries and fish) tissue concentrations and the human receptor characteristics.

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

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

where:

EDI_{food} = estimated daily intake of country food (µg COPC/kg BW/day)
IR = ingestion rate (kg/day)
C_{food} = mean concentration of COPC in food (mg/kg)
F_w = fraction of year consuming country food (unitless, set to 1)
BW = body weight (kg)

The EDI of each COPC for toddler and adult receptors is presented in Table 5.6-1. For this baseline, it was assumed that 100% of the country foods were harvested from the LSA and that each of the COPCs were 100% bioavailable; assumptions that are not entirely possible, and therefore provide a highly conservative estimate. Appendix B provides a sample calculation of the EDI of aluminum for toddlers consuming moose muscle tissue.

Among the COPCs, an assessment of the EDI in country foods shows that humans had the highest EDI of chromium, mercury, and nickel from the consumption of moose, the highest EDI of aluminum, arsenic, and silver from the consumption of grouse, the highest EDI of barium and copper from the consumption of berries, and the highest EDI of cadmium and selenium from the consumption of trout.

The EDI of mercury associated with the consumption of moose is likely an overestimate due to the assumption made in the wildlife model (see Appendix A and Section 7.3). The next highest EDI for mercury is associated with the consumption of trout and whitefish and likely provides a more realistic estimation for the EDI of mercury by toddlers and adults, because the mercury concentration in fish was measured and not modeled.

Table 5.6-1. Estimated Daily Intake of Contaminants of Potential Concern by Human Receptors

	Estimated Daily Intake of COPC (mg/kg BW) for Adult Receptors				
	Baseline				
COPCs	**Moose**	**Grouse**	**Hare**	**Berries**	**Trout**
Aluminum	7.65×10^{-03}	**9.55×10^{-03}**	2.17×10^{-06}	1.69×10^{-03}	3.05×10^{-03}
Arsenic	5.93×10^{-06}	**6.36×10^{-06}**	1.76×10^{-09}	2.03×10^{-06}	2.84×10^{-06}
Barium	1.94×10^{-04}	3.85×10^{-06}	4.45×10^{-08}	**1.90×10^{-03}**	2.43×10^{-04}
Cadmium	1.27×10^{-06}	9.11×10^{-07}	2.60×10^{-10}	4.18×10^{-06}	**7.83×10^{-06}**
Chromium	**1.04×10^{-04}**	3.70×10^{-06}	2.09×10^{-08}	1.19×10^{-05}	1.71×10^{-05}
Copper	3.88×10^{-04}	9.65×10^{-06}	8.68×10^{-08}	**4.49×10^{-04}**	1.21×10^{-04}
Mercury	**6.08×10^{-05}**	2.23×10^{-09}	8.55×10^{-09}	3.25×10^{-07}	3.70×10^{-06}
Nickel	**1.22×10^{-04}**	2.39×10^{-08}	2.82×10^{-08}	5.11×10^{-05}	1.29×10^{-05}
Selenium	3.72×10^{-05}	8.68×10^{-07}	8.20×10^{-09}	5.79×10^{-06}	**1.47×10^{-04}**
Silver	**5.66×10^{-04}**	1.37×10^{-05}	6.47×10^{-09}	ND	ND

	Estimated Daily Intake of COPC (mg/kg BW) for Toddler Receptors				
	Baseline				
COPCs	**Moose**	**Grouse**	**Hare**	**Berries**	**Trout**
Aluminum	1.41×10^{-02}	**1.76×10^{-02}**	3.99×10^{-06}	3.11×10^{-03}	5.63×10^{-03}
Arsenic	1.09×10^{-05}	**1.17×10^{-05}**	3.24×10^{-09}	3.75×10^{-06}	5.23×10^{-06}
Barium	3.57×10^{-04}	7.10×10^{-06}	8.20×10^{-08}	**3.50×10^{-03}**	4.47×10^{-04}
Cadmium	2.33×10^{-06}	1.68×10^{-06}	4.79×10^{-10}	7.71×10^{-06}	**1.44×10^{-05}**
Chromium	**1.92×10^{-04}**	6.82×10^{-06}	3.86×10^{-08}	2.18×10^{-05}	3.16×10^{-05}
Copper	7.16×10^{-04}	1.78×10^{-05}	1.60×10^{-07}	**8.27×10^{-04}**	2.24×10^{-04}
Mercury	**1.12×10^{-04}**	4.11×10^{-09}	1.58×10^{-08}	6.00×10^{-07}	6.81×10^{-06}
Nickel	**2.24×10^{-04}**	4.40×10^{-08}	5.19×10^{-08}	9.41×10^{-05}	2.38×10^{-05}
Selenium	6.85×10^{-05}	1.60×10^{-06}	1.51×10^{-08}	1.07×10^{-05}	**2.71×10^{-04}**
Silver	**1.04×10^{-03}**	2.53×10^{-05}	1.19×10^{-08}	ND	ND

Notes:
ND = Not determined
Shaded numbers denote country food with the highest estimated daily intake for an toddler or adult of a particular COPC.

6. Toxicity Reference Value Assessment

6. Toxicity Reference Value Assessment

6.1 INTRODUCTION

The toxicity reference value (TRV) assessment estimates the amount of COPCs that can be taken into the human body without experiencing adverse health effects. TRVs are considered to be safe levels below which there are minimal risks of adverse health effects. The TRVs used in the country foods assessment were obtained from Health Canada (2010b). The TRVs were derived by Health Canada's Bureau of Chemical Safety, Chemical Health Hazard Division or were adopted by Health Canada from various other regulatory agencies such as the US EPA's Integrated Risk Information Service Database (IRIS) and the Food and Agriculture Organization/World Health Organization's Joint FAO/WHO Expert Committee on Food Additives (JECFA).

Toxicity information often comes from animal studies, where animal dose-response information is extrapolated to humans by applying uncertainty factors. In most cases, uncertainty factors of 100 to 1,000 are applied to laboratory-derived no observable adverse effect levels (NOAELs; i.e., the highest concentration in a toxicity test where no chronic health effects were observed or measured) to account for interspecies extrapolation and 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 observable adverse effects levels (LOAEL) from human studies have smaller uncertainty factors because no extrapolation from animal to humans is required.

The non-carcinogenic TRVs in this assessment are presented as Tolerable Daily Intakes (TDIs) or Provisional Tolerable Daily Intakes (PTDIs). The TRVs for metals considered carcinogenic are presented as oral slope factors (Health Canada 2010b, 2010c). The TDI is defined as the amount of metal per unit body weight (BW) that can be taken into the body each day (e.g., µg/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 avoidably 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. The TDIs used in this baseline assessment are summarized in Table 6.1-1. 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 6.2. Health Canada guidelines were used preferentially unless they were not available for certain COPCs, in which case US EPA guidelines were used.

6.2 TOXICITY REFERENCE VALUES

6.2.1 Aluminum

Health Canada (2010b) does not provide a TDI for aluminum. In 2006, JECFA re-evaluated the toxicology of aluminum and revised the PTWI from 7.0 mg/kg BW/week (1 mg/kg BW/day) previously to 1.0 mg/kg BW/week (143 µg/kg BW/day; JECFA 2007). JECFA concluded that aluminum compounds have the potential to affect the reproductive system and developing nervous system at doses lower than those used in establishing the previous PTWI. The Agency for Toxic Substances and Disease Registry (ATSDR) derived a chronic-duration oral minimal risk level (MRL) of 1 mg Al/kg BW/day for aluminum. This MRL is based on a LOAEL of 100 mg Al/kg BW/day for neurological effects in mice exposed to aluminum lactate in the diet (ATSDR 2008). The EPA has not derived a TRV for aluminum and Health Canada is currently reviewing the dietary exposure to aluminum in Canada. The ATSDR chronic duration oral MRL of 1 mg/kg BW/day is used in this report.

