Environment AECOM

Howse Minerals Limited

Quantitative Human Health Risk Assessment for the Howse Property Environmental Impact Statement

Prepared by:

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Project Number:

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Date:

November, 2015

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AECOM: 2012-01-06

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
0	M.Rankin	2015-10-26	Initial Draft
1	M.Rankin	2015-11-02	Final with Client Comments addressed

AECOM Signatures

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1. Introduction

Howse Minerals Limited (HML) proposes to develop the iron ore deposit at the Howse Project Property located in western Labrador (the Project), approximately 25 km northwest of Schefferville, Quebec. The deposit will be developed as an open pit iron mine with the support of existing adjacent infrastructure in the nearby Schefferville, Quebec area. AECOM has prepared this Report on Human Health Risk Assessment (HHRA) on behalf of HML.

1.1 Purpose and Context of this Report

The Canadian Environmental Assessment Agency (CEA Agency) has issued direction to HML on the scope of the EA in the form of the Environmental Impact Assessment Guidelines (EISGs). HML has prepared a single joint EA submission (the “Submission”) to meet the requirements of both agencies. The EISGs for the Project require that biophysical changes to the environment that may impact human health be considered in the scope of assessment.

Through Aboriginal Consultation, physical health of local residents was identified as a Valued Component (VC) within the context of potential changes to environmental chemistry that might arise from the Project. VCs are components of the natural and human environment that are considered by the proponent, public, Aboriginal Groups, scientists and other technical specialists, and government agencies involved in the assessment process to have scientific, ecological, economic, social, cultural, archaeological, historical, or other importance.

An HHRA is a systematic and well-documented process to define and quantify potential human health risks, which serve as surrogate measure of potential impacts. This report presents the results of the HHRA completed for the Project and supports the Environmental Impact Statement (EIS). The HHRA uses site data and conservative assumptions to predict the toxicological risk potential to humans during the operational phase. Through a combination of conservative assumptions including predicted air quality during blasting and far future conditions accrued from long-term particulate deposition, the HHRA risk estimates are inferred to also adequately describe toxicological risk for the construction phase, and decommissioning and abandonment phase of this project.

1.2 HHRA Supporting Documents

This document is one of a series of reports prepared to support the application process. Table 1.1 lists various documents from which information and data were obtained relevant to the Local Study Area and Regional Study Area (LSA and RSA, respectively) in the development of the HHRA:

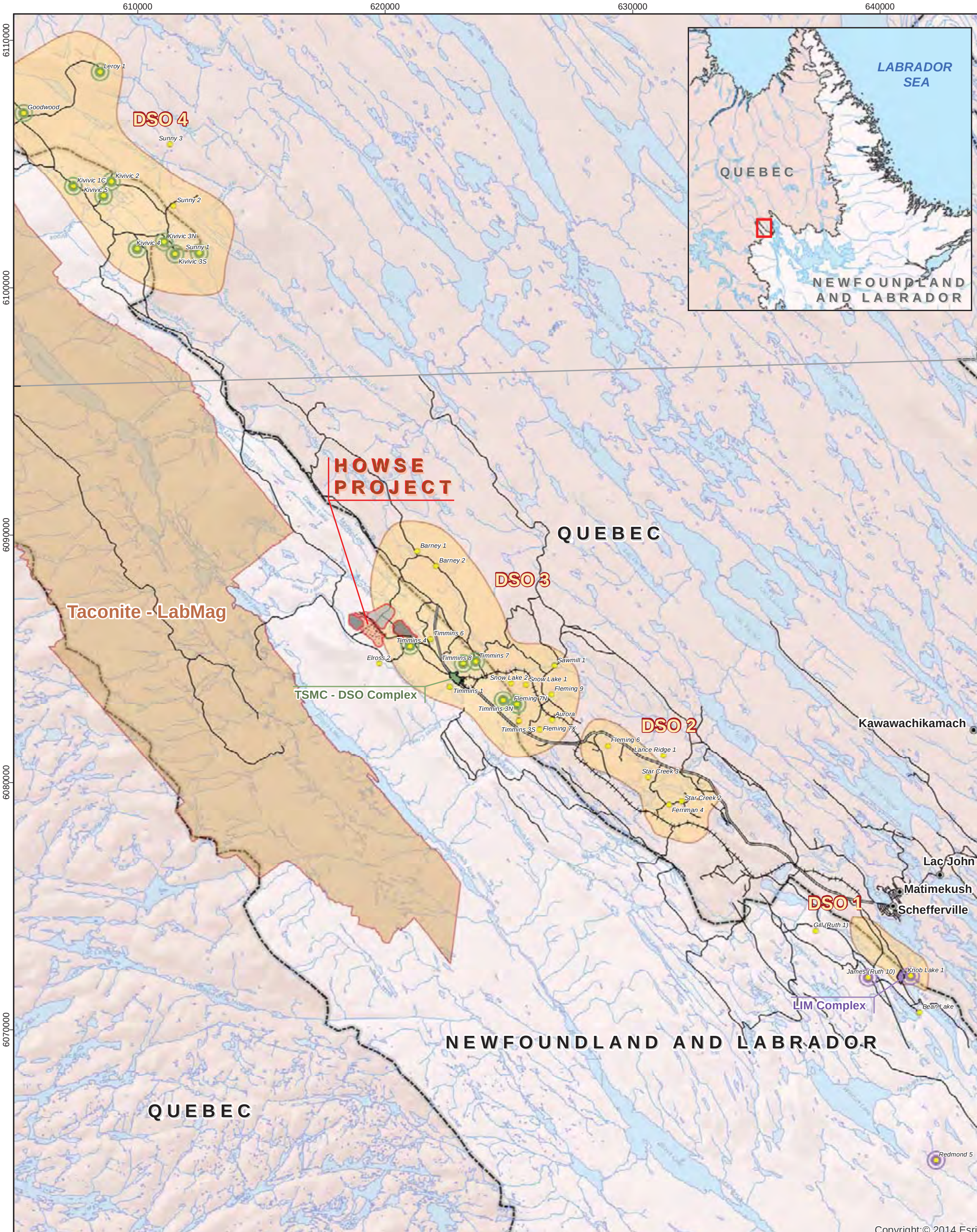
Table 1.1 HHRA Supporting Documents Used to Inform Human Health Risk Assessment

Report	Data Provided
Schefferville Iron Ore EIS (Jacques Whitford 2009)	RSA soil and surface water,
Air Dispersion Modelling Report (AECOM 2015 (Vol. 2, Appendix E))	LSA Air Quality
Hydrogeology and MODFLOW Modeling Howse Property (GEOFOR 2015, (Vol. 2, Appendix C))	LSA Groundwater quality
Aquatic Survey – Howse Pit Study Area (Groupe Hémisphères 2014)	LSA Water quality and Sediment quality
Hydrological Campaign DSO3 and DSO4 (Groupe Hémisphères 2011)	LSA Water quality
Fish and Fish Habitat Investigation for the Direct-Shipping Ore Project (AMEC 2009)	LSA Water quality
Hemisphere Field Report – 2013 Baseline Aquatic Fauna Characterization: Elross Lake Area Iron Ore Mine (ELAIOM) Environmental Effects Monitoring (EEM)	LSA Water quality
KAMI Concentrate Storage and Load-out Facility, Québec (Stantec 2012)	RSA water quality
Air Quality Monitoring Baseline Study (Stantec 2012)	RSA air quality
Howse Property Country Food Survey (June 2015)	Socioeconomic

1.3 Project Overview

This project includes the development and operation of a conventional open pit mine at the Howse Property using a drill and blast mining method (Figure 1). The extracted iron ore will be crushed and screened on-site, hauled by truck to Howse Minerals Limited (HML) DSO project rail loop loading area (less than 5 km from the Project), and then shipped by train to Sept-Îles, QC. The high-grade iron ore from the mine will be transported by haul trucks to the DSO3 product stockyard, where it will be crushed and screened before being loaded onto product reclaiming conveyors for subsequent loading onto rail cars. The low-grade ore, generated by the excavation of high-grade ore, will require beneficiation in a process plant similar to HML's processing unit currently under construction for the DSO project. The processing plant that is currently under construction will be fully utilized over the next 15 years. Hence, the low-grade iron ore will be stockpiled near the Howse deposit and will be processed through the DSO processing plant located approximately 4 km from the Howse deposit (Figure 2). The projected life of the mine is 15 years with a projected closure date in 2032.

The Project requires few new installations and some of the required infrastructure (e.g., the railway, access road, camp, mining equipment and explosive storage) are already in place at the nearby TSMC DSO project complex, which was recently put into operation. The construction of new infrastructure will be required to mine the deposit at the Howse Property. The main physical works and activities involved for the Project are: an open pit, a mobile crushing and screening facility at DSO3, dedicated areas for stockpile/dumps, new access and haul roads to connect to an existing network, power generation facilities, and water management infrastructure. No tailings or tailings process water will be generated by the Howse Project. HML plans to utilize the following approved facilities at TSMC's DSO project plant complex: a processing plant, covered processed ore stockpiles, a rail car loading system, an existing railway track, a camp to accommodate the workers, offices, a warehouse, workshops, garages, a laboratory, a landfill, and a wastewater treatment facility. None of the above listed facilities are part of the scope of the current EIS.



LEGEND

Infrastructure and Mining Components
- DSO - Deposit
- LIM Actual or Planned Deposit Operation
- LIM Complex
- TSMC Actual or Planned Deposit Operation
- DSO Complex - TSMC
- DSO - Other Site
- Taconite - LabMag

Howse Infrastructures
- Proposed Howse Pit
- Proposed Topsoil/Overburden Stockpile
- Proposed Site Infrastructure
- Proposed Waste Dump/In-Pit Dump

Basemap
- Town
- Railroad
- Road
- Watercourse
- Water body
- Provincial Boundary

FILE, PROJECT, DATE, AUTHOR:
GH-0571 , PR185-19-14, 2015-10-21, edickoum

N

0 2 4 6 8 10
Kilometers

UTM 19N NAD 83

SCALE: 1:150 000

SOURCES:

Basemap
Government of Canada, NTDB, 1:50,000, 1979
SNC Lavalin, Groupe Hémisphères, Hydrology update, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/ MET-CHEM, Howse Deposit Design for General Layout., 2013

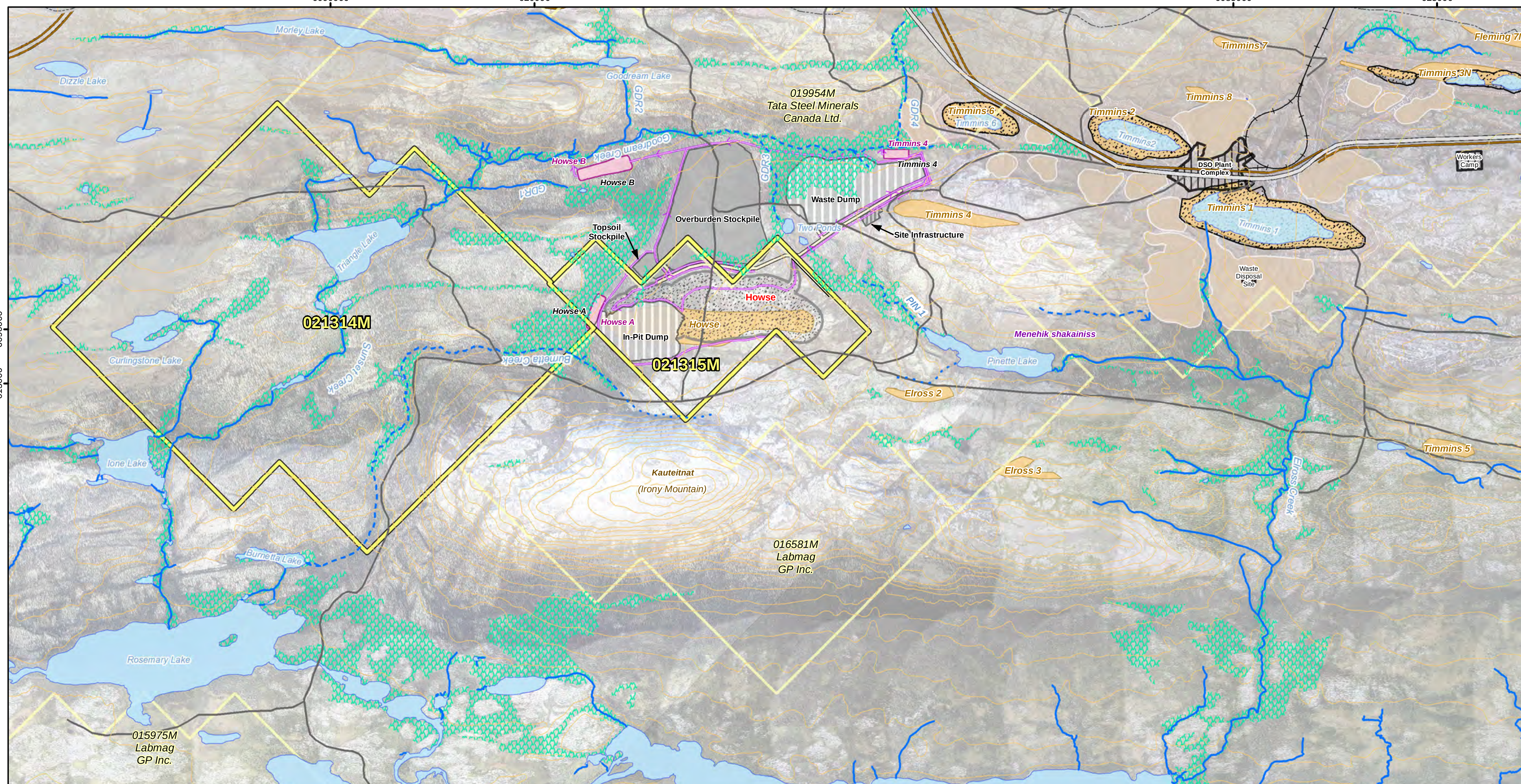
ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Howse Project Location Map

Howse Minerals Limited

GroupeHemispheres
5731, rue Saint-Louis, Bureau 201, Lévis (QC) Canada, G6V 4E2
1453, rue Beaubien est, Bureau 301, Montréal (QC) Canada, H2G 3C6

Figure 1



LEGEND

Infrastructure and Mining Components

Proposed Infrastructures
- Proposed Howse Pit
- Proposed Topsoil/Overburden Stockpile
- Proposed Waste Dump/In-Pit Dump
- Proposed Site Infrastructure
- Proposed Sedimentation Pond
- Proposed Ditch and Outlet
- Proposed Mine Haul Road

Existing Components
- Existing Railroad
- Road to DSO Area 4
- Existing Sedimentation Pond
- DSO Howse - Claim Labrador Iron Mines Limited(49%)/ Howse Minerals Ltd.(51%)
- Other Claim

Elross Lake Area Iron Ore Mine (ELAIOM)
- Plant Infrastructure Footprint
- Existing Dump
- Existing Pit
- Deposit

Basemap
- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water body
- Contour Line (50 ft)
- Provincial Border
- Existing Road
- Main Access Road
- Wetland

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0572a , PR185-19-14, 2015-10-21, edickoum

N

0 500 1 000 1 500 2 000
Meters

UTM 19N NAD 83

SCALE: 1:30 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979 Government of NL and government of Quebec, Boundary used for claims
SNC Lavalin, Groupe Hémisphères, Hydrology update, 2013

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/ MET-CHEM Howse Deposit Design for General Layout, 2013

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Howse Property and HML DSO Project Infrastructure

Howse Minerals Limited

GroupeHemispheres

5731, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 2

The project plan is subject to the satisfactory completion of the feasibility study and acquisition of all necessary environmental approvals from Newfoundland and Labrador, and federal jurisdictions. Once approved the Project will proceed as follows:

- A detailed engineering phase
- A construction phase, that would require about 1 years
- An operations phase that is currently planned for 16 years
- A decommissioning and abandonment phase
- A post-closure phase (mainly environmental monitoring).

1.3.1 Construction and Operation Phase Emissions, Waste and Discharges

Air

Airborne particles and dust will be managed along roadways and in ore storage and processing areas. The Howse Property will not be supplied with electricity and therefore greenhouse gas emission estimates for the Howse Project were based on the need for diesel generators at the DSO3 main plant, worker camp, and for the pit-dewatering pump. Exhaust from diesel power generators will be emitted to the atmosphere and will include CO_2, CH_4, NO_2, combustible hydrocarbons and volatile organic carbons. Overall, GHG emissions from the Howse Project Property are estimated to be approximately 43,000 t CO_2 eq/yr, which represents roughly 0.4% of the total emissions for Newfoundland and Labrador.

Noise

Potential noise sources includes equipment used during the construction phase, facility operation, loading operations, road traffic during the life of the mine, and diesel generators. Within the Howse Property area noise-sensitive areas include Irony Mountain, and Pinette, Rosemary, Elross, and Triangle Lakes. The Town of Schefferville was also assessed, as it is the closest town to the Howse Mine. Project noise is not expected to be above background levels at approximately 5 kilometers from the Howse Mine.

Liquid Waste

Sewage and wastewater generated at each of the camps, the processing complex and the garage will be retained in holding tanks for appropriate off-site disposal. The contents of those tanks are transferred regularly. Except for water management around the open pit the storm water on the project property will be collected using an engineered solution.

Solid Waste

The project will continue the current practice of collecting solid waste from around the site in animal-resistant containers that are disposed of by a contractor in a waste management site near Timmins 1. The mine staff will be staying at an existing nearby camp and therefore no discussion of camp related solid waste is included in this report.

1.3.2 Decommissioning Phase

At the end of the project, site infrastructure will be decommissioned and abandoned according to the mine closure regulations.

1.4 Physical Environment

1.4.1 Topography

The Howse Property is located between Irony Mountain (840 m asl) and Pinette Lake. The topography of the area is dominated by Irony Mountain, which is a prominent bedrock knob, and the meltwater channels on the western flank of Irony Mountain. Based on the NTS map sheet 023J this area is a network of ridges and valley oriented approximately northwest to southeast that is typical of the Labrador Trough.

1.4.2 Geology

The Howse iron ore deposit was discovered in 1979 by the Iron Ore Company of Canada in a test hole drilled on a geophysical anomaly. After the discovery of the deposits further tests were carried out including gravity tests and exploration drilling. Structurally, the deposit occurs in a broad syncline with tight second order folds in the hinge area. The Howse Project Property is located in a geological formation called the Labrador-Quebec Trough. This formation is approximately 1,200 km long and up to 100 km in width and is a complexly folded and faulted geosyncline bearing sedimentary, volcanic and intrusive rocks. The Trough is divided into three regions:

- The north region (Ungava Bay Region);
- The central region (Schefferville Region), and
- The south region (The Grenville).