Table 6.1-1. Toxicity Reference Values for Contaminants of Potential Concern

Metals	TRV (mg/kg BW/d)	
	Adult	**Toddler**
Aluminum	1[a]	1[a]
Arsenic	0.0003[b]	0.0003[b]
Barium	0.2	0.2
Cadmium	0.001	0.001
Chromium, total	0.001	0.001
Copper	0.141	0.091
Methylmercury, general adult population	0.00047	0.00047
Methylmercury, women of childbearing age and children <12 years	0.00023	0.00023
Nickel	0.011	0.011
Selenium	0.0057	0.0062
Silver	0.005[b]	0.005[b]

Notes:
[a] *ATSDR (2008). Toxicological Profile For Aluminum. U.S. Department of Health and Human Services. Public Health Services. Agency for Toxic Substances and Disease Registry*
[b] *US EPA (2012). Integrated Risk Information System. Online: www.epa.gov/iris*
All others from Health Canada 2010 (2010b)

6.2.2 Arsenic

For assessment of non-cancer risks from arsenic, IRIS (US EPA 2012) provides 0.0003 mg/kg BW/day for a chronic oral TDI, while JECFA recommends a PTWI of 0.015 mg/kg BW/week for oral exposures (JECFA 2010).

Arsenic is the only metal in this study that is considered carcinogenic via the ingestion pathway. For carcinogens, slope factors are used as the TRVs (Health Canada 2010b). 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 and relates the exposure dose of a non-threshold substance to the expected probability of developing cancer. 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 $(\text{mg/kg BW/day})^{-1}$ (Health Canada 2010b) based on the 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. A study on freshwater fish estimated the percentage of inorganic arsenic to be about 10% of total arsenic concentration (Slejkovec, Bajc, and Doganoc 2004). Based on American Association for Clinical Chemistry (Borak and Hosgood 2007; AACC 2013), inorganic arsenic in seafood comprises less than 5% of the total arsenic-containing species; therefore, although the concentrations of total arsenic may be high, the metal is mostly present in its non-toxic form. As a conservative measure, for all aquatic species, it was assumed that 10% of the total arsenic concentrations were in the toxic inorganic form.

6.2.3 Cadmium

Health Canada (2010b) provides a PTDI of 0.001 mg/kg BW/day, which was used in this assessment. This TDI is similar to JECFA's PTWI of 0.007 mg/kg BW/week (JECFA 2005), which accounts for the long half-life of cadmium in the body. The PTDI of 0.001 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. Health Canada (2010b) and IRIS (US EPA 2012) provide a TDI of 0.001 mg/kg BW/day for oral exposures to cadmium based on recommendations by the JECFA (1972, 2005).

6.2.4 Chromium

Health Canada (2010b) 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 2012), 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 interhuman 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.

6.2.5 Copper

Health Canada (2010b) 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. Health Canada (2011) provides a medium TDI of 0.125 mg/kg BW/day. No rationale for the derivation of this TDI has been provided, but it coincides with the TDI for the age class 12-19 years provided by Health Canada (Health Canada 2010b). A TDI of 0.091 and 0.141 mg/kg BW/day was used for toddlers and adults, respectively, in this report.

6.2.6 Mercury

Health Canada (2010b) provides a TDI of 0.0003 mg/kg BW/day for total mercury exposure for the general public, based on CCME soil quality guidelines and supporting documentation on health-based guidelines prepared by Health Canada. The Health Canada Bureau of Chemical Safety, Chemical Health Hazard Assessment Division (CHHAD) guideline of 0.00071 mg/kg BW/day (Health Canada 2011) is based on previous JECFA evaluations of a PTWI of 0.005 mg/kg BW/day (0.00071 mg/kg BW/day) for total mercury, established at sixteenth JECFA meeting, which was withdrawn in 2011 and replaced with PTWI of 0.0033 mg/kg BW/week (0.00047 mg/kg BW/day; JECFA 2011).

For methylmercury, JECFA 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), which was adopted by Health Canada (Health Canada 2010b, 2011). Mercury was assumed to be present 100% as methylmercury in fish (Health Canada 2007). Data are not readily available on speciation of the mercury present in the local vegetation and terrestrial animals. Therefore, for moose, grouse, snowshoe hare, and plant tissues (berries), total mercury concentrations were compared to the Health Canada (Health Canada 2010b) methylmercury TDI to be conservative (i.e., assume that 100% of the total mercury is present as methylmercury).

6.2.7 Nickel

Health Canada (2010b) provides a TDI of 0.011 mg/kg BW/day and US EPA IRIS provides a TDI of 0.020 mg/kg BW/day (nickel soluble salts). Health Canada (2011) provides a TDI of 0.025 mg/kg BW/day for nickel. This TDI for total nickel 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. An uncertainty factor of 200 was applied to the NOAEL: 10 for interspecies variation and 10 to protect sensitive populations and a modifying factor of two was applied to account for the inadequacies of the reproductive studies. While the TDIs for nickel are comparable, the most conservative TDI of 0.011 mg/kg BW/day (Health Canada 2010b) was used in this assessment.

6.2.8 Selenium

Health Canada CHHAD (2011) provides a TDI of 0.750 mg/person/day for selenium. As the recommended maximum intake of selenium is not presented as being proportional to an individual's weight, the value was divided by the average adult weight (70.7 kg) to produce a proportional value of 0.011 mg/kg BW/day. Health Canada does not provide a rationale for the derivation of this TDI. IRIS (US EPA 2012) provides an oral TDI of 0.005 mg/kg BW/day for selenium based on a NOAEL of 0.015 mg/kg/day. Health Canada (2010b) provides a range of TDIs between 0.0055 and 0.0063 mg/kg/day specific to age groups as selenium is an essential element. Selenium has been demonstrated to be a cofactor of glutathione peroxidase, a hydrogen and lipid peroxide reducing enzyme. Elevated levels of selenium can induce selenium toxicity and varying forms of selenosis. A TDI of 0.0062 and 0.0057 μg/kg/day was adopted for toddlers and adults, respectively, for this assessment, as recommended by Health Canada (2010b).

6.2.9 Silver

Health Canada does not provide a TRV for silver. The US EPA's IRIS provided a TDI for chronic oral exposure of 0.005 mg/kg/day (US EPA 1996), which is based on argyria. Argyria is a medically benign but permanent bluish-gray discoloration of the skin. Although the deposition of silver is permanent, it is not associated with any adverse health effects. Argyria occurs at levels of exposure much lower than those levels associated with other effects of silver in the cardiovascular and hepatic systems.

7. Results: Risk Characterization

7. Results: Risk Characterization

7.1 INTRODUCTION

Health effects from chemicals are generally divided into two categories: threshold (i.e., non-carcinogenic) and non-threshold (i.e., carcinogenic) response chemicals. These two types of dose-response relationships are evaluated differently. Both adults (older than 19 years of age) and toddlers (six months to four years of age) were evaluated for their susceptibility to threshold chemicals.

Toddlers are considered the most susceptible life stage for threshold chemicals because of their higher relative ingestion rates per unit body weight and their rapid absorption during this important growth period, compared to adults. Elderly people also can experience life stage sensitivity. For carcinogenic risk, all life stages are susceptible. However, adults are used to evaluate carcinogenic risk because this is calculated over an adult lifespan, as recommended by Health Canada (2010a). Therefore, when selecting the human receptors, the category of COPCs was considered.

Using the results of the exposure and TRV assessment, human health risks from the consumption of country foods were quantified using exposure ratios (ER). 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. In addition, the RMWIs were calculated for each country food evaluated. The RMWIs were compared to current weekly consumption rates of the country foods.

7.2 ESTIMATION OF CANCER RISKS

Of the metals evaluated, only arsenic is considered carcinogenic through ingestion. Carcinogenic risks were estimated as incremental lifetime cancer risk (ILCR) according to the following formula (Health Canada 2010d):

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

Appendix C provides a sample calculation for the estimated lifetime daily exposure (ELDE), which is then used to calculate the ILCR. The oral slope factor for arsenic cancer risk is 1.8 mg/kg BW/day (Health Canada 2010d). An ILCR estimate that is less than 1×10^{-5} is normally considered acceptable as this is the negligible risk level for cancer and germ cell mutation above background (1 in 100,000 persons exposed; (1 in 100,000 persons exposed; Health Canada 2010b).

$$ELDE = \frac{\text{Ingestion rate (kg/day) x Fw x inorganic As concentration (mg/kg) x Years exposed (years)}}{\text{Body weight (kg) x Life expectancy (years)}}$$

For the ELDE, a percentage of measured (trout, berries) and predicted (moose, grouse, and snowshoe hare) mean arsenic concentrations in tissue were used in the exposure calculations to estimate the proportion of inorganic arsenic (the carcinogenic species of arsenic).

To account for the low proportion of inorganic arsenic in fish, it was assumed that 10% of the total detected arsenic lake trout is inorganic based on the estimate from Slejkovec, Bajc, and Doganoc (2004). For moose and snowshoe hare, it was assumed that the percent inorganic arsenic was the same as the percent for beef (top sirloin steak baked for 30 minutes at 350°F), which is 0.78% (Schoof et al. 1999). For grouse, it was assumed that the percent inorganic arsenic was the same as the percent for chicken (chicken breast with skin and rib, baked until done at 350°F), which is 1.04% (Schoof et al. 1999).

Nicholson (2002) reported that berries predominantly contain inorganic arsenic, thus it was assumed that 100% of the arsenic in berries is inorganic.

The ILCR from exposure to arsenic in country foods are presented in Table 7.2-1. The calculated ILCRs for (inorganic) arsenic from consumption of all foods were less than 1×10^{-5} and can be considered safe for consumption at the current local consumption rates. Uncertainties associated with this risk estimate are discussed in Section 8 (Uncertainties).

Table 7.2-1. Estimated Daily Lifetime Exposure and Incremental Lifetime Cancer Risk for Human Receptors Exposed to Arsenic in Country Foods

	Baseline	
Country Food	**ELDE mg/kg/day**	**ILCR unitless**
Moose	4.62×10^{-08}	8.32×10^{-08}
Grouse	6.61×10^{-08}	1.19×10^{-07}
Snowshoe Hare	1.37×10^{-11}	2.47×10^{-11}
Berries	2.03×10^{-06}	3.66×10^{-06}
Trout	2.84×10^{-07}	5.11×10^{-07}

7.3 ESTIMATION OF NON-CARCINOGENIC RISKS

Human health risk estimates were calculated based on the following formula:

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

For non-carcinogenic metals, an ER of less than 0.2 represents exposure that does not pose a significant health risk to human receptors (Health Canada 2010a). Health Canada considers an ER value of 0.2 appropriate because only one exposure pathway is evaluated for human health and it is assumed that people are exposed to COPCs from multiple sources such as other food groups, soil, air, water, cigarettes and cigarette second-hand smoke.

ER values greater than 0.2 do not necessarily indicate that adverse health effects will occur since the TRVs are conservative and protect human health based on the application of uncertainty factors. ERs are not a measure of actual risk, but are rather measures of level of concern (Tannenbaum, Johnson, and Bazar 2003). It does suggest potential risks that may require a more detailed evaluation. For instance, when evaluating country foods where the country food comprises a significant proportion of the country foods intake (i.e., moose meat) an ER of 0.2 may be over protective because exposure from other food groups (i.e., berries) would be minimal.

Table 7.3-1 presents the calculated ERs based on predicted and measured tissue concentrations. There is no health risk from COPCs to adults consuming all evaluated country foods (moose, snowshoe hare, grouse, berries, and trout) based on the predicted and measured metal tissue concentrations and assumptions made in this report. There is a slightly elevated ER of 4.87×10^{-01} for mercury in moose for toddlers.

Table 7.3-1. Human Exposure Ratios Based on Predicted and Measured Tissue Concentrations

COPCs	**Exposure Ratio for Adult Receptors**				
	Baseline				
	Moose	**Grouse**	**Hare**	**Berries**	**Trout**
Aluminum	7.65×10^{-03}	9.55×10^{-03}	2.17×10^{-06}	1.69×10^{-03}	3.05×10^{-03}
Arsenic	1.98×10^{-02}	2.12×10^{-02}	5.86×10^{-06}	6.78×10^{-03}	9.47×10^{-03}
Barium	9.69×10^{-04}	1.93×10^{-05}	2.22×10^{-07}	9.49×10^{-03}	1.21×10^{-03}
Cadmium	1.27×10^{-03}	9.11×10^{-04}	2.60×10^{-07}	4.18×10^{-03}	7.83×10^{-03}
Chromium	1.04×10^{-01}	3.70×10^{-03}	2.09×10^{-05}	1.19×10^{-02}	1.71×10^{-02}
Copper	2.75×10^{-03}	6.84×10^{-05}	6.15×10^{-07}	3.18×10^{-03}	8.61×10^{-04}
Mercury	1.29×10^{-01}	4.75×10^{-06}	1.82×10^{-05}	1.08×10^{-03}	7.87×10^{-03}
Nickel	4.86×10^{-03}	9.56×10^{-07}	1.13×10^{-06}	2.04×10^{-03}	5.17×10^{-04}
Selenium	6.52×10^{-03}	1.52×10^{-04}	1.44×10^{-06}	1.02×10^{-03}	2.58×10^{-02}
Silver	8.96×10^{-05}	2.75×10^{-03}	1.29×10^{-06}	ND	ND
COPCs	**Exposure Ratio for Toddler Receptors**				
	Baseline				
	Moose	**Grouse**	**Hare**	**Berries**	**Trout**
Aluminum	1.41×10^{-02}	1.76×10^{-02}	3.99×10^{-06}	3.11×10^{-03}	5.63×10^{-03}
Arsenic	3.64×10^{-02}	3.90×10^{-02}	1.08×10^{-05}	1.25×10^{-02}	1.74×10^{-02}
Barium	1.79×10^{-03}	3.55×10^{-05}	4.10×10^{-07}	1.75×10^{-02}	2.23×10^{-03}
Cadmium	2.33×10^{-03}	1.68×10^{-03}	4.79×10^{-07}	7.71×10^{-03}	1.44×10^{-02}
Chromium	1.92×10^{-01}	6.82×10^{-03}	3.86×10^{-05}	2.18×10^{-02}	3.16×10^{-02}
Copper	5.08×10^{-03}	1.26×10^{-04}	1.13×10^{-06}	5.86×10^{-03}	1.59×10^{-03}
Mercury	**4.87×10^{-01}**	1.79×10^{-05}	6.85×10^{-05}	2.00×10^{-03}	2.96×10^{-02}
Nickel	8.96×10^{-03}	1.76×10^{-06}	2.08×10^{-06}	3.77×10^{-03}	9.53×10^{-04}
Selenium	1.20×10^{-02}	2.80×10^{-04}	2.65×10^{-06}	1.87×10^{-03}	4.36×10^{-02}
Silver	1.65×10^{-04}	5.06×10^{-03}	2.39×10^{-06}	ND	ND

Notes:
ND = Not determined
ER values above 0.2 are shaded and bolded

The elevated ER for mercury in toddlers is likely caused by an overestimation of the concentration of mercury in moose tissue from the wildlife model. Lichen was assumed to constitute 25% of the diet (Appendix A; Timmermann and McNicol 1988; Sharnoff and Rosentreter 1998) and the concentration of mercury in lichen (0.036 mg/kg wet weight (ww)) is higher than in other vegetation analyzed (0.0006 mg/kg ww in berries and 0.0036 mg/kg ww in leaves). Measurement of mercury in pooled moose meat samples collected from BC FN communities found that mercury was non-detectable. Specifically in ecozone 2, relevant to this assessment, moose was not among the top ten contributors of mercury (Chan et al. 2011). Bioaccumulation of mercury in terrestrial ecosystems is relatively small, as shown in the relatively low levels of mercury in tissues of herbivorous mammals such as moose compared to those found in piscivorous mammals (Fortin et al. 2001). Therefore, the ER of 4.87×10^{-01} is likely an artificially over-estimated exposure of toddlers to mercury in moose meat and there are no concerns for toddlers consuming this country food at the amounts and frequencies that they are accustomed to.