The Howse Project Property itself is covered by a relatively uniform layer of till overlying buried glaciofluvial sand and gravel. The landform is interpreted to be a buried kame, more or less centered on the deposit, overridden by a late glacial advance. The till in the area is generally moderately well to well drained and silty sand is the most widespread surficial material in the vicinity of the Project. In depressions where the groundwater table is perched on an impervious layer, the till may be imperfectly to poorly drained. Historical drilling records indicate that the glaciofluvial material encountered was mainly a mixture of sand and gravel, with occasional clay content.

1.4.3 Climate

The climate data for the Local Study Area (LSA) is represented by data collected within a 30 km radius centered on the proposed Howse Property Project site. This includes one governmental weather station at the Schefferville airport and one dedicated weather station for the nearby Taconite project. In the regional study area (RSA) the growing season is very short and precipitation is moderate. The Long-term temperature records for the Schefferville town site (522 m asl) indicate a mean annual air temperature of -5.3°C. The seasonal pattern of air temperature reflects its continental influence, characterized by dramatic extremes. The distribution of precipitation in Labrador is fairly uniform throughout the year. However, the mean annual precipitation varies greatly across Labrador, ranging from 600 mm to 1,400 mm, with the lower end of the precipitation range occurring in north-west Labrador, where the predominant winds provide drier (continental) air. Further climate information including Environment Canada weather normals from the Schefferville A weather station (No. 7117825) is available in the climate section of the EIS.

1.4.4 Hydrology

The Howse Project Property is drained by three watersheds, which ultimately discharge into the Howells River watershed. Under baseline conditions the local water bodies (Triangle Lake and Pinette Lake) are considered to be near neutral with some recorded measurements indicating a slightly acidic pH. The baseline water quality parameters analysed were in compliance with both the Health Canada and Quebec drinking water quality guidelines.

1.5 Ecological Region and Setting

The project is located in both the mid subarctic forest (MSF) Ecoregion and the high subarctic tundra (HST) ecoregion described below:

Winters in the MSF are generally cold and snowy while summers are cool and short, approximately four to five months long. Records for the MSF are similar to climate normals for Schefferville with a mean daily minimum temperature during the coldest month of -28.9 °C and a record low of -50 °C. The severe climate and short summer causes discontinuous forest cover and inhibits continuous tree cover on upland sites. This area represents a transition between the relatively productive closed boreal forests to the south and the treeless subarctic tundra to the north. Evergreen trees dominate this Ecoregion and deciduous trees are sparse. Typical tree species include balsam fir, black spruce, white spruce and tamarack. As is typical in boreal forest areas, forest fires are a common and important part of the forest renewal process and as such forest fires tend to cover large areas. In low lying areas wetland complexes can be extensive and are characterized by patterned or ribbed fens, interspersed with forested fens.

Summers in the HST Ecoregion are typically short followed by long, windy winters. The summer growing season is short lasting approximately 80 to 100 days. The HST Ecoregion contains discontinuous permafrost in upland areas and small pockets of wetlands in depressions and around lakes where thin organic soils dominate. The various ecotypes of the HST Ecoregion are generally found at elevations higher than 650 m. These ecotypes are all treeless and are similar to the alpine tundra, supporting vegetation dominated by shrubs and graminoids.

1.6 Human Context

1.6.1 Social Communities

Two Aboriginal communities, the Naskapi and the Innu, use the land in the vicinity of the Howse Property including Pinette Lake which has recreation value for the Aboriginal people of the area. The nearby Irony Mountain is a culturally and historically significant location to the local communities and Aboriginal people, especially the Innu. .

To minimize the visual and environmental impact on wetlands, water quality and fish habitat, consultations were conducted with local aboriginal organizations and family trap line holders (Section 1.5; Howse EIS). The proposed layout of the Howse pit was selected after consultation with Aboriginal organizations and family trapline holders to accommodate Aboriginal rights or interests. The closest First Nations communities to the project site are located in the Shefferville and Kawawachikamach area of eastern Quebec. The Ville de Schefferville and Matimekush-Lac John, an Innu community, are located approximately 25 km from the Howse Property, and 2 km from the Labrador border. According to the 2011 population census results Schefferville and Matimekush-Lac John have approximately 213 and 540 presidents, respectively. The Naskapi community of Kawawachikamach is located about 15 km northeast of Schefferville.

1.6.2 Terrestrial Ecosystem Services

The human stakeholders in this area include the local First Nations stakeholder groups and residents of nearby communities identified in Section 1.6.1. Based on the socioeconomic surveys conducted for the Howse Project development a variety of aquatic birds and terrestrial mammals are harvested annually along with medicinal plants. Specific species of interest in the vicinity of the Howse property are summarized in Table 1.2. The Irony Mountain area has been identified as a locally sensitive terrestrial environment.

Table 1.2 Terrestrial plants and wildlife collected by First Nations and local hunters within the LSA

Waterfowl and Game Birds		Large /Small Mammals	
Goldeneye	Long-tailed duck	Caribou	Snowshoe hare
Canada goose	Common merganser	Beaver	Porcupine
White-winged scoter	Spruce grouse	**Vegetation**	
Common loon	Willow ptarmigan	Blueberries	Lingonberry (Partridge berry)
American black duck	Rock ptarmigan	Cloudberries	Labrador Tea

1.6.3 Aquatic Ecosystem Services

The Howse Project Property is a mountainous area that has many small lakes and streams. Locally sensitive aquatic habitats have been identified in Burnetta Creek, Goodream creek and the regions low-lying wetlands.

The site of the proposed pit itself is flanked by Triangle Lake and Pinette Lake and Goodream Creek. Based on the socioeconomic surveys conducted for the Howse Project development the fish species collected from these water bodies by local traditional food users are provided in Table 1.3.

Table 1.3 Fish species collected by First Nations within the LSA

Fish	
Brook trout	Sucker (white, longnose)
Lake trout	Landlocked char
Northern pike	Burbot
Lake whitefish	

It is expected that while in the area First Nation hunting and gathering groups utilize the aquatic resources for food (fish) and drinking water.

1.7 Scope of Supporting Environmental Data

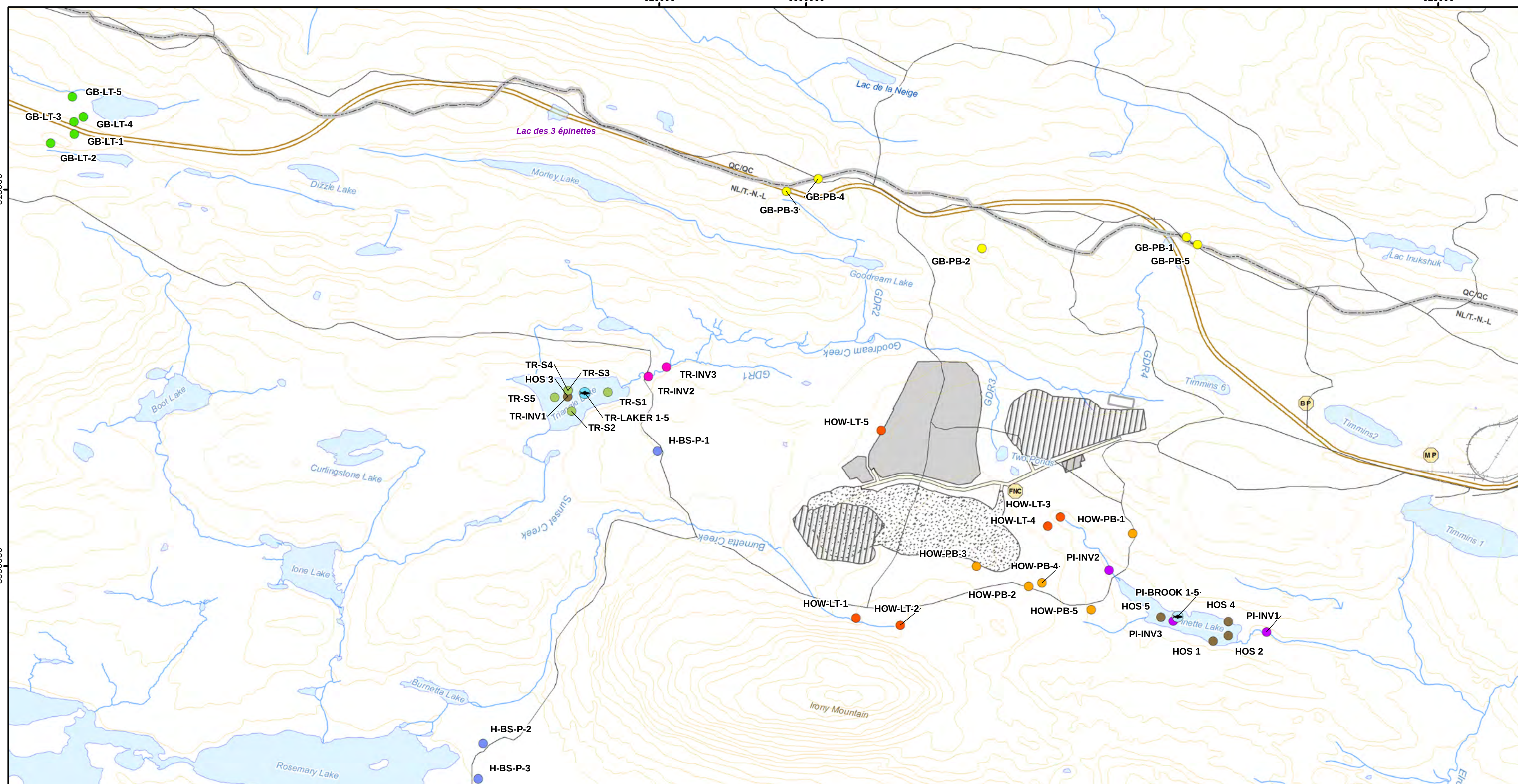
The HHRA evaluated baseline environmental chemistry data from the supporting documents identified in Table 1.1 by the various Project discipline teams:

- Surface Soil
- Subsurface Ore/Rock/Soil
- Surface Water
- Air Quality.

To complete the HHRA the following environmental media and biota were sampled within the LSA to establish or augment baseline chemistry data:

- Sediment
- Benthic Invertebrates
- Food plants
- Medicinal plants
- Terrestrial Bird Tissue
- Fish Tissue.

Sample locations from the 2015 supplemental field programs are presented in Figure 3, and the resulting chemistry data and its applications in the HHRA process are described is subsequent sections; summary chemistry data are provided in Appendix E2. Due to the lack of availability of small mammals at the site during the summer of 2015, small mammals were not collected for chemical evaluation of metals content.



LEGEND

Samples

Fishes
- Pinette Lake
- Triangle Lake

Benthic Invertebrates
- Pinette Lake
- Triangle Lake

Soil and Vegetation
- Howse Partridge Berry
- Greenbush Partridge Berry
- Howse Labrador Tea
- Greenbush Labrador Tea
- Spruce Grouse

Sediments
- Pinette Lake
- Triangle Lake

Infrastructure and Mining Components
- MP Main processing Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- Road to DSO Area 4
- Existing Railroad
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Site Infrastructure
- Proposed Waste Dump/ In-Pit Dump
- Proposed Sedimentation Pond
- Proposed Mine Haul Road

Basemap
- Existing road
- Contour Line (50 ft)
- Provincial Border
- Watercourse
- Water Body

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0672 , PR185-19-14, 2015-10-19, edickoum

N

0 1 2
Kilometers

UTM 19N NAD 83 SCALE: 1:30 000

SOURCES:

Basemap and Land Use Components
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,

Mining Components
TATA Steel Minerals Canada Limited/
MET-CHEM Howse Deposit Design
for General Layout., 2013
Groupe Hémisphères, Hydrology and update, 2013

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Sampling Location Map

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1453, rue Beaubien est, Bureau 301, Montréal (QC) Canada, H2G 3C6

Figure 3

2. Human Health Risk Assessment Approach

2.1 General Approach and Risk Assessment Framework

This HHRA quantifies health impacts of the proposed Howse pit and the project area as defined by the Howse Project Property. In an HHRA, risk is an abstract concept (non-tangible) that embraces (i) a hazard or hazardous event existing with a certain likelihood, and (ii) the adverse consequence and severity that arises from the hazard. Risks to humans are plausible to the extent that a contaminant exists, there are human receptors present, and exposure or contaminant transport pathways exist that connect the human receptors with the contaminants/stressors.

Health impacts were evaluated respecting potential changes in quality of surface water, soil, air and food during the far future operations phase (i.e., after 16 years of operations and accrued dust deposition) and inferred to apply to construction and the post-closure phases of the project. Impacts were assessed relative to the baseline scenario (i.e., current conditions) to provide context of the incremental impacts predicted for the Project. Cumulative effects associated with other proposed projects within the regional area were also considered. Though the scenarios differed, the exposure modeling methods were fundamentally the same for both the baseline and operating scenarios. The process followed basic principles of human risk assessment frameworks endorsed by Health Canada (2010a). Additional details are provided below and in Appendices D1 and D2, which describe the food chain model and the computational model, respectively.

The first step in completing the impact assessment for human health was to determine whether a certain project activity had potential to cause substantive change in environmental and chemical concentrations that may affect health. To this end, the following linkages were made between project activity and potential effect on media:

1. **Activities potentially affecting Air Quality** (considered operable and assessed in the HHRA):
   - Emissions from power generators and truck fleet
   - Fugitive dust emissions from blasting, crushing and hauling

2. **Activities potentially affecting Soil Quality** (considered operable and assessed in the HHRA):
   - Accumulation of ore-based chemical constituents from particulate air deposition

3. **Activities potentially affecting Traditional Food Quality** (considered operable and assessed in the HHRA):
   - Accumulation of ore-based chemical constituents in vegetation (e.g., berries, plants) from soil after prolonged particulate air deposition
   - Accumulation of ore-based chemical constituents in small local game (e.g., game birds, hare) from soil after prolonged particulate air deposition

4. Activities **potentially affecting Surface Water and Fish Tissue Quality** (considered operable but not assessed in the HHRA):
   - The water management plan (SNC Lavalin 2015) establishes that settling pond effluent will comply with all relevant and applicable quality standards
   - Water quality from existing local settling ponds (Timmins operation) and effluent support this position

Subsequently, quantitative risk estimation was conducted for scenarios where receptors, operable exposure pathways and substantive changes in environmental quality were plausible.

2.2 Study Area

The potential effects of the project were assessed within the vicinity of the Howse Project Property which represents areas with operable exposure pathway and the receptors. The following study areas have been defined for the HHRA and are defined spatially in Figure 4. The Regional Study Area (RSA) is considered to be the Howells River watershed and the Schefferville region. This area includes the following:

- In Labrador, Labrador West (Labrador City and Wabush), as well as the Innu Nation and the NunatuKavut Community Council (NCC)
- In Québec, the Ville de Sept-Îles, and the Innu of Ushat and Mani-Utenam (ITUM) which are considered within the LSA for land-use and harvesting activities.

The Local Study area (LSA) for the HHRA is that defined for the Air Quality assessment; this provides continuity in establishing air quality exposure factors. This area encompasses the area where the Howse Property Project facilities and activities will be located and the surrounding wildland areas visited by First Nations for traditional land use activities that may be affected.

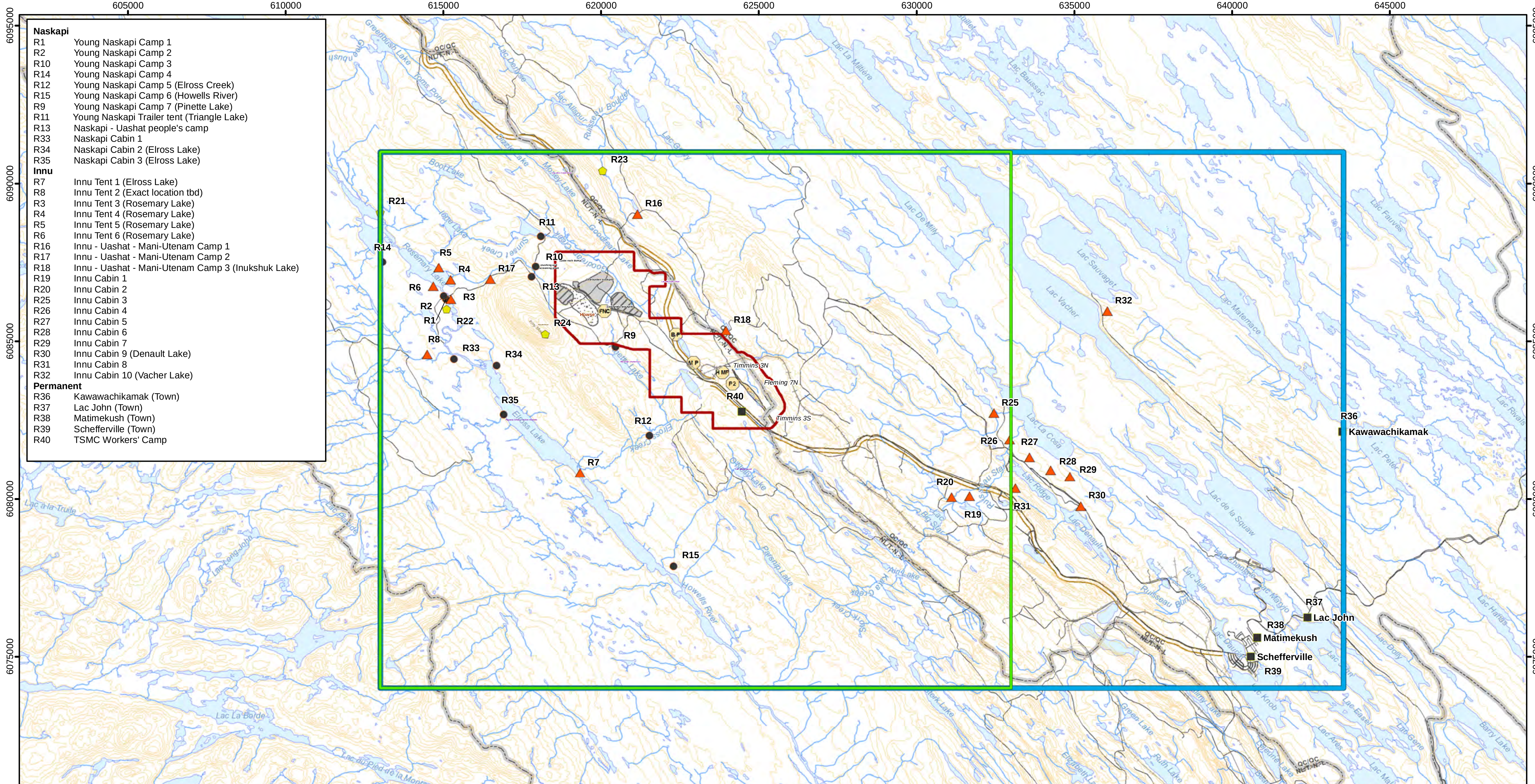
2.3 Environmental Quality Regulatory Regime

An HHRA assesses the possible linkages between contaminant sources and identified receptors. These linkages define the scope of the risk assessment and screen out those contaminant source/receptor combinations which are negligible or inoperable. This HHRA followed the risk assessment guidance and underlying principals from the following:

- The Canadian Council of Ministers of the Environment (CCME)
- Health Canada
- United States Environmental Protection Agency (EPA).