The ER for mercury from fish is below 0.2 (2.96×10^{-02} for toddlers). None of the edible fish samples exceeded the Health Canada mercury guideline of 0.5 mg/kg (Health Canada 2012).

Due to the conservative nature of the assessment used in this report, the risk estimates generally over-estimate risks associated with consumption of country foods. It is noted that there is uncertainty with the risk estimates (see Section 8), and that this risk assessment report examines country foods under baseline conditions, prior to initiation of the Project.

7.4 RECOMMENDED MAXIMUM WEEKLY INTAKE

The RMWIs were calculated as described by Health Canada's guidance (Health Canada 2010d), 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/day)
BW = receptor body weight (kg)
7 = days/week
C_{food} = mean metal concentration in food (μg/g)

This equation was applied to each metal and receptor scenario and the full results are provided in Appendix D. The metal that had the lowest RMWI for each country food was selected as the overall RMWI because the lowest metal-specific RMWI is ultimately the driver of potential risk. The RMWI was converted to the recommended maximum number of servings per week by applying the estimated serving size or consumption rates (Tables 5.5-1, 5.5-3 and Appendix D).

To compare the RMWI with the current weekly intake, the current number of weekly servings was estimated from the frequency of country food consumption provided for the season of highest consumption in Table 4.2-3. Table 7.4-1 presents the RMWI as recommended maximum servings per week.

Table 7.4-1. Recommended Maximum Weekly Number of Servings of Country Food

Human Receptor	Country Food	RMW Intake (kg/week)	Serving Size (kg/serving)	RMW Number of Servings (servings/week)	Current Estimated Weekly Number of Servings[1] (servings/week)
Adult	Moose	4.90	0.189	26	2.8
	Grouse	0.540	0.075	7	0.1
	Hare	720	0.189	3,807	0.1
	Berries	22.3	0.044	507	1.1
	Trout	3.30	0.142	24	0.3
Toddler	Moose	1.15	0.08	14	2.8
	Grouse	0.130	0.03	4	0.1
	Hare	168	0.08	2,066	0.1
	Berries	5.21	0.02	275	1.1
	Trout	0.780	0.06	13	0.3

Notes:
RMW = Recommended Maximum Weekly
[1] *based on annual averages in Chan (2011)*

Recommended maximum number of servings per week were greater than the current country foods weekly intakes for all of the country foods evaluated for toddlers and adults, and women of child-bearing age (moose, snowshoe hare, grouse, trout, and berries). This indicates that current consumption rates are unlikely to lead to health risks to human consumers through incidental intake of COPCs present in the country foods.

To obtain the current weekly intake rates, the consumption data that were obtained from the literature were averaged over the period of one year. However, it is likely that the types of food eaten depend on the time of year (Nuttall et al. 2005), due to seasonal availability (e.g., berries). It is possible that the intake rate for the week of maximum consumption for some country foods is higher than the weekly consumption rate based on annual averages. Country foods that are consumed throughout the year, either fresh or preserved, such as moose, more accurately reflect the true RMWIs due to the accuracy of the daily serving sizes. It should also be noted that when the RMWIs for some foods (i.e., snowshoe hare) are high, this reflects the low concentration of metal modeled or measured in the country food.

The results indicate that the country foods considered in this assessment can continue to be consumed at amounts and frequencies which country foods harvesters are accustomed to and do not pose a health risk to toddlers or adults that consume them.

8. Uncertainty Analysis

8. Uncertainty Analysis

8.1 INTRODUCTION

The process of evaluating human health risks from exposure to environmental media involves multiple steps. Inherent in each step of the health risk assessment are uncertainties that ultimately affect the final risk estimates. Uncertainties may exist in numerous areas, including the collection of samples, laboratory analysis, estimation of potential exposures, the compounding of safety factors through each step, and derivation of TRVs. Individually or collectively these uncertainties may result in either and under- or over-estimation of risk. However, for the present study, where uncertainties existed and where it was appropriate, a conservative approach was taken in order to ensure that risk was overestimated rather than underestimated.

Some of the uncertainties have been mentioned in the preceding sections. The following uncertainty analysis is a qualitative discussion of the significant sources of uncertainty and/or data gaps in this assessment. Where appropriate, information required to fill the data gaps is presented.

8.2 CONTAMINANTS OF POTENTIAL CONCERN

The COPCs for the baseline assessment were metals due to the mineralization in the Project area and the potential for environmental metal concentrations to change as a result of future Project-related activities or development. The metals selected were based on comparing existing surface water (n = 293), sediment (n = 38), and soil (n = 17 to 40) data collected in 2010 to 2012 to the applicable CCME and BC MoE guidelines. Metals where the 95th percentile exceeded the guidelines in one or more of the media were selected for evaluation. Given the large number of soil and water samples collected in the country foods LSA for the Murray River Project, there is high certainty that the metals selected based on their soil and water concentrations for inclusion as COPCs in this assessment were based on data that is reflective of the soil and water quality in the LSA.

However, there exists a possibility that other COPCs (other metals, organic chemicals, etc.) may be associated with the Project operations but do not occur or bioaccumulate under baseline conditions. If identified, any such COPCs would be evaluated as part of future Project monitoring and mitigation measures.

8.3 TISSUE CONCENTRATIONS

There are some uncertainties associated with the tissue concentrations used in this assessment. A description of these uncertainties is provided for aquatic species, terrestrial species, and plants. Uncertainties exist with the actual consumption rates of all country food species in the study FN communities (see Section 5.5).

8.3.1 Aquatic Species

Tissue samples from bull trout, Eastern brook trout, and mountain whitefish were obtained from Murray River and M20 Creek from several locations inside the LSA in 2005, 2011, and 2012. The current EDI is based on 10 tissue samples (Table 5.2-1). Tissue metals were also available for finescale dace and slimy sculpin. Slimy sculpin do not migrate and are therefore used to monitor potential Project effects (Carmichael and Chapman 2006). However, because these two species are not consumed by people, they were excluded from the country foods report.

Bull trout, although included in the assessment, may migrate long distances and may therefore consume prey and be exposed to COPC concentrations outside the LSA. Therefore, increased COPC loads could result from effects or environmental changes unrelated to the Project.

Many tissue concentrations were below the method detection limit in the food fish and values half the detection limit were used to calculate average metal tissue concentrations. This may over- or under-estimate the actual concentrations of metals in the tissues and results 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 detection limits in most samples and selenium was the metal responsible for the lowest recommended weekly servings of trout and whitefish. None of the edible fish samples exceeded the Health Canada mercury guideline of 0.5 mg/kg (Health Canada 2012).

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). 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).

8.3.2 Terrestrial Species

Concentrations in the tissue of moose, snowshoe hare, and grouse were predicted using a food chain model. As with all modeled data, the results are highly dependent on the accuracy of literature-based input parameters and the quality of the model itself. However, standard guidance and models have been used in this assessment and are described throughout this report.

The main uncertainties in the food chain model were associated with the biotransfer factors (BTFs) used. For all potential animal exposure routes, BTFs from food-to-tissue were used. However, it is unlikely that the BTFs from food-to-tissue, water-to-tissue, and soil-to-tissue are equal. BTFs assume that animals are in a steady state and that their chemical intake rates are constant. In addition, moose and snowshoe hare BTFs were based on values for beef, as moose and snowshoe hare BTFs were not available. Similarly, values for grouse BTFs were based on the available avian species, which was the domesticated chicken (*Gallus gallus domesticus*). Notwithstanding these uncertainties and limitations, this method is the accepted way to model uptake of COPCs into animals when empirical data is not available or samples sizes are too small to make conclusions about population tissue concentrations (Health Canada 2010d).