Those contaminant source/receptor combinations which were retained were quantitatively evaluated to ascertain the magnitude and potential consequences. Specifically the environmental media were screened against guidelines from the following sources:

- CCME Environmental Quality Guidelines for the Protection of Human Health
- Health Canada Drinking Water Guidelines
- The Quebec Minister of Sustainable Development, Environment and the Fight against Climate Change (MDDELCC).



LEGEND

Sensitive Receptors
- Naskapi
- Innu
- Permanent
- Other

Study Areas
- Local Study Area (LSA)
- Regional Study Area (RSA)
- Air Quality Modelling Perimeter

Infrastructure and Mining Components
- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- Road to DSO Area 4
- Existing Railroad
- Deposit
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Waste Dump/ In-Pit Dump
- Proposed Mine Haul Road

Basemap
- Existing road
- Contour Line (50 ft)
- Provincial Border
- Watercourse
- Water Body

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0672 , PR185-19-14, 2015-11-02, edickoum

N

0 2 4
Kilometers

UTM 19N NAD 83

SCALE: 1:120 000

SOURCES:

Basemap and Land Use Components
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,

Mining Components
Howse Minerals Limited/
MET-CHEM Howse Deposit Design
for General Layout., 2015
Groupe Hémisphères, Hydrology and update, 2013

AECOM

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Study Area for Purposes of Air Quality Modelling Sensitive Receptors

Howse Minerals Limited

GroupeHemispheres

5731, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 4

2.4 HHRA Objectives and Key Questions

The objective of the HHRA was to evaluate the chemicals found to exceed applicable standards/guidelines and provide quantitative estimates of exposure to dose levels considered to be representative of the projects baseline and future environment. These estimates were compared to dose levels/rates considered by Health Canada or other regulatory agencies to be acceptable or “safe” and evaluated based on the numerical output of this comparison in the form of:

- Hazard Quotients for threshold contaminants; or
- Incremental lifetime cancer risks (ILCR) for carcinogenic substances.

Key questions were defined for the HHRA to address specific issues that may affect area users (e.g., First Nations). Key questions for the HHRA are as follows:

- HH1: What effect will project releases have on water and subsequently human health?
- HH2: What effect will project releases have on air quality and subsequently human health?
- HH3: What effect will project releases have on soil quality and subsequently human health?
- HH4: What effect will project releases have on food quality and subsequently human health?
- HH5: What will be the collective effect of changes to water, air, soil and food on human health?

2.5 Problem Formulation

The objective of the problem formulation is to develop a focused understanding of how chemicals emitted by the different parts of the Project might affect health of people near the Project. The problem formulation focuses the risk assessment on the receptors, chemicals, and exposure pathways of greatest concern. The methods and rationale for screening these entities are described in the sections below.

2.5.1 Screening of Substances of Interest

A broad screening was used to identify substances of interest (SOI) to be evaluated in the baseline and future scenario (Appendix A). The screening included a wide array of metals and at the request of CEAA organic compounds from air emissions were also added. The screening framework evaluated substances against available federal and provincial guidelines for metals and hydrocarbons, site-specific background concentrations, or additional regulatory sources. The screening framework consists of three broad tracks as follows:

1. Maximum concentrations of elements and hydrocarbons measured in site matrices including soil and surface water were examined. Examination of these baseline matrices informed the first component of the objective and identified substances which were at unusual concentration under baseline conditions.
   a) Concentrations of metals measured in soil samples were compared to applicable CCME and Quebec MDDEFP soil quality guidelines.
   b) Concentrations of metals measured in surface water samples were compared to applicable Health Canada and Quebec Drinking Water Guidelines.
2. To identify substances which have a potential to alter baseline conditions during the lifecycle of the proposed development, the raw materials that will be introduced to the process were considered. Concentrations of metals measured in samples of ore, waste rock, and overburden from the Howse Project Property were compared to applicable CCME and Quebec MDDEFP soil quality guidelines.

Substances with concentration in ore or waste rock in exceedance of the soil quality guidelines were considered to have the potential to impact baseline conditions for environmental media during the lifecycle of the mine development; and were retained as substances of interest.

3. At the request of CEAA, organic compounds from air emissions were considered. The air quality substance of interest screening was conducted by comparing predicted air quality for metals and VOCs to air quality standards from Newfoundland/Labrador and Quebec (Details of the air quality screening are provided in Appendix 3 of the Air Dispersion Modeling Report).

A substance which is screened in for any medium is then considered as a contaminant of potential concern in all media and routes of exposure. The screening process yielded the following contaminants of potential concern:

- Arsenic
- Barium
- Beryllium
- Chromium
- Iron
- Lead
- Manganese
- Mercury
- Molybdenum
- Selenium

Note: There are no CCME or Quebec MDDEFP soil quality guidelines for iron. Iron has been included due to local enrichment that has made this area the focus of iron mine developments.

2.5.2 Identification of Potential Receptors

The objective of the receptor screening process was to identify people who are currently living in, or using, areas in the vicinity of the Project Site. According to the socio-economic baseline studies no residents were found within the study area, therefore only First Nations (individual hunters or family groups) were identified as potential receptors for consideration in the HHRA. Worker health risk to on-site workers was not addressed as part of this HHRA assessment, and is considered as separate component within the context of Howse Project Worker Health and Safety.

In accordance with Health Canada Guidance (Health Canada 2010b) not all age groups need be assessed using complete quantitative risk assessment. The most sensitive receptors were identified as critical receptors; assessment and management of risks to critical receptors is considered protective of all individuals. Critical receptors are therefore focussed upon to estimate and manage risk in the interest of the more diverse and larger group of receptors. The critical receptors for the HHRA are defined below.

First Nations

First Nations (individuals or family groups) engaged in traditional land uses are expected to have the greatest potential exposure based on duration of visit and the activities they are involved in. The HHRA incorporated the following receptor age groups into the human health CEM for the Howse Property Project:

- Adult – Travels for hunting and gathering activities may bring individuals into the local study area for a much shorter time period than extended harvesting activities would. However, since the magnitude of exposure to contaminants is, in part, a function of the time spent on site, evaluation of risks based on an extended stay is considered a more conservative (protective) and most relevant exposure scenario to assess human health risks.
- Toddler – It is recognized that people of all ages are part of traditional hunting and gathering parties and therefore entire family units may be present during the late spring to fall period. Toddlers are considered to be more sensitive to the effects of chemicals than adults because they typically have a

greater intake rate to body weight ratio and certain behaviour activities may foster greater contact with exposure media (e.g., playing in soil). Consistent with risk assessment guidance (Health Canada 2010a), the toddler life phase (i.e., 7 months to 4 years of age) was included as a receptor in this scenario.

The critical receptors and the rationale for their selection for the Howse Property Project are presented in Table 2.1.

Table 2.1 Receptor Screening for Human Health Assessment

Receptor Population	Receptor Population Rationale	Critical Receptors	Assessed?	Critical Receptor Rationale
First Nations	The Traditional Land Use Study completed for the Howse Property Project indicated that two Aboriginal groups (Naskapi and the Innu) have traditionally used the territories located within or near the Howse Property Project area.	Adult	Yes	Assumed to have the highest potential frequency and duration of site use. Assumed to visit the site for hunting /fishing activities.
		Toddler	Yes	It is recognized that people of all ages take part in traditional hunting/gathering. Health Canada and the National Public Health Institute of Quebec recommend toddlers as a critical receptor due to their low body weight and high rate of incidental soil/sediment ingestion. Accordingly all human receptors are assumed to take part in a traditional lifestyle and consume traditional country foods throughout the year.

2.5.3 Identification of Exposure Pathways

Exposure pathway screening identifies potential routes by which people could be exposed to chemicals. A chemical represents a potential health risk only if it can reach receptors through an exposure pathway at a concentration that could potentially lead to adverse effects. The following exposure pathways were considered relevant for human receptors at the Howse Project Property:

Ingestion

- Contaminated soil that is incidentally ingested (as soil or non-respirable dust) during outdoor activities such as camping, hunting etc. will result in an ingestion exposure.
- Contaminants in drinking water will be retained by the body and result in an ingestion dose.
- Contaminated produce/vegetation that is ingested will result in an ingestion dose.
- Ingestion of contaminated fish or game will result in an ingestion dose.

Inhalation

- Airborne contaminants (either as vapour or respirable particulates as PM_{10}) at the receptors location will be inhaled and retained within the body resulting in an inhalation exposure.
- Frequency of exceedance of PM10 criteria at the off property maximum locations (assuming 1 day per week of blasting) results in PM10 concentrations in exceedance of regulatory guidelines <1% of the time.

Dermal Absorption

- Dermal contact with contaminated soil will adhere to skin surfaces and result in a dermal exposure.

2.5.4 Conceptual Exposure Model

A conceptual exposure model (CEM), which is qualitative in nature, provides the context for the quantitative risk assessment. The CEM is presented as Figure 5 and illustrates all contaminant sources, release mechanisms, transport pathways, and routes of exposure for the human health assessment at the mine site.

2.6 Approach to Exposure Assessment

For each of the identified exposure pathways, a series of numerical equations were employed to quantify the average daily chemical intake rate, normalized to body weight. Exposure equations used for the human health exposure assessment were drawn from Health Canada (2010a).

The quantitative HHRA evaluated three exposure assessment scenarios as follows:

1. Baseline Scenario
2. Project Scenario (Project plus Baseline Scenario)
3. Cumulative Scenario (Project plus Baseline Scenario plus other local operations and emissions)

The Baseline assessment used measured concentrations in site abiotic and biotic media, and is conducted in order to establish current benchmark risk estimates. This benchmark is then used in the project and cumulative assessments to examine the "incremental" risks resulting from releases associated with the Project and Cumulative Scenarios.

For the Project and Cumulative (future) scenarios, environmental concentrations of PCOCs were predicted based on source emissions and modeled air dispersion within the LSA and RSA (Figure 4 and Figure 6). Project “increment” was computed and reported as the difference and percent change in risk estimates in the Project and Cumulative Scenarios relative to the Baseline.

2.6.1.1 Exposure Frequency and Duration

For the baseline scenario, the assumptions regarding the frequency and duration of exposure for First Nations hunting and fishing groups within or near the Howse Property Project area are guided by the following principles:

1. For the purpose of local harvesting or other traditional land use activities, it is assumed that a group might occupy the site for up to 16 weeks in any year, during either summer or winter. The remainder of the year is spent in nearby communities (Ville de Schefferville, Matimekush-Lac John or Kawawachikamach).
2. While First Nations and recreational users are visiting the vicinity of the mine site, locally gathered foods (plants, berries, fish and game) would constitute a high proportion of total diet. In addition, locally gathered country foods may be preserved (canned, frozen etc.). Therefore consumption of country foods is assumed to continue throughout the year. One exception to this is the partridge berry. It is has been assumed that the partridge berry is consumed when in season (4 months per year), and that a full annual supply of partridge berry is unlikely to be sourced solely from the area of interest.

The receptor characteristics that govern contact rate with substances of interest to form an internal dose are described in Table 2.2. The fundamental exposure scenarios (Baseline, Project and Cumulative) and the assumptions and differences amongst them are described in Table 2.3.

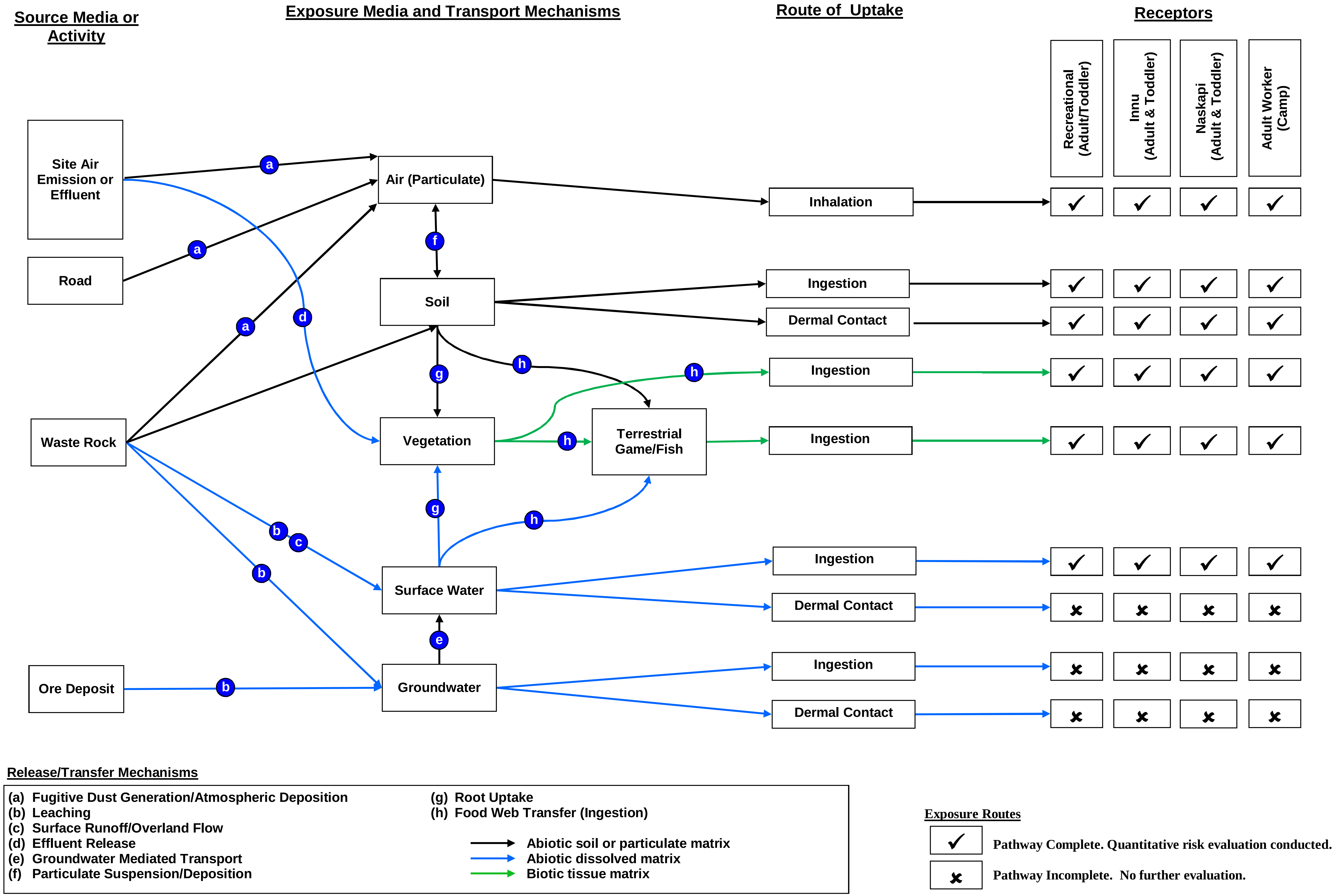
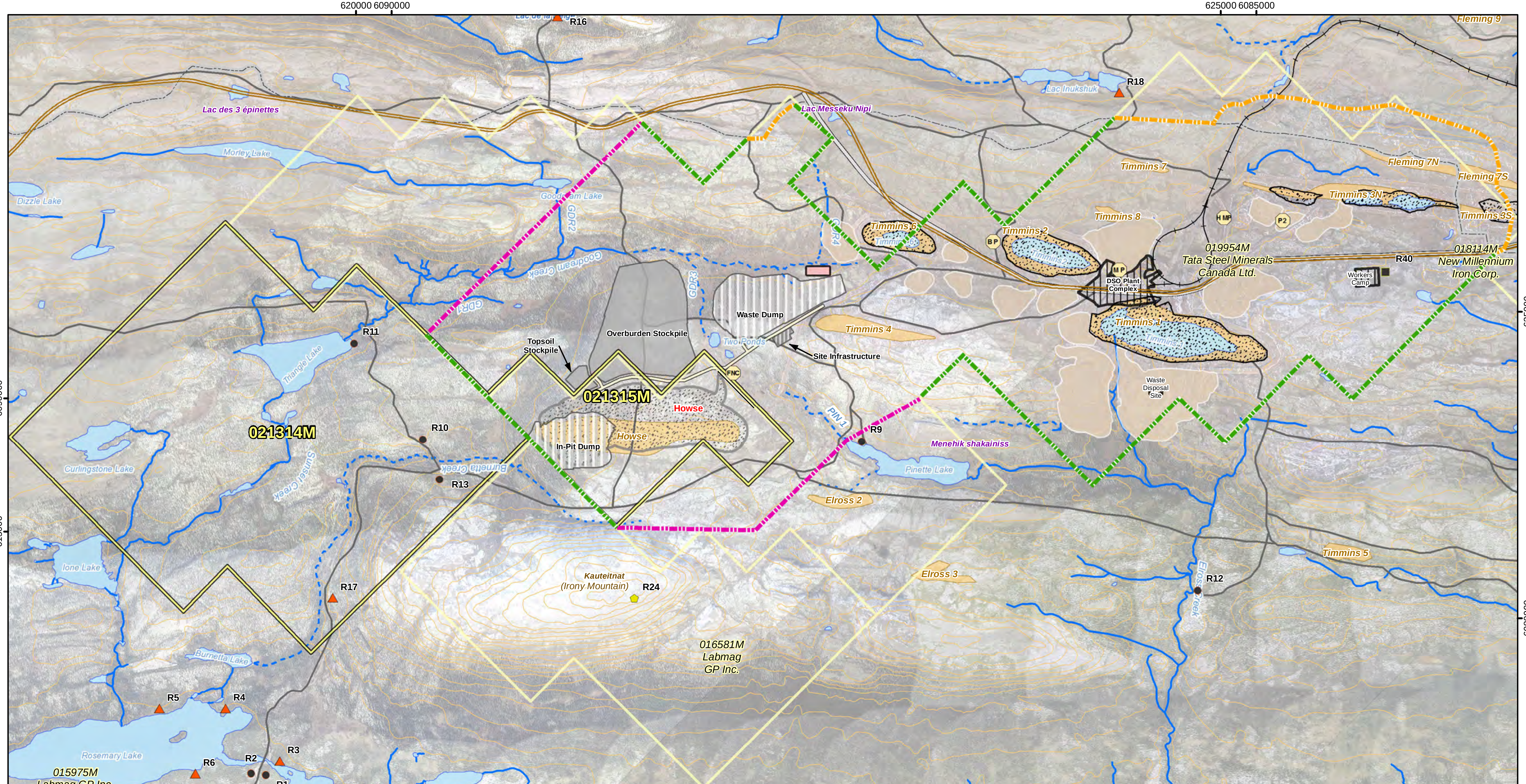


Figure 5: Conceptual Exposure Model for Human Receptors at the Howse Project Property



LEGEND

Infrastructure and Mining Components

Proposed Infrastructures
- Proposed Howse Pit
- Proposed Topsoil/Overburden Stockpile
- Proposed Waste Dump/In-Pit Dump
- Proposed Site Infrastructure
- Proposed Mine Haul Road