Other uncertainties associated with the predicted animal tissue concentrations include the assumption that the diets of moose, snowshoe hare and grouse include solely the lichens, sedges, and berries (leaves and fruit) that were collected in baseline field studies (Rescan 2013c). Although selected for their prevalence, these plants may not have been representative of the actual foods consumed by the evaluated terrestrial mammals and birds. For instance, grouse feed on grass seeds, sprouts, berries, and some lichen (US EPA 1993; Sharnoff and Rosentreter 1998). The snowshoe hare eats a wide variety of plants including seeds, berries, willow leaves, mushrooms, grasses and flowers (US EPA 1993; Sharnoff and Rosentreter 1998). In addition, there is high uncertainty about the relative amounts of the different vegetation that make up an animal's diet. Therefore, uncertainty exists in applying the similar models to animals with different feeding habits (i.e., grouse and snowshoe hare) or applying limited literature data on animal diet. However, the conservative nature of the food chain model is expected to provide adequate protection against these violations.

The predicted animal tissue concentrations were one of the largest sources of uncertainty in this assessment. Overall, empirical tissue data would be preferred as it would increase the certainty of the assessment for moose, snowshoe hare, and grouse.

None of the animals modeled for this report are migratory animals. Therefore, an increase in tissue COPC concentrations can be indicative of Project effects (assuming the home range of the animal is limited to areas close to potential Project influences) and can potentially be used as an indicator during monitoring. In addition, changes relative to baseline can provide information that local people can use to guide their choices about consumption of country foods.

8.3.3 Plant Species

A total of 119 plant samples were collected inside the LSA between 2010 and 2012. A relatively high correlation between the metal concentrations found in soil and vegetation (including lichens) suggests that increased metal loadings may be distributed in some areas either by air (e.g., in form of dust) or by runoff / seepage. There is a high degree of variation in metals concentrations between the plant species, likely due to species-specific physiological characteristics. It is therefore important to collect different plant species wherever possible. Overall, plants are unlikely to be harvested in substantial quantities from in the LSA by people from the three FN study communities, because the communities are a significant distance from the LSA. The contribution of vegetation, especially berries, on total consumed metals is likely to be insignificant compared to animal consumption due to the lower rates of berry consumption.

8.3.4 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) methodologies were followed during the sampling of the soil, water, vegetation, and fish. All persons collecting the tissue samples were trained on appropriate tissue 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 (Rescan 2013a, 2013c, 2013e).

All chemistry samples were analyzed by ALS Environmental in Burnaby, BC. ALS is certified by the Canadian Association of Environmental Analytical Laboratories. Chain of custody forms were completed and transported with all water, soil, and tissue samples that were sent to ALS.

8.4 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 within the LSA. This is an overestimate given the vast area available for harvesting and the distance from the communities to the Project area. This overestimation provides additional conservatism in the risk predictions.

8.5 COUNTRY FOODS CONSUMPTION QUANTITY AND FREQUENCY

Estimated daily intake of major traditional foods used for human characteristics were reported as daily consumption averages. These values are calculated by assessing the intake amounts from 24-hour recall surveys and the frequencies of consumption 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 RMWI provide 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, 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 ecoregion 2, which incorporated survey data from the Doig River FN and the SFN. Data for the WMFN and the MLIB 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 all study communities. In addition, during a telephone conversation in April 2013, SFN indicated that data from the *First Nations Food, Nutrition, and Environment Study* appeared to be underestimating their country food consumption (C. Marshall, pers. comm.). Therefore, 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.

Another level of uncertainty is the assumption that a toddler would eat the country foods at the same frequency as adults, with a serving size of 43% of the adult serving size as described by Richardson (1997). It is anticipated that this assumption overestimates the actual toddler serving size.

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 averaged.

8.6 TOXICITY REFERENCE VALUES

There is uncertainty associated with estimating toxicity benchmarks by extrapolating potential effects on humans from animal studies in the laboratory. Thus, 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). This large margin ensures that doses less than the toxicity benchmarks are safe and that minor exceedance of these benchmarks are unlikely to cause adverse health effects.

TRVs are derived for individual contaminants. However, it is recognized that within any traditional food resource from the natural environment, multiple chemicals may be present 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), or synergism (overall effect is greater than the sum of the individual effects). Many of these interactions are poorly understood or remain unknown by modern science. Furthermore, numerous physical variables (e.g., media temperature, pH, salinity, hardness, etc.) in natural systems 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 concentrations and not for overall health effects associated with exposure to mixtures of COPCs.

8.7 DEFINITION OF HEALTH

The First Nation perspective 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 (INAC 2003).

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). However, it is recognized that health is defined by more than just physical health related to exposure to metals. Country foods play an important role in the First Nation perspective of health and well-being that cannot be assessed in the same quantitative manner as in this baseline report.

9. Summary and Conclusions

9. Summary and Conclusions

This country foods assessment integrated the results of land use reports, survey-based country foods consumption and frequency patterns, the environmental media baseline studies (i.e., water, soil, and fish), and regulatory-based TRVs. The quality of country foods has been estimated prior to development of the Project and thus is reflective of baseline levels of metals. It also evaluated current potential health risks associated from the ingestion of baseline metal concentrations in the country foods. This baseline assessment will be used as a basis for comparison with future assessments using predictive models (i.e. water quality) as part of the Environmental Assessment.

The Project is within the boundaries of Treaty 8. The three Treaty 8 First Nations that live near the Project area are the West Moberly First Nation, Saulteau First Nations and McLeod Lake Indian Band. They are the primary country food harvesters in the country foods LSA and were selected as study communities. Country food consumption amounts and frequencies were based on aggregated survey results for Saulteau and Doig River First Nation as presented in the 2008-2010 *First Nations Food Nutrition & Environment Study*.

The country foods evaluated were moose (*Alces alces*), snowshoe hare (*Lepus americanus*), grouse (*Dendragapus sp.*), bull trout (*Salvelinus confluentus*), Eastern brook trout (*Salvelinus fontinalis*), mountain whitefish (*Prosopium williamsoni*), highbush cranberry (*Viburnum edule*) and currants (*Ribes* sp.).

Metals were the focus of this assessment because metals occur naturally under baseline conditions in environmental media (*i.e.*, soil, water, and plant and animal tissue). Furthermore, changes in environmental metal concentrations may be associated with Project activities and released in the process of coal mining. Ten metals were selected as COPCs and evaluated in this baseline assessment of country foods: aluminum, arsenic, barium, cadmium, chromium, copper, mercury, nickel, selenium, and silver. Concentrations of these metals in moose, snowshoe hare, and grouse were predicted using a food chain model, recommended by Health Canada (2010d). For trout, whitefish, and berries (highbush cranberries and currants), measured metal concentrations in tissues from samples collected from within the country foods study area were used.

Based on the consumption patterns described in the report, the exposure ratios (ER) of all metals are at or below Health Canada's recommended upper limit of 0.2 for moose, snowshoe hare, grouse, trout and whitefish, and berries (Section 7.3). One exception is a slightly elevated ER of 0.49 for mercury for toddlers consuming moose meat. The modeled mercury moose tissue concentration is likely artificially high due to the conservative assumptions used in the food chain model. Measurement of mercury in pooled moose meat samples collected from BC FN communities found that mercury concentrations in tissue were not detectable. Moose tissue was not among the top ten contributors of mercury in ecozone 2 (Chan et al. 2011). Bioaccumulation of mercury in terrestrial ecosystems is relatively small, as shown in the low levels of mercury in tissues of herbivorous mammals such as moose compared to those found in piscivorous mammals (Fortin et al. 2001). Therefore, the ER 0f 0.49 is likely an artificially over-estimated exposure of toddlers to mercury in moose meat and it is unlikely that toddlers would experience significant health effects due to consumption of moose at the amounts and frequencies assumed in this assessment (142.5 g/person/day for adults and 61.3 g/person/day for toddlers, averaged over the course of one year).

The current estimated number of weekly servings of all country foods examined in this assessment was below the recommended number of maximum weekly servings calculated for each country food

(Appendix D and Section 7.4). Country foods harvesters can continue to consume the assessed foods at levels they are accustomed to.

The assessment did not detect an incremental lifetime cancer risk (ILCR) greater than the accepted ILCR of one in 100,000 from the consumption of any of the assessed country foods due to the ingestion of inorganic arsenic (Appendix C and Section 7.2).

This country foods study predicts no unacceptable health risks to people from the consumption of meat from moose, snowshoe hare, grouse, trout and whitefish, and berries. Based on the measured and predicted levels of metals in these foods, the amounts currently consumed by the country foods harvesters are within the RMWIs. Thus, country foods harvesters may safely continue to eat these country foods.

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Engineers and Scientists

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Appendix A

Predicted Tissues Concentrations

Appendix A. Predicted Tissue Concentrations

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Appendix A. Predicted Tissue Concentrations

1.1 INTRODUCTION

Tissue concentrations for grouse, snowshoe hare, and moose were estimated based on a food chain model. The model used the measured concentrations of metals in soil, vegetation (Rescan 2013b) and water (Rescan 2013a) during baseline studies, animal specific ingestion rates (US EPA 1993) and metal specific biotransfer factors (Staven et al. 2003; RAIS 2010; US EPA 2012).

This section provides details on the methodology of the food chain model and the resultant modeled metal concentrations in the tissue of the terrestrial and marine country foods. The modeled metal concentrations were used in the country food baseline study.

1.2 METHODS

The following equation was used to predict terrestrial animal tissue concentrations, C_{meat}:

$$C_{meat}\ (mg/kg) = C_{msoil} + C_{mveg} + C_{mwater}$$

where:
C_{msoil} = concentration in meat from the animal's exposure to metals in soil,
C_{mveg} = concentration in meat from the animal's exposure to metals in vegetation, and
C_{mwater} = concentration in meat from the animal's exposure to metals in water.

The terrestrial wildlife uptake equations used to obtain the concentrations in meat from exposure to soil, vegetation, and water are presented in Table A-1.

Table A-1. Terrestrial Wildlife Uptake Equations

Pathway	Equation and Equation Parameters
Soil ingestion	$C_{msoil} = BTF_{tissue\text{-}food}\ (day/kg) \times C_{soil}\ (mg/kg) \times IR_{soil}\ (kg/day) \times fw \times ET$
Vegetation ingestion	$C_{mveg} = BTF_{tissue\text{-}food}\ (day/kg) \times C_{veg}\ (mg/kg\ wet\ weight) \times IR_{veg}\ (kg\ wet\ weight/day) \times fw \times ET$
Water ingestion	$C_{mwater} = BTF_{tissue\text{-}food}\ (day/kg) \times C_{water}\ (mg/L) \times IR_{water}\ (L/day) \times fw \times ET$

BTF = Biotransfer Factor (day/kg)
IR = ingestion rate for soil/vegetation/water by wildlife (kg/day or L/day)
C = concentration of COPC in soil/vegetation/water (mg/kg or mg/L)
fw = fraction of daily consumption (assumed 1, since metal concentration was calculated for vegetation mix prior to being entered into formula [Table A-2]; unitless)
ET = fraction of the year the animal is on site (unitless)

1.2.1 Metal Concentrations in Environmental Media

Rescan conducted several field studies from 2010 to 2012 to determine the current metal concentrations in surface waters, sediments, soils, and vegetation in the country foods study area (Table A-2). Mean concentrations were calculated for each medium and were used to predict the concentrations in animal muscle tissue.

The data used from the water sampling program from 2010 to 2012 included surface water samples collected throughout the year from 15 sites at Murray River and tributaries (Rescan 2013a) within the country foods study area. The mean surface water concentrations of COPCs were calculated from a total of 293 samples (Figure 5.3-1 and Table 5.3-1).

Table A-2. Mean Concentrations of Contaminants of Potential Concern in Plant Tissue, Surface Water, and Soil

COPCs	Mean Measured Baseline Concentrations							
	Vegetation (mg/kg ww)			Vegetation mix (mg/kg ww) for				
	Berries (fruit)	Lichen	Sedges and berries (leaves)	Moose[1] $C_{moose\text{-}veg}$	Hare[2] $C_{hare\text{-}veg}$	Grouse[3] $C_{grouse\text{-}veg}$	Soil mg/kg dw $C_{base\text{-}soil}$	Water mg/L $C_{base\text{-}water}$
Aluminum	3.15	420	53	144.7	84.6	84.6	7248.8	0.9
Arsenic	0.0038	0.24	0.02	0.1	0.0	0.0	4.7	0.0006
Barium	3.55	31	50	45.5	43.8	43.8	211.0	0.1290
Cadmium	0.0078	0.16	0.09	0.1	0.1	0.1	0.6	0.0001
Chromium	0.022	2.05	0.37	0.8	0.5	0.5	10.797	0.00160
Copper	0.839	2.18	1.69	1.8	1.7	1.7	9.9	0.0019
Mercury	0.0006	0.0360	0.0036	0.0117	0.0065	0.0065	0.0379	0.000012
Nickel	0.096	1.61	0.54	0.8	0.6	0.6	14.0	0.0024
Selenium	0.011	0.08	0.13	0.1	0.1	0.1	0.337	0.00068
Silver	ND	ND	ND	ND	ND	ND	0.5	0.000027

Notes:
ww = wet weight
dw = dry weight
ND = not determined
[1] *Moose vegetation: 25% lichen + 75% sedges and berry leaves*
[2] *Vegetation mix for hare: 10% lichen + 10% berries (fruit) + 80% sedges and berries (leaves)*
[3] *Vegetation mix for grouse: 10% lichen + 10% berries (fruit) + 80% sedges and berries (leaves)*

The data from the soil sampling program in 2010-2012 (Rescan 2013b) for sites within the country foods LSA included only samples from a depth of 0-10 cm (Figure 5.3-2). Mean soil metal concentrations of COPCs were calculated from a total of 17 or 40 samples, depending on the COPC (Table 5.3-3).

The plant sampling program for tissue metals in 2010-2012 included 39 lichen samples (*Cladina rangiferina, Stereocaulon paschale*, and *Peltigera scabrosa*), 57 samples of leaves from *Viburnum edule* (highbush cranberry) and wetland sedges (*Carex sp.)*, and 23 samples of berry fruit from *V. edule* and *Ribes* sp. (currant) from inside the country foods LSA (Table A-3, Figure 5.3-2; Rescan 2012). To model the terrestrial wildlife uptake of metals from plants, the mean metal concentrations were calculated for all plant tissues. For moose, it was assumed that the diet consisted of 25% lichen and 75% other browse and aquatic vegetation (berry and sedge leaves; (Timmermann and McNicol 1988; Sharnoff and Rosentreter 1998). Further, it was assumed that grouse and hare consume 80% leaves, 10% lichen, and 10% berries, based on data collected from the literature (US EPA 1993; Sharnoff and Rosentreter 1998).

Table A-3. Species Collected and Analysed for Metals

Genus Species Name	Common Name
Carex sp.	Sedges (leaves)
Virburnum edule	Highbush cranberry (leaves and berries)
Ribes sp.	Currants (berries)
Cladina rangiferina	Reindeer lichen (thallus)
Stereocaulon paschale	Snow lichen (thallus)
Peltigera scabrosa	Felt lichen (thallus)

1.2.2 Terrestrial Wildlife Characteristics

Terrestrial wildlife characteristics were based on values provided in the primary literature (Demarchi 2003) and guidance from the Oakridge National Laboratory (ORNL 1997), the US EPA *Wildlife Exposure Handbook* (US EPA 1993), and the Central Science Laboratory CSL (Central Science Laboratory 2002). Table A-4 presents the species-specific characteristics that were used to predict meat concentrations.