Existing Components
- Existing Railroad
- Road to DSO Area 4
- Existing Sedimentation Pond
- DSO Howse - Claim Labrador Iron Mines Limited(49%)/ Howse Minerals Ltd.(51%)
- Other Claim
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure Footprint
- Existing Dump
- Existing Pit
- Deposit
- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener

Sensitives Receptors
- Naskapi
- Innu
- Permanent
- Other/Autre

Air Dispersion Modeling Perimeter
- Administrative Boundaries using Newfoundland Methodology with Receptors on Claim Lines
- Alternative Boundary Limits within Newfoundland to Include Possible sensitive Areas into the Receptors grid
- Administrative Boundaries using a Methodology used by Quebec in a previous Impact Study

Basemap
- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water body
- Contour Line (50 ft)
- Provincial Border
- Existing Road
- Main Access

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0673 , PR185-19-14, 2015-10-16, edickoum

0 500 1 000 1 500 2 000
Meters
UTM 19N NAD 83
SCALE: 1:31 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979 Government of NL and government of Quebec, Boundary used for claims
SNC Lavalin, Groupe Hémisphères, Hydrology update, 2013

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/ MET-CHEM Howse Deposit Design for General Layout, 2013

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Air Dispersion Modeling Perimeter
Howse Minerals Limited

GroupeHemispheres
5731, rue Saint-Louis, Bureau 201, Lévis (QC) Canada, G6V 4E2
1453, rue Beaubien est, Bureau 301, Montréal (QC) Canada, H2G 3C6

Figure 6

Table 2.2 Receptor Characteristics Carried Forward for Quantitative Assessment

	Toddler*	Adult*
Age	7 mo – 4 yr	≥20
Body Weight (kg)	16.5	70.7
Soil Ingestion Rate (kg/day)	0.00008	0.00002
Inhalation Rate (m^3/day)	8.3	16.6
Water Ingestion Rate (L/day)	0.6	1.5
Time Spent Outdoors (hr/day)	1.5	1.5
Skin Surface Area (cm^2)		
Hands	430	890
Arms	890	2,500
Legs	1,690	5,720
Face	0	0
Total Body	6,130	17,640
Soil Loading to Exposed Skin (kg/cm^2/event)		
Hands	0.0000001	0.0000001
Surfaces other than hands	0.00000001	0.00000001
Country Food Ingestion Rates (kg/day)		
Berries	0.003	0.002
Labrador Tea	0.001	0.003
Fish	0.06	0.120
Game Fowl	0.0195	0.039
Small Mammals	0.028	0.056
Caribou	0.0972	0.187

** Appendix B1 summarizes the selection of ingestion rates used in the HHRA.*

Incremental Lifetime Cancer Risks (ILCR) were calculated assuming an exposure regime of 16 weeks per year at 90th percentile of blast (1 day per week) and no blast (6 days per week) annual daily maximum values for PM_{10}. The remaining 36 weeks are assumed to be at baseline dose rates. The time-weighted dose rate (16/52 + 36/52 = 1) is not amortized over the lifetime and an ILCR is calculated. (i.e., an individual is conservatively assumed to spend 16 weeks per year at the site for all 80 years of their life).

Table 2.3 Fundamental Exposure Scenarios and Associated Assumptions

Parameter	Baseline Scenario	Project Scenario	Cumulative Scenario
Abiotic Site Media			
Soil	Site specific 95% Upper Confidence Limit of the Mean (UCLM95) soil samples collected within the LSA during 2015. Summary statistics of soil data are presented in Appendix E1.	Calculated as sum of baseline soil concentration and Project Incremental Soil Concentration (ISC) as a result of particulate deposition. See Appendix D1 for calculation of ISC.	Calculated as sum of baseline soil concentration and Cumulative Incremental Soil Concentration (ISC) as a result of particulate deposition. See Appendix D1 for calculation of ISC.
Surface Water	Site specific maximum measured concentration from Pinette or Triangle Lake.	No change from baseline	No change from baseline
Particulate	Calculated assuming baseline PM_{10} concentration of 4 $\mu g/m^3$ and chemical composition of baseline soils.	Calculated as 10.1 ($\mu g/m^3$) using 90th percentile predicted maximum PM_{10} concentrations for the project activities. Chemical composition of particulates assumed to be equal to the 95%UCLM of the ore dataset.	Calculated as 31.5 ($\mu g/m^3$) using 90th percentile predicted maximum PM_{10} concentrations for the cumulative activities. Chemical composition of particulates assumed to be equal to the 95%UCLM of the rock dataset. **Note:** In addition inhalation risks were assessed following probabilistic risk assessment principals. Details of the probabilistic risk assessment are presented in Section 3.3.4.
Biological Tissues			
Berries	The 90th percentile for unwashed partridge berry samples collected from the LSA. Barium, Iron and Manganese were the only elements that exceeded analytical detection limits. Elements not detected in berry samples were modelled from soil concentrations using literature derived transfer factors.	Modeled based on predicted soil chemistry and literature derived soil to berry transfer factors (See Appendix D1)	Modeled based on predicted soil chemistry and literature derived soil to berry transfer factors (See Appendix D1)
Labrador Tea	The 90th percentile for unwashed Labrador tea samples collected from the LSA. Barium, Iron and Manganese were the only elements that exceeded analytical detection limits. Elements not detected in berry samples were modelled from soil concentrations using literature derived transfer factors,	Modeled based on predicted soil chemistry and literature derived soil to vegetation transfer factors (See Appendix D1)	Modeled based on predicted soil chemistry and literature derived soil to vegetation transfer factors (See Appendix D1)
Fish	Maximum measured concentrations in fish collected from Triangle Lake or Pinette Lake. Beryllium, chromium and molybdenum modelled from surface water using literature derived transfer factors.	No change from baseline	No change from baseline
Game Bird	Site specific maximum measured concentrations from game bird (Spruce Grouse) collected from the LSA.	Modeled based on receptor characteristics, predicted chemistry and literature derived transfer factors. (See Appendix D1)	Modeled based on receptor characteristics, predicted chemistry and literature derived transfer factors. (See Appendix D1)
Caribou	Literature derived maximum concentrations measured in muscle tissue. (See Appendix B2).	No change from baseline	No change from baseline
Hare	Modeled based on receptor characteristics, abiotic chemistry and literature derived transfer factors. (See Appendix D1)	Modeled based on receptor characteristics, predicted chemistry and literature derived transfer factors. (See Appendix D1)	Modeled based on receptor characteristics, predicted chemistry and literature derived transfer factors. (See Appendix D1)

2.7 Approach to Toxicity Assessment

Toxicity is an inherent property of a substance, which is brought about by the physical-chemical properties of the substance and its chemical reactivity within living organisms. Toxicity assessment in this context involves identification of the potential toxic effects of chemicals, and determination of the rate of intake of a chemical that can be tolerated over a lifetime without experiencing adverse health effects. Toxicity assessment also considers the following concepts:

- Non-carcinogens (chemicals that do not cause cancer)
- Carcinogens (chemicals that have the potential to cause cancer)
- Bioavailability (the proportion of chemical in a medium that is considered to be available for uptake by a human after the human contacts the medium)

These concepts and how they are integrated into the process are described in further detail in Appendix C. A tabulated summary of the toxicity reference values adopted for the risk estimation are provided below (Table 2.4).

Table 2.4 Toxicity Reference Values used in HHRA

PCOC	TDI (mg/kg bw/day)	Chronic Effects Endpoint	Tolerable Concentration (mg/m^3)	Oral Cancer Slope Factor (mg/kg bw/day)$^{-1}$	Inhalation Cancer Slope Factor (mg/kg bw/day)$^{-1}$
Arsenic	3.00E-04	Hyperkeratosis, hyperpigmentation and possible vascular complications		1.8	27
Barium	0.2	Nephropathy			
Beryllium	2.00E-02	Small intestinal lesions.	2.00E-05		7.3
Chromium	0.001	Hepatotoxicity, gastrointestinal irritation or corrosion, and encephalitis.			46
Iron	0.7	Gastrointestinal distress			
Lead	1.00E-03	Increase in systolic blood pressure			
Manganese	0.156 (0.136)	CNS effects			
Mercury	0.0003	CNS effects			
Molybdenum	28 (23)	Increased uric acid levels			
Selenium	5.7 (6.2)	Clinical selenosis			

2.8 Approach to Risk Characterization

2.8.1 Assessment and Measurement Endpoints

For a human health risk assessment, the concept of assessment and measurement endpoint are underpinned on the basis that no significant health risk should arise from the Project. Thus, the *assessment* endpoint is that a Project should yield no significant (unacceptable) health effects to human receptors over duration of the Project life cycle, or a human lifetime. Accordingly, the *measurement* endpoint requires that toxicity reference levels (TRVs) used to judge estimated environmental exposure be reflective of no-effect levels over a lifetime of exposure.

For substances presenting a risk other than cancer, a hazard quotient is the measurement endpoint and is calculated as the ratio of the estimated daily exposure to the applicable toxicity reference value (i.e., safe dose) for each contaminant as follows:

$$HQ = \frac{TDD}{RfD\ or\ TDI}$$

Where:
HQ = hazard quotient (unitless)
TDD = total daily dose from all exposure routes (mg/kg day^{-1})
TDI = Health Canada published tolerable daily intake (mg/kg day^{-1})
RfD = US EPA published reference dose (mg/kg day^{-1})

For threshold contaminants which impart a specific health risk to the respiratory system a separate hazard quotient is calculated as follows:

$$HQ = \frac{Air\ Concentration\ (mg/m^3)}{Tolerable\ Concentration\ (mg/m^3)}$$

For substances with no threshold dose response (i.e., carcinogens) the risk estimate is a calculation of the Incremental Lifetime Cancer Risk (ILCR). ILCR is the predicted risk of an individual in a population of a given size developing cancer over a lifetime. The ILCR is expressed as the one additional person per n people that would develop cancer, where the magnitude of n reflects the risks to that population; for example, if the ILCR is 1 person per 10, the predicted risks of any individual developing cancer would be higher than if the ILCR is 1 per 100,000. The generic equation for the calculation of an ILCR is as follows:

(ILCR) = Estimated Lifetime Exposure (mg/kg-d) x Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$

Due to the estimation nature of the prediction of ILCR, Health Canada recommends that ILCRs only be calculated for adult exposures.

2.8.2 Definition Negligible Human Health Risks

Negligible Hazard Quotient: Whereas a hazard quotient of unity infers the estimated exposure rate (dose) is equal to the toxicological reference value (tolerable daily intake (TDI)) and is considered protective of health, Health Canada guidance (Health Canada 2010b) generally scrutinizes HQ expressions of health risk against a value of 0.2 as a threshold of acceptable risk. The rationale is that site or project incremental exposure (i.e., that caused by the site alone) does not account for other potential exposure sources, and benchmarking acceptable risk to a value of 0.2 (i.e., 20% of the protective threshold) allows “reserved protective space” for potential exposure from other sources (e.g., soil, air, food, water). Thus, in risk assessments where a more comprehensive exposure analysis is considered, Health Canada supports interpretation of HQ values against a benchmark of unity (1.0)(Health Canada 2010b). In the present study, as described in subsequent sections, the HHRA evaluates exposure from a traditional food diet that is based on Aboriginal data, and also includes additional background contributions from sources that are not considered to be potentially affected by the Project (e.g., caribou meat). Accordingly, the benchmark for acceptable risk as expressed by the HQ metric is a value equal to or less than unity (1.0), in alignment with Health Canada policy respecting a comprehensive dietary exposure.

Negligible Incremental Lifetime Cancer Risk (ILCR): Health Canada defines a negligible incremental lifetime cancer risk as being a probability of less than 1 incremental cancer case in 100,000 individuals, or $<1x10^{-5}$. For environmental health risk, the ILCR considers only those substance considered environmentally relevant, and excludes consideration of voluntary risk such as tobacco-related lung cancer.

2.8.3 Interpretation of Risk Estimates

In the present case, the exposure scenario employs considerable conservative assumptions that are designed to err in overestimating actual risk, and this is accomplished through assumptions that overestimate particulate (PM_{10} and TPM) dispersion, exposure point concentrations, and frequency of receptors' presence for exposure. The degree of conservatism is an important concept that must be considered when interpreting risk estimates against regulatory definition of negligible risk.

To provide interpretive insight on the risk levels and conservative assumptions employed to offset various sources of uncertainty normally encountered in health risk assessment, the following categories were used to describe the risk magnitudes for non-carcinogenic compounds:

- Negligible: HQ<1.0. (consistent with Health Canada (2010a,b) guidance for a comprehensive multi-media exposure and has become accepted common practice)
- Low and likely to be negligible: 1.0>HQ≤10 (acknowledges in this case that considerable conservatism is employed by the risk assessor and that over estimation of risk is likely)
- Potentially elevated: HQ>10 (acknowledges in this case that considerable conservatism is employed by the risk assessor and that over estimation of risk is likely)

In cases where an estimated HQ may exceed any of the above categories by a change of <10% from the Baseline case, the Baseline is noted as the risk driver, and the incremental contribution from the Project is considered separately for interpretation of significance.

For carcinogenic compounds, the magnitude of the cancer risk was rated as follows with similar interpretation as note above for hazard quotients:

- negligible: ILCR ≤ $1x10^{-5}$
- low and likely to be negligible: $1x10^{-5}$ < ILCR ≤$1x10^{-4}$
- potentially elevated: ILCR>$1x10^{-4}$

3. Risk Estimates

3.1 Baseline Scenario

The HHRA integrates baseline data collected specifically for the HHRA and data from other biophysical and social assessments conducted by other consultants in support of the Project EIS. The quantitation of baseline risks is conducted as a benchmark from which to observe the incremental human health risks as a result of the Howse project, or cumulative resource extraction activities within the LSA.

3.1.1 Exposure Assessment

Doses to human receptors were calculated based on receptor characteristics described in Table 2.2, as well as scenario specific exposure conditions described in Table 2.3. Exposure point concentrations carried forward into the quantitative exposure assessment are presented in Table 3.1

Table 3.1 Concentrations of Assessed Metals in Abiotic and Biotic Media Carried Forward into the Quantitative Dose Estimates for the Baseline Scenario

PCOC	Soil (mg/kg dw)	Water (mg/L)	Particulate (mg/kg)	Berries (mg/kg dw)	Labrador Tea (mg/kg dw)	Fish (mg/kg ww)	Grouse (mg/kg ww)	Caribou (mg/kg ww)	Hare [b] (mg/kg ww)
Arsenic	1.1E+1	5.0E-4 [c]	4.3E-8	3.9E-1 [a]	3.9E-1 [a]	3.6E-2	1.2E-2	6.0E-2	5.6E-4
Barium	4.9E+1	3.3E-3	2.0E-7	2.3E+1	8.3E+1	9.3E-2	3.4E-2 [a]	0.0E+0	2.8E-1
Beryllium	3.7E-1	1.0E-4 [c]	1.5E-9	5.6E-4 [a]	3.7E-3 [a]	1.0E-2 [a]	1.9E-4 [a]	0.0E+0	2.1E-6
Chromium	2.0E-1	2.5E-3 [c]	8.0E-10	1.5E-3 [a]	1.5E-3 [a]	1.0E-2 [a]	3.0E-5 [a]	0.0E+0	2.1E-4
Iron	4.9E+4	1.1E+0	2.0E-4	5.6E+2	3.2E+3	7.2E+0	6.0E+1	2.8E+1	5.7E+0
Lead	1.7E+1	2.5E-4 [c]	6.9E-8	2.6E-1 [a]	7.8E-1 [a]	1.0E-2	3.4E-1	1.4E-1	1.8E-2
Manganese	1.2E+3	1.0E-1	4.7E-6	3.8E+2	1.6E+3	2.3E-1	6.3E-1	0.0E+0	6.4E-1
Mercury	8.0E-2	5.0E-5 [c]	3.2E-10	2.3E-2 [a]	6.8E-2 [a]	3.2E-1	2.6E-3	2.7E-2	3.9E-4
Molybdenum	2.2E+0	5.0E-4 [c]	9.0E-9	1.1E+0 [a]	1.3E+0 [a]	5.0E-3 [a]	1.7E-2	0.0E+0	6.7E-4
Selenium	8.0E-1	1.5E-3 [c]	3.2E-9	1.5E-2 [a]	1.3E-2 [a]	1.5E+0	3.9E-1	9.4E-2	2.1E-3

Notes: a Concentrations in baseline tissues were below the analytical limits of detection. Exposure point concentrations were estimated using abiotic media and literature derived transfer factors.

b No snowshoe hare samples could be obtained. Baseline tissue concentrations are estimated using food and water ingestion rates sourced from FCSAP (2012), abiotic baseline concentrations and literature derived transfer factors.

c Concentrations were below analytical limits of detection. The limit of detection has been substituted in order to allow the greatest possible predicted concentration in biotic tissues.

3.1.1.1 Calculated Dose

The calculated daily doses (and % contribution to the total) for each route of exposure for adult and toddler receptors in the baseline scenario are presented Table 3.2 and Table 3.3 respectively.

Table 3.2 Calculated Dose (mg/kg/day) and Percent of Total (Value in Parentheses) for All Routes of Exposure for the Adult Receptor Under the Baseline Scenario

PCOC	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	3.0E-6 (1.1%)	9.8E-7 (0.0%)	7.3E-10 (0.0%)	7.4E-10 (0.0%)	1.4E-2 (4.4%)	4.9E-6 (0.7%)	1.3E-5 (0.0%)	2.3E-8 (0.0%)	6.3E-7 (0.6%)	2.3E-7 (0.0%)
Particulate Inhalation	1.0E-8 (0.0%)	4.6E-8 (0.0%)	3.5E-10 (0.0%)	1.9E-10 (0.0%)	4.6E-5 (0.0%)	1.6E-8 (0.0%)	1.1E-6 (0.0%)	7.5E-11 (0.0%)	2.1E-9 (0.0%)	7.5E-10 (0.0%)
Soil Dermal Contact	7.8E-7 (0.3%)	1.2E-5 (0.3%)	9.0E-7 (4.4%)	4.8E-8 (0.1%)	1.2E-2 (3.7%)	4.2E-5 (6.1%)	2.9E-3 (3.4%)	1.9E-7 (0.0%)	5.4E-8 (0.0%)	1.9E-8 (0.0%)
Surface Water Ingestion	1.1E-5 (4.0%)	7.0E-5 (1.5%)	2.1E-6 (10.5%)	5.3E-5 (75.4%)	2.3E-2 (7.2%)	5.3E-6 (0.8%)	2.2E-3 (2.7%)	1.1E-6 (0.2%)	1.1E-5 (9.3%)	3.2E-5 (1.1%)
Berry Ingestion	1.1E-5 (4.0%)	6.4E-4 (14.2%)	1.6E-8 (0.1%)	4.2E-8 (0.1%)	1.6E-2 (4.9%)	7.3E-6 (1.1%)	1.1E-2 (12.7%)	6.4E-7 (0.1%)	3.1E-5 (27.4%)	4.3E-7 (0.0%)
Labrador Tea Ingestion	1.6E-5 (6.0%)	3.4E-3 (75.2%)	1.5E-7 (0.8%)	6.2E-8 (0.1%)	1.3E-1 (41.3%)	3.2E-5 (4.7%)	6.6E-2 (79.6%)	2.8E-6 (0.5%)	5.3E-5 (46.7%)	5.3E-7 (0.0%)
Game Bird Ingestion	6.8E-6 (2.5%)	1.9E-5 (0.4%)	1.1E-7 (0.5%)	1.6E-8 (0.0%)	3.3E-2 (10.4%)	1.9E-4 (27.6%)	3.5E-4 (0.4%)	1.4E-6 (0.2%)	9.4E-6 (8.2%)	2.1E-4 (7.1%)
Small Mammal Ingestion	4.4E-7 (0.2%)	2.2E-4 (4.9%)	1.7E-9 (0.0%)	1.7E-7 (0.2%)	4.5E-3 (1.4%)	1.4E-5 (2.1%)	5.1E-4 (0.6%)	3.1E-7 (0.1%)	5.3E-7 (0.5%)	1.7E-6 (0.1%)
Large Mammal Ingestion	1.6E-4 (59.4%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	7.3E-2 (22.9%)	3.7E-4 (54.4%)	0.0E+0 (0.0%)	7.1E-5 (11.7%)	0.0E+0 (0.0%)	2.5E-4 (8.2%)
Fish Ingestion	6.0E-5 (22.5%)	1.6E-4 (3.5%)	1.7E-5 (83.7%)	1.7E-5 (24.1%)	1.2E-2 (3.8%)	1.7E-5 (2.5%)	4.0E-4 (0.5%)	5.3E-4 (87.3%)	8.5E-6 (7.4%)	2.5E-3 (83.6%)
Total	2.7E-4	4.5E-3	2.0E-5	7.0E-5	3.2E-1	6.8E-4	8.3E-2	6.1E-4	1.1E-4	3.0E-3

Table 3.3 Calculated Dose (mg/kg/day) and Percent of Total (Value in Parentheses) for All Routes of Exposure for the Toddler Receptor Under the Baseline Scenario

Pathway	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	5.2E-5 (7.5%)	1.7E-5 (0.2%)	1.3E-8 (0.0%)	1.3E-8 (0.0%)	2.4E-1 (25.7%)	8.4E-5 (5.3%)	2.3E-4 (0.1%)	3.9E-7 (0.0%)	1.1E-5 (2.7%)	3.9E-6 (0.1%)
Particulate Inhalation	4.3E-8 (0.0%)	2.0E-7 (0.0%)	1.5E-9 (0.0%)	8.0E-10 (0.0%)	2.0E-4 (0.0%)	6.9E-8 (0.0%)	4.7E-6 (0.0%)	3.2E-10 (0.0%)	9.0E-9 (0.0%)	3.2E-9 (0.0%)
Soil Dermal Contact	1.3E-6 (0.2%)	2.1E-5 (0.2%)	1.5E-6 (3.2%)	8.3E-8 (0.0%)	2.0E-2 (2.2%)	7.2E-5 (4.6%)	4.9E-3 (2.6%)	3.3E-7 (0.0%)	9.3E-8 (0.0%)	3.3E-8 (0.0%)
Surface Water Ingestion	4.5E-5 (6.5%)	3.0E-4 (2.8%)	9.1E-6 (19.1%)	2.3E-4 (85.9%)	9.8E-2 (10.6%)	2.3E-5 (1.4%)	9.5E-3 (5.1%)	4.5E-6 (0.3%)	4.5E-5 (11.4%)	1.4E-4 (2.1%)
Berry Ingestion	7.9E-5 (11.3%)	4.7E-3 (43.8%)	1.1E-7 (0.2%)	3.1E-7 (0.1%)	1.1E-1 (12.3%)	5.3E-5 (3.4%)	7.7E-2 (41.0%)	4.7E-6 (0.4%)	2.3E-4 (57.1%)	3.1E-6 (0.0%)
Labrador Tea Ingestion	2.3E-5 (3.2%)	4.8E-3 (45.1%)	2.2E-7 (0.5%)	8.7E-8 (0.0%)	1.9E-1 (20.1%)	4.5E-5 (2.9%)	9.3E-2 (49.8%)	4.0E-6 (0.3%)	7.6E-5 (18.9%)	7.4E-7 (0.0%)
Game Bird Ingestion	1.5E-5 (2.1%)	4.0E-5 (0.4%)	2.3E-7 (0.5%)	3.5E-8 (0.0%)	7.1E-2 (7.7%)	4.0E-4 (25.7%)	7.4E-4 (0.4%)	3.1E-6 (0.2%)	2.0E-5 (5.0%)	4.6E-4 (7.0%)
Small Mammal Ingestion	9.5E-7 (0.1%)	4.8E-4 (4.5%)	3.6E-9 (0.0%)	3.6E-7 (0.1%)	9.8E-3 (1.1%)	3.1E-5 (1.9%)	1.1E-3 (0.6%)	6.6E-7 (0.1%)	1.1E-6 (0.3%)	3.6E-6 (0.1%)
Large Mammal Ingestion	3.5E-4 (50.6%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	1.6E-1 (17.5%)	8.2E-4 (52.5%)	0.0E+0 (0.0%)	1.6E-4 (12.0%)	0.0E+0 (0.0%)	5.5E-4 (8.4%)
Fish Ingestion	1.3E-4 (18.5%)	3.4E-4 (3.2%)	3.6E-5 (76.4%)	3.6E-5 (13.7%)	2.6E-2 (2.8%)	3.6E-5 (2.3%)	8.5E-4 (0.5%)	1.1E-3 (86.6%)	1.8E-5 (4.5%)	5.4E-3 (82.4%)
Total	7.0E-4	1.1E-2	4.8E-5	2.6E-4	9.3E-1	1.6E-3	1.9E-1	1.3E-3	4.0E-4	6.6E-3

3.1.2 Risk Characterization

Risks to human health as a result of multi-media exposure to contaminants of concern under baseline conditions are characterized using calculated hazard quotients and incremental lifetime cancer risks as described in Section 2.8. The following section provides calculated hazard quotients for threshold contaminant exposures (Section 3.1.2.1), locally acting chemicals (Section 3.1.2.2), and non-threshold carcinogenic substances (Section 3.1.2.3).

3.1.2.1 General Threshold Contaminant Risks

Calculated hazard quotients for threshold contaminant exposures are presented in Table 3.4 and Table 3.5 for adult and toddler receptors respectively.

Table 3.4 Calculated Hazard Quotients for Each Route of Exposure for the Adult Receptor Under the Baseline Scenario

PCOC	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	1.0E-2	4.9E-6	3.7E-8	7.4E-7	2.0E-2	4.9E-3	8.5E-5	7.5E-5	2.3E-8	4.0E-8
Particulate Inhalation	3.4E-5	2.3E-7	1.7E-8	1.9E-7	6.6E-5	1.6E-5	7.1E-6	2.5E-7	7.5E-11	1.3E-10
Soil Dermal Contact	2.6E-3	6.0E-5	4.5E-5	4.8E-5	1.7E-2	4.2E-2	1.8E-2	6.5E-4	1.9E-9	3.4E-9
Surface Water Ingestion	3.5E-2	3.5E-4	1.1E-4	5.3E-2	3.3E-2	5.3E-3	1.4E-2	3.5E-3	3.8E-7	5.6E-6
Berry Ingestion	3.6E-2	3.2E-3	7.8E-7	4.2E-5	2.2E-2	7.3E-3	6.7E-2	2.1E-3	1.1E-6	7.5E-8
Labrador Tea Ingestion	5.3E-2	1.7E-2	7.6E-6	6.2E-5	1.9E-1	3.2E-2	**4.2E-1**	9.3E-3	1.9E-6	9.2E-8
Game Bird Ingestion	2.3E-2	9.4E-5	5.3E-6	1.6E-5	4.7E-2	1.9E-1	2.2E-3	4.8E-3	3.3E-7	3.8E-5
Small Mammal Ingestion	1.5E-3	1.1E-3	8.4E-8	1.7E-4	6.5E-3	1.4E-2	3.3E-3	1.0E-3	1.9E-8	2.9E-7
Large Mammal Ingestion	**5.3E-1**	0.0E+0	0.0E+0	0.0E+0	1.0E-1	**3.7E-1**	0.0E+0	**2.4E-1**	0.0E+0	4.3E-5
Fish Ingestion	**2.0E-1**	7.9E-4	8.5E-4	1.7E-2	1.7E-2	1.7E-2	2.5E-3	**1.8E+0**	3.0E-7	4.4E-4
Total	**8.9E-1**	2.3E-2	1.0E-3	7.0E-2	**4.6E-1**	**6.8E-1**	**5.3E-1**	**2.0E+0**	4.1E-6	5.3E-4

Table 3.5 Calculated Hazard Quotients for Each Route of Exposure for the Toddler Receptor Under the Baseline Scenario

PCOC	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	1.7E-1	8.4E-5	6.3E-7	1.3E-5	**3.4E-1**	8.4E-2	1.7E-3	1.3E-3	4.7E-7	6.3E-7
Particulate Inhalation	1.4E-4	9.9E-7	7.4E-8	8.0E-7	2.8E-4	6.9E-5	3.5E-5	1.1E-6	3.9E-10	5.2E-10
Soil Dermal Contact	4.5E-3	1.0E-4	7.7E-5	8.3E-5	2.9E-2	7.2E-2	3.6E-2	1.1E-3	4.1E-9	5.4E-9
Surface Water Ingestion	1.5E-1	1.5E-3	4.5E-4	**2.3E-1**	1.4E-1	2.3E-2	7.0E-2	1.5E-2	2.0E-6	2.2E-5

PCOC	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Berry Ingestion	**2.6E-1**	2.3E-2	5.7E-6	3.1E-4	1.6E-1	5.3E-2	**5.6E-1**	1.6E-2	9.9E-6	5.0E-7
Labrador Tea Ingestion	7.5E-2	2.4E-2	1.1E-5	8.7E-5	**2.7E-1**	4.5E-2	**6.8E-1**	1.3E-2	3.3E-6	1.2E-7
Game Bird Ingestion	4.8E-2	2.0E-4	1.1E-5	3.5E-5	1.0E-1	**4.0E-1**	5.5E-3	1.0E-2	8.7E-7	7.4E-5
Small Mammal Ingestion	3.2E-3	2.4E-3	1.8E-7	3.6E-4	1.4E-2	3.1E-2	8.0E-3	2.2E-3	4.9E-8	5.8E-7
Large Mammal Ingestion	**1.2E+0**	0.0E+0	0.0E+0	0.0E+0	**2.3E-1**	**8.2E-1**	0.0E+0	**5.3E-1**	0.0E+0	8.9E-5
Fish Ingestion	**4.3E-1**	1.7E-3	1.8E-3	3.6E-2	3.7E-2	3.6E-2	6.2E-3	**3.8E+0**	7.9E-7	8.7E-4
Total	**2.3E+0**	5.4E-2	2.4E-3	**2.6E-1**	**1.3E+0**	**1.6E+0**	**1.4E+0**	**4.4E+0**	1.7E-5	1.1E-3

3.1.2.2 Locally Acting Respiratory Risks

In the case of the Howse project, beryllium is the only PCOC for which a specific tolerable concentration (0.00002 mg/m^3) could be identified. The calculated respiratory hazard quotient as a result of baseline exposure to beryllium in airborne particulates is $7.4x10^{-5}$, a value below the de minimis level of 0.2.

Risks to respiratory health as a result of baseline exposure to beryllium in airborne particulates are therefore considered to be negligible.

3.1.2.3 Non-Threshold Cancer Risk

When assessing risks posed by genotoxic carcinogenic substances it is assumed that any level of exposure carries an associated hypothetical cancer risk (i.e., cancer effects do not rely on exceeding some safe threshold dose).

Non-threshold contaminants assessed in the present HHRA include arsenic, beryllium and chromium (total). Cancer risks as a result of oral exposure (ingestion of soil, water, food + dermal contact with contaminated soil), as well as cancer risks as a result of exposure to arsenic, beryllium and chromium through inhalation of fugitive dust are presented in Table 3.6.

Table 3.6 Calculated Incremental Lifetime Cancer Risks from Non-threshold Contaminants Under Baseline Conditions

PCOC	Oral Cancer Risks	Inhalation Cancer Risks	Total
Arsenic	4.81E-04	2.72E-07	4.82E-04
Beryllium		2.54E-09	2.54E-09
Chromium		8.64E-09	8.64E-09

3.1.3 Summary of Baseline Scenario Assessment

Arsenic

- The calculated total daily dose of arsenic to human receptors is primarily influenced by consumption of fish and caribou.
  - Ingestion of caribou accounts for 59.4% and 50.6% of the total dose to adults and toddlers respectively
  - Ingestion of fish accounts for 22.5% and 18.5% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of arsenic are 0.89 and 2.3 for adult and toddler receptors respectively and suggest risks are low and likely negligible given the conservative nature of the exposure scenario and quantitative assessment.
- The incremental lifetime cancer risk associated with oral exposure is calculated to be $4.8x10^{-4}$.
  - This value is driven primarily by fish and caribou ingestion.
  - This value exceeds the de minimis level of $1x10^{-5}$, however it is based on highly conservative assumptions and elevated detection limits which inflate the calculated exposure and risk estimates.
- The ILCR for exposure through inhalation of fugitive dust is calculated to be $2.7x10^{-7}$, a value well below the de minimis level of $1x10^{-5}$ (i.e., negligible risk). .

Human health risks as a result of arsenic exposure under baseline conditions are considered to be low and likely to be negligible.

Barium

- The calculated total daily dose of barium to human receptors is primarily influenced by consumption of Labrador tea and partridge berry.
  - Ingestion of Labrador tea accounts for 75% and 45% of the total dose to adults and toddlers respectively
  - Ingestion of partridge berry accounts for 14% and 44% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of barium are 0.02 and 0.05 for adult and toddler receptors respectively and are deemed to be negligible.

Human health risks as a result of barium exposure under baseline conditions are considered to be negligible.

Beryllium

- The calculated total daily dose of beryllium to human receptors is primarily influenced by ingestion of fish and surface water ingestion.
  - Ingestion of fish accounts for 84% and 75% of the total dose to adults and toddlers respectively
  - Ingestion of surface water accounts for 11% and 19% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of beryllium are 0.001 and 0.002 for adult and toddler receptors respectively and deemed to be negligible.
- The calculated hazard quotient for local beryllium respiratory toxicity is $7.4x10^{-5}$, and deemed to be negligible.
- The ILCR for exposure through inhalation of fugitive dust is calculated to be $2.5x10^{-9}$, a value well below the de minimis level of $1x10^{-5}$ (i.e., negligible risk).

Human health risks as a result of beryllium exposure under baseline conditions are considered to be negligible.

Chromium

- The calculated total daily dose of chromium to human receptors is primarily influenced by consumption of surface water and fish tissue.
  - Ingestion of surface water accounts for 75% and 86% of the total dose to adults and toddlers respectively
  - Ingestion of fish accounts for 24% and 14% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of chromium are 0.07 and 0.26 for adult

and toddler receptors respectively and are deemed to be negligible.

- The ILCR for exposure through inhalation of fugitive dust is calculated to be 8.6×10^{-9}, a value well below the de minimis level of 1×10^{-5} (i.e., negligible risk).

Human health risks as a result of chromium exposure under baseline conditions are considered to be negligible.

Iron

- The calculated total daily dose of iron to adult receptors is primarily influenced by ingestion of Labrador tea and caribou, accounting for 41% and 23% of the total dose respectively.
- The calculated total daily dose of iron to toddlers is primarily influenced by soil ingestion and ingestion of Labrador tea, accounting for 25% and 20% of the total dose respectively.
- Calculated hazard quotients for total daily dose of iron are 0.46 and 1.3 for adult and toddler receptors respectively and suggest risks are low and likely to be negligible given the highly conservative nature of the exposure scenario and quantitative assessment.

Human health risks as a result of iron exposure under baseline conditions are considered to be low and likely to be negligible.

Lead

- The calculated total daily dose of lead to human receptors is primarily influenced by ingestion of caribou and game fowl.
  - Ingestion of caribou accounts for 54% and 52% of the total dose to adults and toddlers respectively
  - Ingestion of game fowl accounts for 28% and 26% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of lead are 0.68 and 1.6 for adult and toddler receptors respectively and suggest that risks are low and likely to be negligible given the highly conservative nature of the exposure scenario and quantitative assessment.

Human health risks as a result of lead exposure under baseline conditions are considered to be low and likely to be negligible.

Manganese

- The calculated total daily dose of manganese to human receptors is primarily influenced by consumption of Labrador tea and partridge berry.
  - Ingestion of Labrador tea accounts for 80% and 50% of the total dose to adults and toddlers respectively
  - Ingestion of partridge berry accounts for 13% and 41% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of manganese are 0.5 and 1.4 for adult and toddler receptors respectively and suggest that risks are low and likely to be negligible given the highly conservative nature of the exposure scenario and quantitative assessment.

Human health risks as a result of manganese exposure under baseline conditions are considered to be low and likely to be negligible.

Mercury

- The calculated total daily dose of mercury to human receptors is primarily influenced by consumption of fish and caribou.
  - Ingestion of fish accounts for 87% of the total dose to adults and toddlers.
  - Ingestion of caribou accounts for 12% of the total dose to adults and toddlers.
- Calculated hazard quotients for total daily dose of mercury are 2.0 and 4.4 for adult and toddler receptors respectively and suggest that risks are low and likely to be negligible given the highly conservative nature of the exposure scenario and quantitative assessment.
  - 100% of fish collected from Howse property
  - Fish consumed daily

    - Maximum measured concentration used as exposure point concentration

Human health risks as a result of mercury exposure under baseline conditions are considered to be low and likely to be negligible.

Molybdenum

- The calculated total daily dose of molybdenum to human receptors is primarily influenced by consumption of Labrador tea and partridge berry.
    - Ingestion of Labrador tea accounts for 47% and 19% of the total dose to adults and toddlers respectively
    - Ingestion of partridge berry accounts for 27% and 57% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of molybdenum are $4.1x10^{-6}$ and $1.7x10^{-5}$ for adult and toddler receptors respectively (i.e., negligible risk).

Human health risks as a result of molybdenum exposure under baseline conditions are considered to be negligible.

Selenium

- The calculated total daily dose of selenium to human receptors is primarily influenced by consumption of fish and caribou.
    - Ingestion of fish accounts for 84% and 82% of the total dose to adults and toddlers respectively.
    - Ingestion of caribou accounts for 8% of the total dose to adults and toddlers.
- Calculated hazard quotients for total daily dose of selenium are 0.89 and 2.3 for adult and toddler receptors respectively and suggest that risks are low and likely to be negligible given the highly conservative nature of the exposure scenario and quantitative assessment.