Table A-4. Terrestrial Wildlife Characteristics

Parameter	Unit	Symbol	Moose	Grouse	Hare
Bodyweight	kg	BW	461	1.2	1.35
Total Food Ingestion Rate	kg/day	IR	9.95	0.085	0.109
Vegetation Ingestion Rate	kg-ww/day	IR_{veg}	9.8	0.084	0.105
Soil Ingestion Rate	kg-dw/day	IR_{soil}	0.15	0.07	0.0036
Water Ingestion Rate	L/day	IR_{water}	25	0.07	0.0135
Baseline Scenario					
Exposure Time in LSA		ET_{base}	1	1	1

Moose are known to stay within one watershed. For moose, a non-migratory home range of 4,220 ha was assumed (Demarchi 2003). In addition, moose were assumed to be active in the area for the entire year (52 weeks) because during winter months they may attempt to forage for grass and lichens beneath the snow. A conservative assumption was made that the moose would use its entire home range equally and since the LSA (12,093 ha) is larger than a moose's home range, it could spend the entire year in the country foods LSA (ET=1). This conservative assumption would result in human health risks being overestimated rather than underestimated. Uncertainties associated with assumptions made for the food chain model are presented in the main text of the country foods report.

The home range of snowshoe hares is small and estimated to be between 0.057 to 0.1 km^2 (Adams 1959). For country foods assessments, it is preferable to use organisms that have small home ranges that may be located entirely within the country foods study area. As such, snowshoe hare were included in the country foods baseline assessment.

Most grouse have a relatively small home range and, with the exception of sage grouse, are not know to migrate (Parks Canada 2011). It was assumed that grouse have a home range of 0.4 km^2 (spruce grouse; Williamson et al. 2008). As metal exposure from the country foods study area would be most relevant to non-migratory foraging birds, consumption of grouse would likely represent the conservatively high exposure to metals in birds harvested from the country foods study area.

As a result, grouse and snowshoe hare were assumed to spend all year eating and drinking from within the LSA (ET=1).

The terrestrial wildlife uptake equations recognize that different wildlife species consume environmental media at different ingestion rates (IRs). Therefore, IRs for each environmental media are species-specific for wildlife.

1.2.3 Biotransfer Factors

The tissue metal 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, water, and soil. No species-specific BTF for moose or snowshoe hare were available, therefore beef BTFs were used. The metal-specific BTFs for food-to-tissue were used for all uptake pathways (i.e. from vegetation, soil, and water), because no BTFs were found for soil-to-tissue or water-to-tissue (Table A-5). This methodology is based on the document prepared by Health Canada (2010).

Table A-5. Biotransfer Factors Used to Predict Metal Uptake into Wildlife Tissue

	BTF beef		BTF chicken	
COPC (Total)	**day/kg**	**Reference**	**day/kg**	**Reference**
Aluminum	0.0015	1	0.8	2
Arsenic	0.002	1	0.83	3
Barium	0.0002	3	0.009	3
Cadmium	0.00055	1	0.8	4
Chromium	0.0055	1	0.2	3
Copper	0.01	1	0.5	3
Mercury	0.25	1	0.03	3
Nickel	0.006	1	0.001	3
Selenium	0.015	1	1.12625	4
Silver	0.003	3	2	3

References:
1 RAIS 2010
2 BTF chicken for aluminum is based on BTF chicken for gallium
3 Staven 2003
4 US EPA 2012

There were no species-specific BTFs for grouse, therefore chicken BTFs were used (RAIS 2010). The chicken BTFs were obtained from the Pacific Northwest National Laboratory's (PNNL), primary literature (Staven et al. 2003), and the Integrated Risk Information System (US EPA 2012). The metal-specific food-to-tissue chicken BTFs were used for all exposure pathways for grouse (Table A-5).

BTFs are designed to predict the uptake of metals into animal tissue (i.e., muscle). However, many metals become concentrated in organs (i.e., kidney and liver). Moose organs were not selected for evaluation because of the relatively lower consumption frequency of individual organs among country food harvesters when compared to muscle meat.

1.3 SAMPLE CALCULATION AND RESULTS

Table A-6 provides a sample calculation for the concentration of aluminum in moose tissue from the consumption of vegetation, soil, and drinking water. Table A-7 presents the estimated tissue concentrations in moose, grouse, and snowshoe hare from uptake of COPCs in vegetation, soil and water. The modeled total metal concentrations in muscle from all ingestion pathways for each country food was used to determine the potential for human health effects associated with consumption of that food (section 6.6 of the main report).

Table A-6. Sample Calculation Mean Aluminum Concentration in Moose Tissue from Exposure to Surface Waters, Soil, and Vegetation

Overall Equation:

$C_{meat} = C_{mveg} + C_{msoil} + C_{mwater}$

Where:

$C_{mveg} = BTF_{\textit{tissue-food}} \times C_{veg} \times IR_{veg} \times ET_{base}$

$C_{msoil} = BTF_{\textit{tissue-food}} \times C_{soil} \times IR_{soil} \times ET_{base}$

$C_{mwater} = BTF_{\textit{tissue-food}} \times C_{water} \times IR_{water} \times ET_{base}$

Parameters:

C_{meat} = Total concentration of aluminum in moose tissue from all ingestion pathways

C_{mveg} = Total concentration of metal (aluminum) in animal tissue (moose) from vegetation ingestion

C_{msoil} = Total concentration of metal (aluminum) in animal tissue (moose) from soil ingestion

C_{mwater} = Total concentration of metal (aluminum) in animal tissue (moose) from water ingestion

$BTF_{beef\text{-}aluminum}$ = Biotransfer factor from food consumption to tissues for a selected metal

$C_{soil/veg/water}$ = Media concentration of aluminum during baseline studies

$IR_{soil/veg/water}$ = Ingestion rate of environmental media (i.e., soil, vegetation, or water)

ET_{base} = Exposure time in the country foods LSA at baseline

Sample Calculation (see Table A-2 for input data):

C_{mveg} = (0.0015 day/kg) x (144.7 mg/kg ww) x (9.8 kg/day) x 1
= 2.13 mg/kg

C_{msoil} = (0.0015 day/kg) x (7,248.8 mg/kg dw) x (0.15 kg/day) x 1
= 1.63 mg/kg