Human health risks as a result of selenium exposure under baseline conditions are considered to be low and likely to be negligible.

3.2 Project Scenario

3.2.1 Exposure Assessment

Doses to adult and toddler human receptors were calculated based on receptor characteristics described in Table 2.2, as well as scenario specific exposure conditions described in Table 2.3. Exposure point concentrations carried forward into the quantitative exposure assessment are presented in Table 3.7.

Table 3.7 Concentrations of Assessed Metals in Abiotic and Biotic Media Carried Forward into the Quantitative Dose Estimates for the Project Scenario

PCOC	Soil (mg/kg dw)	Water (mg/L)	Particulate (mg/kg)	Berries (mg/kg dw)	Labrador Tea (mg/kg dw)	Fish (mg/kg ww)	Grouse (mg/kg ww)	Caribou (mg/kg ww)	Hare (mg/kg ww)
Arsenic	1.1E+1	5.0E-4	3.1E+1	3.9E-1	3.9E-1	3.6E-2	1.4E-2	6.0E-2	5.6E-4
Barium	5.0E+1	3.3E-3	1.1E+2	1.5E-1	7.4E+0	9.3E-2	3.6E-3	0.0E+0	3.5E-2
Beryllium	3.7E-1	1.0E-4	1.8E+0	5.6E-4	3.7E-3	1.0E-2	1.9E-4	0.0E+0	2.1E-6
Chromium	3.1E-1	2.5E-3	4.3E+1	2.3E-3	2.3E-3	1.0E-2	3.5E-5	0.0E+0	3.0E-4
Iron	5.0E+4	1.1E+0	3.7E+6	1.7E+2	6.4E+1	7.2E+0	5.7E+1	2.8E+1	3.1E+0
Lead	1.7E+1	2.5E-4	3.8E+1	2.6E-1	7.8E-1	1.0E-2	1.5E-2	1.4E-1	1.8E-2
Manganese	1.2E+3	1.0E-1	1.1E+3	2.7E+1	4.8E+2	2.3E-1	2.0E-2	0.0E+0	2.1E-1
Mercury	8.0E-2	5.0E-5	2.9E+1	2.3E-2	6.8E-2	3.2E-1	4.7E-5	2.7E-2	3.9E-4
Molybdenum	2.2E+0	5.0E-4	3.0E+0	1.1E+0	1.3E+0	5.0E-3	6.7E-3	0.0E+0	6.7E-4
Selenium	8.0E-1	1.5E-3	5.3E-1	1.5E-2	1.3E-2	1.5E+0	1.3E-2	9.4E-2	2.1E-3

3.2.1.1 Calculated Dose

The calculated daily doses (and relative contribution to the total) for each route of exposure for adult and toddler receptors in the project scenario are presented in Table 3.8 and Table 3.9 respectively.

Table 3.8 Calculated Dose (mg/kg/day) and Percent of Total (Value in Parentheses) for All Routes of Exposure for the Adult Receptor Under the Project Scenario

PCOC	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	3.0E-6 (1.1%)	9.8E-7 (0.2%)	7.3E-10 (0.0%)	8.5E-10 (0.0%)	1.4E-2 (7.8%)	4.9E-6 (1.0%)	1.3E-5 (0.1%)	2.3E-8 (0.0%)	6.3E-7 (0.6%)	2.3E-7 (0.0%)
Particulate Inhalation	3.0E-8 (0.0%)	1.1E-7 (0.0%)	1.6E-9 (0.0%)	3.1E-8 (0.0%)	2.8E-3 (1.6%)	3.9E-8 (0.0%)	1.5E-6 (0.0%)	2.2E-8 (0.0%)	3.6E-9 (0.0%)	9.1E-10 (0.0%)
Soil Dermal Contact	7.8E-7 (0.3%)	1.2E-5 (2.1%)	9.0E-7 (4.4%)	5.6E-8 (0.1%)	1.2E-2 (6.7%)	4.2E-5 (8.3%)	2.9E-3 (10.8%)	1.9E-7 (0.0%)	5.4E-8 (0.0%)	1.9E-8 (0.0%)
Surface Water Ingestion	1.1E-5 (4.0%)	7.0E-5 (12.0%)	2.1E-6 (10.5%)	5.3E-5 (75.2%)	2.3E-2 (12.9%)	5.3E-6 (1.1%)	2.2E-3 (8.4%)	1.1E-6 (0.2%)	1.1E-5 (9.7%)	3.2E-5 (1.1%)
Berry Ingestion	1.1E-5 (4.0%)	4.2E-6 (0.7%)	1.6E-8 (0.1%)	6.4E-8 (0.1%)	4.8E-3 (2.7%)	7.3E-6 (1.4%)	7.6E-4 (2.9%)	6.4E-7 (0.1%)	3.1E-5 (28.8%)	4.3E-7 (0.0%)
Labrador Tea Ingestion	1.6E-5 (5.9%)	3.1E-4 (52.7%)	1.5E-7 (0.8%)	9.4E-8 (0.1%)	2.7E-3 (1.5%)	3.2E-5 (6.4%)	2.0E-2 (75.6%)	2.8E-6 (0.5%)	5.4E-5 (49.1%)	5.3E-7 (0.0%)
Game Bird Ingestion	7.7E-6 (2.9%)	2.0E-6 (0.3%)	1.1E-7 (0.5%)	2.0E-8 (0.0%)	3.1E-2 (17.6%)	8.5E-6 (1.7%)	1.1E-5 (0.0%)	2.6E-8 (0.0%)	3.7E-6 (3.4%)	7.0E-6 (0.2%)
Small Mammal Ingestion	4.5E-7 (0.2%)	2.8E-5 (4.7%)	1.7E-9 (0.0%)	2.4E-7 (0.3%)	2.4E-3 (1.4%)	1.4E-5 (2.8%)	1.7E-4 (0.6%)	3.1E-7 (0.1%)	5.3E-7 (0.5%)	1.7E-6 (0.1%)
Large Mammal Ingestion	1.6E-4 (59.1%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	7.3E-2 (41.0%)	3.7E-4 (73.9%)	0.0E+0 (0.0%)	7.1E-5 (11.7%)	0.0E+0 (0.0%)	2.5E-4 (8.8%)
Fish Ingestion	6.0E-5 (22.4%)	1.6E-4 (27.2%)	1.7E-5 (83.7%)	1.7E-5 (24.1%)	1.2E-2 (6.9%)	1.7E-5 (3.4%)	4.0E-4 (1.5%)	5.3E-4 (87.5%)	8.5E-6 (7.8%)	2.5E-3 (89.7%)
Total	2.7E-4	5.8E-4	2.0E-5	7.1E-5	1.8E-1	5.0E-4	2.6E-2	6.1E-4	1.1E-4	2.8E-3

Table 3.9 Calculated Dose (mg/kg/day) and Percent of Total (Value in Parentheses) for All Routes of Exposure for the Toddler Receptor Under the Project Scenario

Pathway	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	5.2E-5 (7.4%)	1.7E-5 (1.4%)	1.3E-8 (0.0%)	1.5E-8 (0.0%)	2.4E-1 (35.7%)	8.4E-5 (7.1%)	2.3E-4 (0.5%)	3.9E-7 (0.0%)	1.1E-5 (2.8%)	3.9E-6 (0.1%)
Particulate Inhalation	1.3E-7 (0.0%)	4.8E-7 (0.0%)	6.8E-9 (0.0%)	1.3E-7 (0.1%)	1.2E-2 (1.8%)	1.7E-7 (0.0%)	6.6E-6 (0.0%)	9.2E-8 (0.0%)	1.6E-8 (0.0%)	3.9E-9 (0.0%)
Soil Dermal Contact	1.3E-6 (0.2%)	2.1E-5 (1.7%)	1.5E-6 (3.2%)	9.7E-8 (0.0%)	2.1E-2 (3.1%)	7.2E-5 (6.1%)	4.9E-3 (9.9%)	3.3E-7 (0.0%)	9.3E-8 (0.0%)	3.3E-8 (0.0%)
Surface Water Ingestion	4.5E-5 (6.5%)	3.0E-4 (24.9%)	9.1E-6 (19.1%)	2.3E-4 (85.8%)	9.8E-2 (14.7%)	2.3E-5 (1.9%)	9.5E-3 (19.1%)	4.5E-6 (0.3%)	4.5E-5 (11.7%)	1.4E-4 (2.2%)
Berry Ingestion	7.9E-5 (11.3%)	3.0E-5 (2.5%)	1.1E-7 (0.2%)	4.7E-7 (0.2%)	3.5E-2 (5.3%)	5.3E-5 (4.5%)	5.5E-3 (11.2%)	4.7E-6 (0.4%)	2.3E-4 (58.9%)	3.1E-6 (0.1%)
Labrador Tea Ingestion	2.3E-5 (3.2%)	4.3E-4 (36.0%)	2.2E-7 (0.5%)	1.3E-7 (0.1%)	3.7E-3 (0.6%)	4.5E-5 (3.8%)	2.8E-2 (56.8%)	4.0E-6 (0.3%)	7.6E-5 (19.5%)	7.5E-7 (0.0%)
Game Bird Ingestion	1.6E-5 (2.3%)	4.3E-6 (0.4%)	2.3E-7 (0.5%)	4.2E-8 (0.0%)	6.7E-2 (10.0%)	1.8E-5 (1.5%)	2.3E-5 (0.0%)	5.5E-8 (0.0%)	7.9E-6 (2.0%)	1.5E-5 (0.2%)
Small Mammal Ingestion	9.6E-7 (0.1%)	5.9E-5 (4.9%)	3.6E-9 (0.0%)	5.1E-7 (0.2%)	5.2E-3 (0.8%)	3.1E-5 (2.6%)	3.6E-4 (0.7%)	6.7E-7 (0.1%)	1.1E-6 (0.3%)	3.6E-6 (0.1%)
Large Mammal Ingestion	3.5E-4 (50.4%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	1.6E-1 (24.2%)	8.2E-4 (69.5%)	0.0E+0 (0.0%)	1.6E-4 (12.1%)	0.0E+0 (0.0%)	5.5E-4 (9.0%)
Fish Ingestion	1.3E-4 (18.4%)	3.4E-4 (28.1%)	3.6E-5 (76.4%)	3.6E-5 (13.7%)	2.6E-2 (3.9%)	3.6E-5 (3.1%)	8.5E-4 (1.7%)	1.1E-3 (86.8%)	1.8E-5 (4.7%)	5.4E-3 (88.4%)
Total	7.0E-4	1.2E-3	4.8E-5	2.7E-4	6.7E-1	1.2E-3	4.9E-2	1.3E-3	3.9E-4	6.1E-3

3.2.2 Risk Characterization

Risks to human health as a result of multi-media exposure to contaminants of concern under the project scenario are characterized using calculated hazard quotients and incremental lifetime cancer risks as described in Section 2.8. The following sections provides calculated hazard quotients for threshold contaminant exposures (Section 3.2.2.1), locally acting chemicals (Section 3.2.2.2), and non-threshold carcinogenic substances (Section 3.2.2.3).

3.2.2.1 General Threshold Contaminant Risks

Calculated hazard quotients, and percent increase from baseline (value in parentheses) for threshold contaminant exposures are presented in Table 3.10 and Table 3.11 for adult and toddler receptors respectively. Percent change from baseline is displayed only where calculated HQs exceed 0.2.

Table 3.10 Calculated Hazard Quotients (and Percent Change from Baseline Conditions) for Each Route of Exposure for the Adult Receptor Under the Project Scenario

Pathway	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	1.0E-2	4.9E-6	3.7E-8	8.5E-7	2.0E-2	4.9E-3	8.5E-5	7.5E-5	2.3E-8	4.0E-8
Particulate Inhalation	9.9E-5	5.6E-7	7.9E-8	3.1E-5	3.9E-3	3.9E-5	9.9E-6	7.2E-5	1.3E-10	1.6E-10
Soil Dermal Contact	2.6E-3	6.0E-5	4.5E-5	5.6E-5	1.7E-2	4.2E-2	1.8E-2	6.5E-4	1.9E-9	3.4E-9

Pathway	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Surface Water Ingestion	3.5E-2	3.5E-4	1.1E-4	5.3E-2	3.3E-2	5.3E-3	1.4E-2	3.5E-3	3.8E-7	5.6E-6
Berry Ingestion	3.6E-2	2.1E-5	7.8E-7	6.4E-5	6.9E-3	7.3E-3	4.9E-3	2.1E-3	1.1E-6	7.5E-8
Labrador Tea Ingestion	5.3E-2	1.5E-3	7.7E-6	9.4E-5	3.8E-3	3.2E-2	1.3E-1	9.3E-3	1.9E-6	9.2E-8
Game Bird Ingestion	2.6E-2	1.0E-5	5.3E-6	2.0E-5	4.5E-2	8.5E-3	6.9E-5	8.6E-5	1.3E-7	1.2E-6
Small Mammal Ingestion	1.5E-3	1.4E-4	8.5E-8	2.4E-4	3.5E-3	1.4E-2	1.1E-3	1.0E-3	1.9E-8	2.9E-7
Large Mammal Ingestion	**5.3E-1 (0.0%)**				1.0E-1	**3.7E-1 (0.0%)**		**2.4E-1 (0.0%)**		4.3E-5
Fish Ingestion	**2.0E-1 (0.0%)**	7.9E-4	8.5E-4	1.7E-2	1.7E-2	1.7E-2	2.5E-3	**1.8E+0 (0.0%)**	3.0E-7	4.4E-4
Total	**8.9E-1 (0.4%)**	2.9E-3	1.0E-3	7.1E-2	**2.5E-1 (-44.2%)**	**5.0E-1 (-26.3%)**	1.7E-1	**2.0E+0 (-0.2%)**	3.9E-6	4.9E-4

Table 3.11 Calculated Hazard Quotients (and Percent Change from Baseline Conditions) for Each Route of Exposure for the Toddler Receptor Under the Project Scenario

Pathway	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	1.7E-1	8.4E-5	6.3E-7	1.5E-5	**3.4E-1 (0.3%)**	8.4E-2	1.7E-3	1.3E-3	4.7E-7	6.3E-7
Particulate Inhalation	4.2E-4	2.4E-6	3.4E-7	1.3E-4	1.7E-2	1.7E-4	4.9E-5	3.1E-4	6.8E-10	6.3E-10
Soil Dermal Contact	4.5E-3	1.0E-4	7.7E-5	9.7E-5	2.9E-2	7.2E-2	3.6E-2	1.1E-3	4.1E-9	5.4E-9
Surface Water Ingestion	1.5E-1	1.5E-3	4.5E-4	**2.3E-1 (0.0%)**	1.4E-1	2.3E-2	7.0E-2	1.5E-2	2.0E-6	2.2E-5
Berry Ingestion	**2.6E-1 (0.3%)**	1.5E-4	5.7E-6	4.7E-4	5.0E-2	5.3E-2	4.1E-2	1.6E-2	9.9E-6	5.0E-7
Labrador Tea Ingestion	7.5E-2	2.2E-3	1.1E-5	1.3E-4	5.4E-3	4.5E-2	**2.1E-1 (-69.8%)**	1.3E-2	3.3E-6	1.2E-7
Game Bird Ingestion	5.5E-2	2.1E-5	1.1E-5	4.2E-5	9.6E-2	1.8E-2	1.7E-4	1.8E-4	3.4E-7	2.4E-6
Small Mammal Ingestion	3.2E-3	3.0E-4	1.8E-7	5.1E-4	7.4E-3	3.1E-2	2.6E-3	2.2E-3	4.9E-8	5.8E-7
Large Mammal Ingestion	**1.2E+0 (0.0%)**				**2.3E-1 (0.0%)**	**8.2E-1 (0.0%)**		**5.3E-1 (0.0%)**		8.9E-5
Fish Ingestion	**4.3E-1 (0.0%)**	1.7E-3	1.8E-3	3.6E-2	3.7E-2	3.6E-2	6.2E-3	**3.8E+0 (0.0%)**	7.9E-7	8.7E-4
Total	**2.3E+0 (0.3%)**	6.0E-3	2.4E-3	**2.7E-1 (0.2%)**	**9.6E-1 (-27.8%)**	**1.2E+0 (-24.4%)**	**3.6E-1 (-73.5%)**	**4.4E+0 (-0.2%)**	1.7E-5	9.9E-4

3.2.2.2 Locally Acting Respiratory Risks

In the case of the Howe project, beryllium is the only PCOC for which a specific tolerable concentration (0.00002 mg/m^3) could be identified. The calculated respiratory hazard quotient as a result of beryllium in airborne particulates under the project activities scenario is 9.24x10^{-5}, a value below the de minimis minimum level of 0.2.

Risks to respiratory health as a result of beryllium exposure in airborne particulates as a result of project activities are therefore considered to be negligible.

3.2.2.3 Non-Threshold Cancer Risk

Non-threshold contaminants assessed in the present HHRA include arsenic, beryllium and chromium (total). Cancer risks as a result of oral exposure (ingestion of soil, water, food + dermal contact with contaminated soil), as well as cancer risks as a result of exposure to arsenic, beryllium and chromium through inhalation of fugitive dust are presented in Table 3.12.

Table 3.12 Calculated Incremental Lifetime Cancer Risks from Non-threshold Contaminants under Project Conditions

PCOC	Oral Cancer Risks	Inhalation Cancer Risks	Total
Arsenic	4.65E-04	7.98E-07	4.66E-04
Beryllium		1.15E-08	1.15E-08
Chromium		1.43E-06	1.43E-06

3.2.3 Summary of Project Risks

Arsenic

- The calculated total daily dose of arsenic to human receptors is primarily influenced by consumption of fish and caribou.
  - Ingestion of caribou accounts for 59.1% and 50.4% of the total dose to adults and toddlers respectively
  - Ingestion of fish accounts for 22.4% and 18.4% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of arsenic are 0.89 and 2.3 for adult and toddler receptors respectively and both represent hazard quotient changes of <1% compared to baseline conditions. Given the conservative nature of the exposure scenario and quantitative assessment, this suggests risks are low and likely negligible.
- The incremental lifetime cancer risk associated with oral exposure is calculated to be $4.7x10^{-4}$.
  - This value is driven primarily by fish and caribou ingestion.
  - This value exceeds the de minimis level of $1x10^{-5}$, however it is based on highly conservative assumptions and elevated detection limits which inflate the calculated exposure and risk estimates.
- The ILCR for exposure through inhalation of fugitive dust is calculated to be $8.0x10^{-7}$, a value well below the de minimis level of $1x10^{-5}$ (i.e., negligible risk). .

Human health risks as a result of arsenic exposure under the project scenario are considered low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%

Barium

- The calculated total daily dose of barium to human receptors is primarily influenced by consumption of Labrador tea and partridge berry.
  - Ingestion of Labrador tea accounts for 53% and 36% of the total dose to adults and toddlers respectively
  - Ingestion of partridge berry accounts for 0.7% and 2.5% of the total dose to adults and toddlers respectively

- Calculated hazard quotients for total daily dose of barium are 0.003 and 0.006 for adult and toddler receptors respectively and are deemed to be negligible.

Human health risks as a result of barium exposure under the project scenario are considered to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%

Beryllium

- The calculated total daily dose of beryllium to human receptors is primarily influenced by ingestion of fish and surface water ingestion.
  - Ingestion of fish accounts for 84% and 76% of the total dose to adults and toddlers respectively
  - Ingestion of surface water accounts for 11% and 19% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of beryllium are 0.001 and 0.002 for adult and toddler receptors respectively and deemed to be negligible.
- The calculated hazard quotient for local beryllium respiratory toxicity is 9.24×10^{-5}, and deemed to be negligible.
- The ILCR for exposure through inhalation of fugitive dust is calculated to be 1.15×10^{-8}, a value well below the de minimis level of 1×10^{-5} (i.e., negligible risk).

- *Human health risks as a result of beryllium exposure under the project scenario are considered to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%*

Chromium

- The calculated total daily dose of chromium to human receptors is primarily influenced by consumption of surface water and fish tissue.
  - Ingestion of surface water accounts for 75% and 86% of the total dose to adults and toddlers respectively
  - Ingestion of fish accounts for 24% and 14% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of chromium are 0.07 and 0.27 for adult and toddler receptors respectively and both represent hazard quotient changes of <1% compared to baseline conditions. This suggests that the risks are deemed to be negligible.
- The ILCR for exposure through inhalation of fugitive dust is calculated to be 1.4×10^{-6}, a value that is an order of magnitude below the de minimis level of 1×10^{-5} (i.e., negligible risk).

Human health risks as a result of chromium exposure under the project scenario are considered to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%

Iron

- The calculated total daily dose of iron to adult receptors is primarily influenced by ingestion of caribou and spruce grouse, accounting for 41% and 18% of the total dose respectively.
- The calculated total daily dose of iron to toddlers is primarily influenced by soil ingestion and ingestion of caribou, accounting for 36% and 24% of the total dose respectively.
- Calculated hazard quotients for total daily dose of iron are 0.25 and 0.96 for adult and toddler receptors respectively. Both represent hazard quotient reductions compared to baseline conditions. This is a result of the soil to tissue transfer factors for the project scenario predicting a lower risk than the assumed detection limits from the baseline scenario.. Given the highly conservative nature of the exposure scenario and quantitative assessment the risks are low and likely to be negligible.

Human health risks as a result of iron exposure under the project scenario are considered to be low and likely to be negligible. In addition, the project *incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%*

Lead

- The calculated total daily dose of lead to adult receptors is primarily influenced by ingestion of caribou and soil dermal contact accounting for 74% and 8%, respectively, of the total dose to adults.
- The calculated total daily dose of lead to toddler receptors is primarily influenced by ingestion of caribou and soil ingestion accounting for 70% and 7%, respectively, of the total dose to toddlers.
- Calculated hazard quotients for total daily dose of lead are 0.5 and 1.0 for adult and toddler receptors respectively. Both represent hazard quotient reductions compared to baseline conditions. This is a result of the soil to tissue transfer factors for the project scenario predicting a lower risk than the assumed detection limits from the baseline scenario. Given the highly conservative nature of the exposure scenario and quantitative assessment the risks are low and likely to be negligible..

Human health risks as a result of lead exposure under the project scenario are considered low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%

Manganese

- The calculated total daily dose of manganese to human receptors is primarily influenced by consumption of Labrador tea (both adults and toddlers), soil dermal contact (adults), and partridge berry.(toddlers)
  - Ingestion of Labrador tea and soil dermal contact accounts for 76% and 11% of the total dose, respectively. to
  - Ingestion of Labrador tea accounts for 57% and partridge berry accounts for 41% of the total dose to toddlers.
- Calculated hazard quotients for total daily dose of manganese are 0.2 and 0.4 for adult and toddler receptors respectively. For toddlers this represents a hazard quotient reduction compared to baseline conditions. This is a result of the soil to tissue transfer factors for the project scenario predicting a lower risk than the assumed detection limits from the baseline scenario. Given the highly conservative nature of the exposure scenario and quantitative assessment the risks are low and likely to be negligible.

Human health risks as a result of manganese exposure under the project scenario are considered to be low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Mercury

- The calculated total daily dose of mercury to human receptors is primarily influenced by consumption of fish and caribou.
  - Ingestion of fish accounts for 87% of the total dose to adults and toddlers.
  - Ingestion of caribou accounts for 12% of the total dose to adults and toddlers.
- Calculated hazard quotients for total daily dose of mercury are 2.0 and 4.4 for adult and toddler receptors respectively and both represent hazard quotient changes of <1% compared to baseline conditions and suggest that risks are low and likely to be negligible given the highly conservative nature of the exposure scenario and quantitative assessment.
  - 100% of fish collected from Howse property
  - Fish consumed daily
  - Maximum measured concentration used as exposure point concentration

Human health risks as a result of mercury exposure under the project scenario are considered to be low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Molybdenum

- The calculated total daily dose of molybdenum to human receptors is primarily influenced by consumption of Labrador tea and partridge berry.

- Ingestion of Labrador tea accounts for 49% and 20% of the total dose to adults and toddlers respectively
- Ingestion of partridge berry accounts for 29% and 59% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of molybdenum are 3.9×10^{-6} and 1.7×10^{-5} for adult and toddler receptors respectively (i.e., negligible risk).

Human health risks as a result of molybdenum exposure under the project scenario are considered to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%

Selenium

- The calculated total daily dose of selenium to human receptors is primarily influenced by consumption of fish and caribou.
  - Ingestion of fish accounts for 90% and 88% of the total dose to adults and toddlers respectively.
  - Ingestion of caribou accounts for 9% of the total dose to adults and toddlers.
- Calculated hazard quotients for total daily dose of selenium are 4.9×10^{-4} and 9.9×10^{-4} for adult and toddler receptors respectively and suggest that risks are low and likely to be negligible given the highly conservative nature of the exposure scenario and quantitative assessment.

Human health risks as a result of selenium exposure under the project scenario are considered to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%

3.3 Cumulative Scenario

3.3.1 Deterministic Exposure Assessment

Doses to adult and toddler human receptors were calculated based on receptor characteristics described in Table 2.2, as well as scenario specific exposure conditions described in Table 2.3. Exposure point concentrations carried forward into the quantitative exposure assessment are presented Table 3.13.

Table 3.13 Concentrations of Assessed Metals in Abiotic and Biotic Media Carried Forward into the Quantitative Dose Estimates for the Cumulative Scenario

PCOC	Soil (mg/kg dw)	Water (mg/L)	Particulate (mg/kg)	Berries (mg/kg dw)	Labrador Tea (mg/kg dw)	Fish (mg/kg ww)	Grouse (mg/kg ww)	Caribou (mg/kg ww)	Hare (mg/kg ww)
Arsenic	1.1E+1	5.0E-4	3.1E+1	3.9E-1	3.9E-1	3.6E-2	1.4E-2	6.0E-2	5.7E-4
Barium	5.0E+1	3.3E-3	1.1E+2	1.5E-1	7.6E+0	9.3E-2	3.7E-3	0.0E+0	3.5E-2
Beryllium	3.8E-1	1.0E-4	1.8E+0	5.6E-4	3.8E-3	1.0E-2	2.0E-4	0.0E+0	2.2E-6
Chromium	5.4E-1	2.5E-3	4.3E+1	4.0E-3	4.0E-3	1.0E-2	4.7E-5	0.0E+0	4.9E-4
Iron	5.0E+4	1.1E+0	3.7E+6	1.8E+2	6.6E+1	7.2E+0	5.8E+1	2.8E+1	3.1E+0
Lead	1.7E+1	2.5E-4	3.8E+1	2.6E-1	7.8E-1	1.0E-2	1.6E-2	1.4E-1	1.8E-2
Manganese	1.2E+3	1.0E-1	1.1E+3	2.7E+1	4.8E+2	2.3E-1	2.0E-2	0.0E+0	2.1E-1
Mercury	8.0E-2	5.0E-5	2.9E+1	2.3E-2	6.8E-2	3.2E-1	4.7E-5	2.7E-2	3.9E-4

PCOC	Soil (mg/kg dw)	Water (mg/L)	Particulate (mg/kg)	Berries (mg/kg dw)	Labrador Tea (mg/kg dw)	Fish (mg/kg ww)	Grouse (mg/kg ww)	Caribou (mg/kg ww)	Hare (mg/kg ww)
Molybdenum	2.3E+0	5.0E-4	3.0E+0	1.1E+0	1.3E+0	5.0E-3	6.7E-3	0.0E+0	6.7E-4
Selenium	8.0E-1	1.5E-3	5.3E-1	1.5E-2	1.3E-2	1.5E+0	1.3E-2	9.4E-2	2.1E-3

3.3.1.1 Calculated Dose

The calculated daily doses (and % contribution to the total) for each route of exposure for adult and toddler receptors in the baseline scenario are presented in Table 3.14 and Table 3.15 respectively.

Table 3.14 Calculated Dose (mg/kg/day) and Percent of Total (Value in Parentheses) Dose for All Routes of Exposure for the Adult Receptor Under the Cumulative Scenario

PCOC	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	3.0E-6 (1.1%)	9.8E-7 (0.2%)	7.4E-10 (0.0%)	1.1E-9 (0.0%)	1.4E-2 (7.6%)	4.9E-6 (1.0%)	1.3E-5 (0.1%)	2.3E-8 (0.0%)	6.3E-7 (0.6%)	2.3E-7 (0.0%)
Particulate Inhalation	7.7E-8 (0.0%)	2.8E-7 (0.0%)	4.4E-9 (0.0%)	9.7E-8 (0.1%)	8.5E-3 (4.6%)	9.8E-8 (0.0%)	3.2E-6 (0.0%)	6.7E-8 (0.0%)	8.3E-9 (0.0%)	1.7E-9 (0.0%)
Soil Dermal Contact	7.8E-7 (0.3%)	1.2E-5 (2.0%)	9.0E-7 (4.4%)	7.4E-8 (0.1%)	1.2E-2 (6.5%)	4.2E-5 (8.3%)	2.9E-3 (10.8%)	1.9E-7 (0.0%)	5.4E-8 (0.0%)	1.9E-8 (0.0%)
Surface Water Ingestion	1.1E-5 (3.9%)	7.0E-5 (11.9%)	2.1E-6 (10.5%)	5.3E-5 (74.8%)	2.3E-2 (12.4%)	5.3E-6 (1.1%)	2.2E-3 (8.4%)	1.1E-6 (0.2%)	1.1E-5 (9.7%)	3.2E-5 (1.1%)
Berry Ingestion	1.1E-5 (4.1%)	4.2E-6 (0.7%)	1.6E-8 (0.1%)	1.1E-7 (0.2%)	4.9E-3 (2.7%)	7.3E-6 (1.5%)	7.6E-4 (2.9%)	6.4E-7 (0.1%)	3.2E-5 (28.8%)	4.3E-7 (0.0%)
Labrador Tea Ingestion	1.6E-5 (6.0%)	3.1E-4 (53.1%)	1.5E-7 (0.8%)	1.7E-7 (0.2%)	2.7E-3 (1.5%)	3.2E-5 (6.4%)	2.0E-2 (75.7%)	2.8E-6 (0.5%)	5.4E-5 (49.2%)	5.3E-7 (0.0%)
Game Bird Ingestion	7.7E-6 (2.9%)	2.0E-6 (0.3%)	1.1E-7 (0.5%)	2.6E-8 (0.0%)	3.2E-2 (17.3%)	8.6E-6 (1.7%)	1.1E-5 (0.0%)	2.6E-8 (0.0%)	3.7E-6 (3.4%)	7.0E-6 (0.2%)
Small Mammal Ingestion	4.5E-7 (0.2%)	2.8E-5 (4.8%)	1.7E-9 (0.0%)	3.9E-7 (0.5%)	2.5E-3 (1.3%)	1.4E-5 (2.9%)	1.7E-4 (0.6%)	3.1E-7 (0.1%)	5.3E-7 (0.5%)	1.7E-6 (0.1%)
Large Mammal Ingestion	1.6E-4 (59.1%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	7.3E-2 (39.5%)	3.7E-4 (73.8%)	0.0E+0 (0.0%)	7.1E-5 (11.7%)	0.0E+0 (0.0%)	2.5E-4 (8.8%)
Fish Ingestion	6.0E-5 (22.4%)	1.6E-4 (26.9%)	1.7E-5 (83.7%)	1.7E-5 (23.9%)	1.2E-2 (6.6%)	1.7E-5 (3.4%)	4.0E-4 (1.5%)	5.3E-4 (87.5%)	8.5E-6 (7.8%)	2.5E-3 (89.7%)
Total	2.7E-4	5.9E-4	2.0E-5	7.1E-5	1.8E-1	5.0E-4	2.6E-2	6.1E-4	1.1E-4	2.8E-3

Table 3.15 Calculated Dose (mg/kg/day) and Percent of Total (Value in Parentheses) for All Routes of Exposure for the Toddler receptor Under the Cumulative Scenario

Pathway	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	5.2E-5 (7.4%)	1.7E-5 (1.4%)	1.3E-8 (0.0%)	1.9E-8 (0.0%)	2.4E-1 (34.4%)	8.4E-5 (7.1%)	2.3E-4 (0.5%)	3.9E-7 (0.0%)	1.1E-5 (2.8%)	3.9E-6 (0.1%)
Particulate Inhalation	3.3E-7 (0.0%)	1.2E-6 (0.1%)	1.9E-8 (0.0%)	4.2E-7 (0.2%)	3.7E-2 (5.2%)	4.2E-7 (0.0%)	1.4E-5 (0.0%)	2.9E-7 (0.0%)	3.5E-8 (0.0%)	7.4E-9 (0.0%)
Soil Dermal Contact	1.3E-6 (0.2%)	2.1E-5 (1.7%)	1.6E-6 (3.3%)	1.3E-7 (0.0%)	2.1E-2 (3.0%)	7.2E-5 (6.1%)	4.9E-3 (9.9%)	3.3E-7 (0.0%)	9.4E-8 (0.0%)	3.3E-8 (0.0%)
Surface Water Ingestion	4.5E-5 (6.5%)	3.0E-4 (24.7%)	9.1E-6 (19.1%)	2.3E-4 (85.4%)	9.8E-2 (14.1%)	2.3E-5 (1.9%)	9.5E-3 (19.1%)	4.5E-6 (0.3%)	4.5E-5 (11.7%)	1.4E-4 (2.2%)

Pathway	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Berry Ingestion	8.0E-5 (11.4%)	3.1E-5 (2.5%)	1.2E-7 (0.2%)	8.2E-7 (0.3%)	3.6E-2 (5.1%)	5.3E-5 (4.5%)	5.5E-3 (11.2%)	4.7E-6 (0.4%)	2.3E-4 (59.0%)	3.1E-6 (0.1%)
Labrador Tea Ingestion	2.3E-5 (3.2%)	4.4E-4 (36.3%)	2.2E-7 (0.5%)	2.3E-7 (0.1%)	3.8E-3 (0.5%)	4.6E-5 (3.8%)	2.8E-2 (56.9%)	4.0E-6 (0.3%)	7.6E-5 (19.5%)	7.5E-7 (0.0%)
Game Bird Ingestion	1.7E-5 (2.4%)	4.4E-6 (0.4%)	2.3E-7 (0.5%)	5.6E-8 (0.0%)	6.8E-2 (9.8%)	1.8E-5 (1.5%)	2.3E-5 (0.0%)	5.5E-8 (0.0%)	7.9E-6 (2.0%)	1.5E-5 (0.2%)
Small Mammal Ingestion	9.6E-7 (0.1%)	6.0E-5 (5.0%)	3.7E-9 (0.0%)	8.3E-7 (0.3%)	5.3E-3 (0.8%)	3.1E-5 (2.6%)	3.6E-4 (0.7%)	6.7E-7 (0.1%)	1.1E-6 (0.3%)	3.6E-6 (0.1%)
Large Mammal Ingestion	3.5E-4 (50.4%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	0.0E+0 (0.0%)	1.6E-1 (23.3%)	8.2E-4 (69.4%)	0.0E+0 (0.0%)	1.6E-4 (12.1%)	0.0E+0 (0.0%)	5.5E-4 (9.0%)
Fish Ingestion	1.3E-4 (18.4%)	3.4E-4 (27.9%)	3.6E-5 (76.4%)	3.6E-5 (13.7%)	2.6E-2 (3.8%)	3.6E-5 (3.1%)	8.5E-4 (1.7%)	1.1E-3 (86.8%)	1.8E-5 (4.7%)	5.4E-3 (88.4%)
Total	7.0E-4	1.2E-3	4.8E-5	2.7E-4	7.0E-1	1.2E-3	5.0E-2	1.3E-3	3.9E-4	6.1E-3

3.3.2 Risk Characterization

Risks to human health as a result of multi-media exposure to contaminants of concern under project conditions are characterized using calculated hazard quotients and incremental lifetime cancer risks as described in Section 2.8. The following sections provides calculated hazard quotients for threshold contaminant exposures (Section 3.3.2.1), locally acting chemicals (Section 3.3.2.2), and non-threshold carcinogenic substances (Section 3.3.2.3).

3.3.2.1 General Threshold Contaminant Risks

Calculated hazard quotients, and percent increase from baseline (value in parentheses) for threshold contaminant exposures are presented Table 3.16 and Table 3.17 for adult and toddler receptors respectively. Percent change from baseline is displayed only where calculated HQs exceed 0.2.