C_{mwater} = (0.0015mg/kg) x (0.9 mg/L) x 25 L/day) x 1
= 0.0349 mg/kg

C_{meat} = (3.79+1.63+0.0349) mg/kg
= 3.79 mg/kg

Table A-7. Modeled Metal Concentrations in Moose, Grouse, and Hare Tissue

COPC	Concentration (mg/kg) - moose				Concentration (mg/kg) - grouse				Concentration (mg/kg) - hare			
	C_{mveg}	C_{msoil}	C_{mwater}	C_{meat}	C_{mveg}	C_{msoil}	C_{mwater}	C_{meat}	C_{mveg}	C_{msoil}	C_{mwater}	C_{meat}
Aluminum	$2.13 \times 10^{+00}$	$1.63 \times 10^{+00}$	3.49×10^{-02}	**$3.79 \times 10^{+00}$**	$5.69 \times 10^{+00}$	$4.06 \times 10^{+02}$	5.21×10^{-02}	**$4.12 \times 10^{+02}$**	1.34×10^{-02}	3.89×10^{-02}	1.88×10^{-05}	**5.23×10^{-02}**
Arsenic	1.51×10^{-03}	1.40×10^{-03}	2.99×10^{-05}	**2.94×10^{-03}**	2.98×10^{-03}	2.71×10^{-01}	3.47×10^{-05}	**2.74×10^{-01}**	8.99×10^{-06}	3.34×10^{-05}	1.61×10^{-08}	**4.24×10^{-05}**
Barium	8.92×10^{-02}	6.33×10^{-03}	6.45×10^{-04}	**9.61×10^{-02}**	3.31×10^{-02}	1.33×10^{-01}	8.13×10^{-05}	**1.66×10^{-01}**	9.22×10^{-04}	1.51×10^{-04}	3.47×10^{-07}	**1.07×10^{-03}**
Cadmium	5.78×10^{-04}	4.91×10^{-05}	8.69×10^{-07}	**6.28×10^{-04}**	5.92×10^{-03}	3.34×10^{-02}	3.54×10^{-06}	**3.93×10^{-02}**	5.10×10^{-06}	1.17×10^{-06}	4.68×10^{-10}	**6.28×10^{-06}**
Chromium	4.27×10^{-02}	8.91×10^{-03}	2.20×10^{-04}	**5.18×10^{-02}**	8.48×10^{-03}	1.51×10^{-01}	2.24×10^{-05}	**1.60×10^{-01}**	2.92×10^{-04}	2.13×10^{-04}	1.18×10^{-07}	**5.05×10^{-04}**
Copper	1.77×10^{-01}	1.48×10^{-02}	4.85×10^{-04}	**1.93×10^{-01}**	6.93×10^{-02}	3.46×10^{-01}	6.79×10^{-05}	**4.16×10^{-01}**	1.74×10^{-03}	3.54×10^{-04}	2.61×10^{-07}	**2.09×10^{-03}**
Mercury	2.87×10^{-02}	1.42×10^{-03}	7.44×10^{-05}	**3.02×10^{-02}**	1.65×10^{-05}	7.96×10^{-05}	2.50×10^{-08}	**9.62×10^{-05}**	1.72×10^{-04}	3.39×10^{-05}	4.00×10^{-08}	**2.06×10^{-04}**
Nickel	4.73×10^{-02}	1.26×10^{-02}	3.65×10^{-04}	**6.03×10^{-02}**	5.04×10^{-05}	9.80×10^{-04}	1.70×10^{-07}	**1.03×10^{-03}**	3.79×10^{-04}	3.01×10^{-04}	1.96×10^{-07}	**6.80×10^{-04}**
Selenium	1.74×10^{-02}	7.59×10^{-04}	2.54×10^{-04}	**1.84×10^{-02}**	1.08×10^{-02}	2.66×10^{-02}	5.35×10^{-05}	**3.74×10^{-02}**	1.80×10^{-04}	1.81×10^{-05}	1.37×10^{-07}	**1.98×10^{-04}**
Silver	NC	2.20×10^{-04}	2.02×10^{-06}	**2.22×10^{-04}**	NC	6.85×10^{-02}	3.77×10^{-06}	**6.86×10^{-02}**	NC	5.26×10^{-06}	1.09×10^{-09}	**5.26×10^{-06}**

NC = not calculated due to lack of environmental media data.
Bolded numbers indicate the total modeled concentration of COPC in meat

1.4 REFERENCES

An explanation of the acronyms used throughout this reference list can be found in the *Acronyms and Abbreviations* section of the main report.

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Appendix B

Sample Calculation of Estimated Daily Intake of Arsenic for a Toddler Consuming Moose Tissue

Appendix B. Sample Calculation of Estimated Daily Intake of Arsenic for a Toddler Consuming Moose Tissue

$$EDI_{countryfood} = \frac{IR \times Fw \times C_{country\,food}}{BW}$$

$EDI_{countryfood}$ = estimated daily intake of country food (mg/kg BW/day)

IR = ingestion rate (kg/day)

$C_{country\ food}$ = metal concentration in country food (mg/kg wet weight)

Fw = fraction of year consuming country foods (unitless, set to 1)

BW = receptor body weight (kg)

Parameter	**Value**	
IR	0.0613	kg/day
C_{moose}	0.00294	mg/kg wet weight
Fw	1	
BW	16.5	kg/day

$$EDI_{countryfood} = \frac{0.0613 \times 1 \times 0.00294}{16.5}$$

$$EDI_{countryfood} = 1.1\ \times 10^{-5}\ mg/(kg\ \times day)$$

Appendix C

Sample Calculation of Estimated Daily Lifetime Exposure of Arsenic for an Adult Consuming Trout Tissue (Baseline)

Appendix C. Sample Calculation of Estimated Lifetime Daily Exposure of Arsenic for an Adult Consuming Trout Tissue (Baseline)

$$ELDE_{\text{country food}} = \frac{IR \times Fw \times C_{\text{countryfood}} \times YE}{BW \times LE}$$

$ELDE_{\text{country food}}$ = estimated lifetime daily intake of coutry food (mg/kg bw/day)
IR = ingestion rate (kg/day)
$C_{\text{countryfood}}$ = inorganic arsenic concentration in country food (mg/kg)
(incorporates measured total arsenic and percent inorganic arsenic based on Schoof et al. [1999])
Fw = fraction of year consuming country food (unitless)
YE = years exposed (yr)
BW = receptor body weight (kg)
LE = life expectancy (yr)

Parameter	**Value**
IR	0.0123
$C_{\text{countryfood}}$	0.00163
Fw	1
YE = LE	70
BW	70.7

$$ELDE_{\text{country food}} = \frac{0.0114 \text{ kg/day} \times 1 \times 0.00163 \text{ mg/kg ww} \times 70 \text{ yr}}{70.7 \text{ kg bw} \times 70 \text{ yr}}$$

$ELDE_{\text{country food}} = 4.74 \times 10^{-7}$ mg/kg bw/day

Reference: *Schoof, R. A., L. J. Yost, J. Eickhoff, E. A. Crecelius, D. W. Cragin, D. M. Meacher, and D. B. Menzel. 1999. A market based survey of inorganic arsenic in food. Food and Chemical Toxicology, 37: 839-46.*

Appendix D

Metal-specific Recommended Maximum Weekly Intakes

Appendix D. Metal-specific Recommended Maximum Weekly Intakes

Table D-1. Sample Calculation of RMWI in Toddlers Consuming Moose Tissue under Baseline Scenario

$$RMWI_{metal} = \frac{TRV_{metal} \times BW_{toddler} \times 7d/week}{C_{base\text{-}moose}}$$

$$RMWI_{aluminum} = \frac{1\ mg/kg/d \times 16.5\ kg \times 7d/week}{3.8\ mg/kg}$$

COPCs	TRV_{metal} mg/kg/d	$BW_{toddler}$ kg	$C_{base\text{-}moose}$ mg/kg	$RMWI_{metal}$ kg/week
Aluminum	1	16.5	3.8	30.4
Arsenic	0.0003	16.5	0.003	11.8
Barium	0.2	16.5	0.096	240.3
Cadmium	0.001	16.5	0.000628	183.8
Chromium	0.001	16.5	0.052	2.2
Copper	0.141	16.5	0.193	84.5
Mercury	0.00023	16.5	0.0302	1.1
Nickel	0.025	16.5	0.060	47.9
Selenium	0.0062	16.5	0.0184	38.9
Silver	0.005	16.5	0.0002	2,597

Highlight = Final RMWI = 1.1 kg/week, based on metal with the lowest RMWI

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

	Baseline RMWI (kg/week)				
COPCs	Moose	Grouse	Hare	Berries	Trout
Aluminum	130	1.20	9461	157	28
Arsenic	50	0.54	3500	39	9
Barium	1030	596	92219	28	71
Cadmium	788	13	78858	63	11
Chromium	10	3.10	980	22	5
Copper	362	168	33336	83	100
Mercury	5	1544	720	244	11
Nickel	205	12006	18201	129	167
Selenium	153	75	14253	261	3
Silver	11129	36	470468	ND	ND
RMWI	**4.9**	**0.54**	**720**	**22**	**3.3**

Notes:

ND = Not determined

Units are (kg/week)

Table D-3. Summary of Recommended Maximum Weekly Intakes for Toddlers

	Baseline RMWI (kg/week)				
COPCs	Moose	Grouse	Hare	Berries	Trout
Aluminum	30	0.28	2208	37	7
Arsenic	12	0.13	817	9	2.12
Barium	240	139	21522	7	17
Cadmium	184	3	18404	15	3
Chromium	2	1	229	5	1
Copper	85	39	7780	19	23
Mercury	1	360	168	57	1
Nickel	48	2802	4248	30	39
Selenium	39	19	3618	66	1
Silver	2597	8	109798	ND	ND
RMWI	**1**	**0.13**	**168**	**5**	**0.85**

Notes:

ND = Not determined

Units are (kg/week)