Table 3.16 Calculated Hazard Quotients (and Percent Change from Baseline Conditions) for Each Route of Exposure for the Adult Receptor Under the Cumulative Scenario

PCOC	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	1.0E-2	4.9E-6	3.7E-8	1.1E-6	2.0E-2	4.9E-3	8.5E-5	7.5E-5	2.3E-8	4.0E-8
Particulate Inhalation	2.6E-4	1.4E-6	2.2E-7	9.7E-5	1.2E-2	9.8E-5	2.0E-5	2.2E-4	3.0E-10	3.0E-10
Soil Dermal Contact	2.6E-3	6.0E-5	4.5E-5	7.4E-5	1.7E-2	4.2E-2	1.8E-2	6.5E-4	1.9E-9	3.4E-9
Surface Water Ingestion	3.5E-2	3.5E-4	1.1E-4	5.3E-2	3.3E-2	5.3E-3	1.4E-2	3.5E-3	3.8E-7	5.6E-6
Berry Ingestion	3.6E-2	2.1E-5	7.9E-7	1.1E-4	7.0E-3	7.3E-3	4.9E-3	2.1E-3	1.1E-6	7.5E-8
Labrador Tea Ingestion	5.4E-2	1.6E-3	7.7E-6	1.7E-4	3.9E-3	3.2E-2	1.3E-1	9.3E-3	1.9E-6	9.3E-8
Game Bird Ingestion	2.6E-2	1.0E-5	5.4E-6	2.6E-5	4.6E-2	8.6E-3	7.0E-5	8.6E-5	1.3E-7	1.2E-6
Small Mammal Ingestion	1.5E-3	1.4E-4	8.5E-8	3.9E-4	3.5E-3	1.4E-2	1.1E-3	1.0E-3	1.9E-8	2.9E-7
Large Mammal Ingestion	**5.3E-1 (0.0%)**				1.0E-1	**3.7E-1 (0.0%)**		**2.4E-1 (0.0%)**		4.3E-5

PCOC	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Fish Ingestion	**2.0E-1 (0.0%)**	7.9E-4	8.5E-4	1.7E-2	1.7E-2	1.7E-2	2.5E-3	**1.8E+0 (0.0%)**	3.0E-7	4.4E-4
Total	**9.0E-1 (0.5%)**	2.9E-3	1.0E-3	7.1E-2	**2.6E-1 (-42.1%)**	**5.0E-1 (-26.2%)**	1.7E-1	**2.0E+0 (-0.2%)**	3.9E-6	4.9E-4

Table 3.17 Calculated Hazard Quotients (and Percent Change from Baseline Conditions) for Each Route of Exposure for the Toddler Receptor Under the Cumulative Scenario

PCOC	As	Ba	Be	Cr	Fe	Pb	Mn	Hg	Mo	Se
Soil Ingestion	1.7E-1	8.4E-5	6.3E-7	1.9E-5	**3.4E-1 (0.8%)**	8.4E-2	1.7E-3	1.3E-3	4.7E-7	6.3E-7
Particulate Inhalation	1.1E-3	6.0E-6	9.4E-7	4.2E-4	5.2E-2	4.2E-4	1.0E-4	9.6E-4	1.5E-9	1.2E-9
Soil Dermal Contact	4.5E-3	1.0E-4	7.8E-5	1.3E-4	3.0E-2	7.2E-2	3.6E-2	1.1E-3	4.1E-9	5.4E-9
Surface Water Ingestion	1.5E-1	1.5E-3	4.5E-4	**2.3E-1 (0.0%)**	1.4E-1	2.3E-2	7.0E-2	1.5E-2	2.0E-6	2.2E-5
Berry Ingestion	**2.7E-1 (1.1%)**	1.5E-4	5.8E-6	8.2E-4	5.1E-2	5.3E-2	4.1E-2	1.6E-2	1.0E-5	5.0E-7
Labrador Tea Ingestion	7.6E-2	2.2E-3	1.1E-5	2.3E-4	5.5E-3	4.6E-2	**2.1E-1 (-69.7%)**	1.3E-2	3.3E-6	1.2E-7
Game Bird Ingestion	5.5E-2	2.2E-5	1.2E-5	5.6E-5	9.8E-2	1.8E-2	1.7E-4	1.8E-4	3.4E-7	2.4E-6
Small Mammal Ingestion	3.2E-3	3.0E-4	1.8E-7	8.3E-4	7.6E-3	3.1E-2	2.7E-3	2.2E-3	4.9E-8	5.8E-7
Large Mammal Ingestion	**1.2E+0 (0.0%)**				**2.3E-1 (0.0%)**	**8.2E-1 (0.0%)**		**5.3E-1 (0.0%)**		8.9E-5
Fish Ingestion	**4.3E-1 (0.0%)**	1.7E-3	1.8E-3	3.6E-2	3.7E-2	3.6E-2	6.2E-3	**3.8E+0 (0.0%)**	7.9E-7	8.7E-4
Total	**2.3E+0 (0.5%)**	6.1E-3	2.4E-3	**2.7E-1 (0.6%)**	**1.0E+0 (-24.7%)**	**1.2E+0 (-24.3%)**	**3.6E-1 (-73.5%)**	**4.4E+0 (-0.2%)**	1.7E-5	9.9E-4

3.3.2.2 Locally Acting Respiratory Risks

In the case of the Howe project, beryllium is the only PCOC for which a specific tolerable concentration (0.00002 mg/m^3) could be identified. The calculated respiratory hazard quotient as a result of beryllium in airborne particulates under the cumulative activities scenario is $2.88x10^{-5}$, a value below the de minimis level of 0.2.

Risks to respiratory health as a result of beryllium exposure in airborne particulates as a result of cumulative activities are therefore considered to be negligible.

3.3.2.3 Non-Threshold Cancer Risk

Non-threshold contaminants assessed in the present HHRA include arsenic, beryllium and chromium (total). Cancer risks as a result of oral exposure (ingestion of soil, water, food + dermal contact with contaminated soil), as well as cancer risks as a result of exposure to arsenic, beryllium and chromium through inhalation of fugitive dust are presented in Table 3.18.

Table 3.18 Calculated Incremental Lifetime Cancer Risks from Non-threshold Contaminants Under Cumulative Conditions

PCOC	Oral Cancer Risks	Inhalation Cancer Risks	Total
Arsenic	4.66E-04	2.09E-06	4.68E-04
Beryllium		3.22E-08	3.22E-08
Chromium		4.46E-06	4.46E-06

3.3.3 Summary of Deterministic Cumulative Risks Estimates

Arsenic

- The calculated total daily dose of arsenic to human receptors is primarily influenced by consumption of fish and caribou.
    - Ingestion of caribou accounts for 59.1% and 50.4% of the total dose to adults and toddlers respectively and both represent hazard quotient changes of <1% compared to baseline conditions.
    - Ingestion of fish accounts for 22.4% and 18.4% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of arsenic are 0.9 and 2.3 for adult and toddler receptors respectively and both represent changes of ‘1% compared to baseline conflations. Given the conservative nature of the exposure scenario and quantitative assessment this suggests risks are low and likely negligible.
- The incremental lifetime cancer risk associated with oral exposure is calculated to be $4.7x10^{-4}$.
    - This value is driven primarily by fish and caribou ingestion.
    - This value exceeds the de minimis level of $1x10^{-5}$, however it is based on highly conservative assumptions and elevated detection limits which inflate the calculated exposure and risk estimates.
- The ILCR for exposure through inhalation of fugitive dust is calculated to be $2.1x10^{-6}$, a value well below the de minimis level of $1x10^{-5}$ (i.e., negligible risk).

Human health risks as a result of arsenic exposure under the cumulative scenario are considered to be low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Barium

- The calculated total daily dose of barium to human receptors is primarily influenced by consumption of Labrador tea and fish ingestion.
    - Ingestion of Labrador tea accounts for 53% and 36% of the total dose to adults and toddlers respectively
    - Fish ingestion accounts for 27% and 28% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of barium are 0.003 and 0.006 for adult and toddler receptors respectively and are deemed to be negligible.

Human health risks as a result of barium exposure under the cumulative scenario are considered to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Beryllium

- The calculated total daily dose of beryllium to human receptors is primarily influenced by ingestion of fish and surface water ingestion.
    - Ingestion of fish accounts for 84% and 76% of the total dose to adults and toddlers respectively
    - Ingestion of surface water accounts for 11% and 19% of the total dose to adults and toddlers respectively

- Calculated hazard quotients for total daily dose of beryllium are 0.001 and 0.002 for adult and toddler receptors respectively and deemed to be negligible.
- The calculated hazard quotient for local beryllium respiratory toxicity is $2.9\text{x}10^{-5}$, and deemed to be negligible.
- The ILCR for exposure through inhalation of fugitive dust is calculated to be $3.2\text{x}10^{-8}$, a value well below the de minimis level of $1\text{x}10^{-5}$ (i.e., negligible risk).

Human health risks as a result of beryllium exposure under the cumulative scenario are considered to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Chromium

- The calculated total daily dose of chromium to human receptors is primarily influenced by consumption of surface water and fish tissue.
    - Ingestion of surface water accounts for 75% and 85% of the total dose to adults and toddlers respectively
    - Ingestion of fish accounts for 24% and 14% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of chromium are 0.07 and 0.27 for adult and toddler receptors respectively. For toddlers the hazard quotient changes by <1% compared to baseline conditions. This suggests that the risks are deemed to be negligible.
- The ILCR for exposure through inhalation of fugitive dust is calculated to be $4.5\text{x}10^{-6}$, a value well below the de minimis level of $1\text{x}10^{-5}$ (i.e., negligible risk).

Human health risks as a result of chromium exposure under the cumulative scenario are considered to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Iron

- The calculated total daily dose of iron to adult receptors is primarily influenced by ingestion of caribou and spruce grouse, accounting for 40% and 17% of the total dose respectively.
- The calculated total daily dose of iron to toddlers is primarily influenced by soil ingestion and ingestion of caribou, accounting for 34% and 23% of the total dose respectively.
- Calculated hazard quotients for total daily dose of iron are 0.26 and 1.0 for adult and toddler receptors respectively. Both represent hazard quotient reductions compared to baseline conditions. This is a result of the soil to tissue transfer factors for the project scenario predicting a lower risk than the assumed detection limits from the baseline scenario. Given the highly conservative nature of the exposure scenario and quantitative assessment the risks are low and likely to be negligible.

Human health risks as a result of iron exposure under the cumulative scenario are considered to be low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Lead

- The calculated total daily dose of lead to adult receptors is primarily influenced by ingestion of caribou and soil dermal contact accounting for 74% and 8%, respectively, of the total dose to adults.
- The calculated total daily dose of lead to toddler receptors is primarily influenced by ingestion of caribou and soil ingestion accounting for 69% and 7%, respectively, of the total dose to toddlers.

  Calculated hazard quotients for total daily dose of lead are 0.5 and 1.2 for adult and toddler receptors, respectively. Both represent hazard quotient reductions compared to baseline conditions. This is a result of the soil to tissue transfer factors for the project scenario predicting a lower risk than the assumed detection limits from the baseline scenario. Given the highly conservative nature of the exposure scenario and quantitative assessment the risks are low and likely to be negligible.

Human health risks as a result of lead exposure under the cumulative scenario are considered to be low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Manganese

- The calculated total daily dose of manganese to human receptors is primarily influenced by consumption of Labrador tea (both adults and toddlers), soil dermal contact (adults), and surface water ingestion (toddlers).
  - For adults the ingestion of Labrador tea accounts for 76% of the total dose and soil dermal contact accounts for 11% of the total dose of manganese.
  - For toddlers the ingestion of Labrador tea accounts for 57% of the total dose and surface water ingestion accounts for 19% of the total dose.
- Calculated hazard quotients for total daily dose of manganese are 0.2 and 0.4 for adult and toddler receptors respectively. For toddlers this represents a hazard quotient reduction compared to baseline conditions. This is a result of the soil to tissue transfer factors for the project scenario predicting a lower risk than the assumed detection limits from the baseline scenario. Given the highly conservative nature of the exposure scenario and quantitative assessment the risks are low and likely to be negligible.

Human health risks as a result of manganese exposure under the cumulative scenario are considered to be low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Mercury

- The calculated total daily dose of mercury to human receptors is primarily influenced by consumption of fish and caribou.
  - Ingestion of fish accounts for 87% of the total dose to adults and toddlers.
  - Ingestion of caribou accounts for 12% of the total dose to adults and toddlers.
- Calculated hazard quotients for total daily dose of mercury are 2.0 and 4.4 for adult and toddler receptors respectively and suggest that risks are low and likely to be negligible given the highly conservative nature of the exposure scenario and quantitative assessment.
  - 100% of fish collected from Howse property
  - Fish consumed daily
  - Maximum measured concentration used as exposure point concentration

Human health risks as a result of mercury exposure under the cumulative scenario are considered to be low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Molybdenum

- The calculated total daily dose of molybdenum to human receptors is primarily influenced by consumption of Labrador tea and partridge berry.
  - Ingestion of Labrador tea accounts for 49% and 20% of the total dose to adults and toddlers respectively
  - Ingestion of partridge berry accounts for 29% and 59% of the total dose to adults and toddlers respectively
- Calculated hazard quotients for total daily dose of molybdenum are 3.9×10^{-6} and 1.7×10^{-5} for adult and toddler receptors respectively (i.e., negligible risk).

Human health risks as a result of molybdenum exposure under the cumulative scenario are considered to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

Selenium

- The calculated total daily dose of selenium to human receptors is primarily influenced by consumption of fish and caribou.
  - Ingestion of fish accounts for 90% and 88% of the total dose to adults and toddlers respectively.

- Ingestion of caribou accounts for 9% of the total dose to adults and toddlers.

Calculated hazard quotients for total daily dose of selenium are $4.9x10^{-4}$ and $9.9\ x10^{-4}$ for adult and toddler receptors respectively and suggest that risks are low and likely to be negligible given the highly conservative nature of the exposure scenario and quantitative assessment.

Human health risks as a result of selenium exposure under the cumulative scenario are considered to be low and likely to be negligible. In addition, the project incremental risks are negligible because the marginal change in project risk relative to the baseline is <10%.

3.3.4 Probabilistic Assessment of Cumulative Inhalation Risks

The deterministic risk assessment presented above indicates that fugitive dust is a key uncontrolled release associated with project or cumulative activities. In consideration of this fact, and the fact that fugitive dust can disperse large distances, a probabilistic risk assessment was conducted to examine the stochastic nature of human health risks from fugitive dust as a result of cumulative mineral extraction activities.

Deterministic quantitative HHRA relies on assignment of point estimates for a variety of input exposure parameters to derive quantitative estimates of risk. Although these input parameter values may be selected with some knowledge of their variability or uncertainty, a deterministic risk assessment provides no information on the variability of the resulting risk estimates.

In comparison, probabilistic risk assessment uses probability distributions to characterize stochastic (natural) variability and uncertainty in key input parameters, and produces a probability distribution of the resulting risk estimates. This provides not only a description of the variability in the calculated risk estimates, but also a basis for selecting a risk estimate whose likelihood of exceedance can be quantified for decision-making purposes.

3.3.4.1 Simulation Methods

The GoldSim® modeling platform was used to develop a spatially explicit inhalation exposure model of the project area using Monte-Carlo simulation (Appendix D2). GoldSim is a graphically oriented, programming platform for modelling dynamic, probabilistic simulations and is particularly well suited to quantitatively address the inherent uncertainty which is present in real-world systems. GoldSim uses Monte Carlo Simulation to propagate uncertainties in model inputs into uncertainties in model outputs. The variability/uncertainty associated with the probability functions from which the data are drawn is propagated through the model by the multiple resampling/recalculation of the Monte Carlo Simulation. In this case, the Monte-Carlo simulation was conducted with 2000 iterations. This type of simulation explicitly and quantitatively addresses uncertainties.

3.3.4.2 Exposure Assessment

Dose and associated risks from inhalation of fugitive dust were modelled using the standard Health Canada (2010a) guidance for detailed quantitative risk assessment for those contaminants for which a specific inhalation toxicity effect has been documented (i.e., arsenic, beryllium, and chromium).

Review of the deterministic risk assessment identified four model elements related to fugitive dust for which sufficient data exists to assign probability distributions. The stochastic elements used in the probabilistic risk assessment, their assigned distributions, and the rationale for their use are provided in Table 3.19 below.

Table 3.19 Stochastic Elements, Probability Distributions and Rationale Supporting Assignment of Specific Distributions Considered in the Probabilistic Risk Assessment on Inhalation of Fugitive Arsenic, Beryllium and Chromium Particulate Matter

Parameter	Distribution	Rationale
PM_{10} During Blasting Conditions (μg/m^3)	The probability distribution for concentration of airborne particulates during blasting conditions was developed as a cumulative distribution specific for each geographic receptor location based on predicted hourly particulate concentrations for a period of 5 years. The dataset used to create the cumulative distribution consists of 43,848 predicted concentrations. Predicted concentration incorporate variability in meteorological conditions responsible for fugitive dust dispersion.	
PM_{10} During Non-Blasting Conditions (μg/m^3)	The probability distribution for concentration of airborne particulates during non-blasting conditions was developed as a cumulative distribution specific for each geographic receptor location based on predicted hourly particulate concentrations for a period of 5 years. The dataset used to create the cumulative distribution consists of 43,848 predicted concentrations. Predicted concentration incorporate variability in meteorological conditions responsible for fugitive dust dispersion.	
Inhalation Rate	Log-normal distribution with a mean (± Std.Dev.) of 16.6 (± 4.1) and 7.9 (± 2.2) for adult and toddler receptors respectively.	Inhalation rates and assumed log-normal distributions were sourced from the 2013 Canadian Exposure Factors Handbook (Richardson & SCL, 2013).
C_Particulate (Concentration of PCOC in PM_{10} (mg/kg))	Log-Normal Distribution Arsenic: Mean= 26.09 Std.Dev.=±18.51 Beryllium: Mean= 1.538 Std.Dev.= ± 0.895 Chromium: Mean= 23.32 Std.Dev.= ± 18.44	Rock chemistry from the drill core dataset (n=39) was examined to determine statistical distribution of the contaminants of potential concern. Log-normal distributions were confirmed using ProUCL version 5.0 statistical software to conduct Shapiro-Wilk tests to a confidence level of 95%. (i.e., p-value<0.05). All distributions truncated at a minimum value of 0 mg/kg.

Receptors Assessed

The probabilistic risk assessment of cumulative fugitive dust impacts to human health specifically addressed adult human receptors at specific geographic locations. The toddler was excluded from the probabilistic assessment on the basis that the inhalation effects of interest are primarily carcinogenic endpoints which are assessed based on a lifetime-amortized dose and not applicable to specific age classes. One exception to this is the respiratory risks posed by beryllium, which is based on a chronic reference concentration. The reference concentration is analogous to an oral reference dose in that it represents a tolerable daily exposure concentration to the human population (with the inclusion of sensitive sub-groups) over a lifetime of exposure. However, it is expressed as a concentration, not a dose and is not specific to a particular age group. Beryllium was therefore assessed for adult receptors only.

Receptor Locations and Exposure Duration

The framework of the detailed probabilistic risk assessment has allowed for a spatially explicit assessment of potential health risks. A total of 13 critical receptors, and 4 grid receptors were selected from the Air Quality assessment for inclusion in the probabilistic assessment of inhalation risks. These receptors were selected to represent either (i) the worst-case scenario (as is the case with the off-property maximum locations), (ii) areas of the RSA having a high potential for seasonal human occupation (e.g., traditional food harvesting/hunting locations), or (iii) areas of potential full time residence (towns, worker camp). The specific geographic locations assessed are described in Table 3.20 and presented on Figure 7 and Figure 9.

Inhalation exposures were assessed assuming full-time occupancy of the receptor locations (i.e., 52 weeks per year) assuming one blasting day per week. This is a highly conservative assumption; it is unlikely individuals would be occupying hunting/gathering locations for 52 weeks per year, and mine workers are likely to occupy the worker camp on a rotation schedule. Additionally, information presented in the air modelling chapter indicate a planned blasting schedule of one blast day per week during the summer months, but only one blast day per month in winter months.

Table 3.20 Critical and Grid Receptors Assessed as Part of the Probabilistic Inhalation Assessment

Receptor ID	Receptor Class	Name
147	Grid Receptor	Location of off-property maximum particulate concentration during blasting events
156	Grid Receptor	Location of off-property maximum particulate concentration during blasting events
59	Grid Receptor	Location of off-property maximum particulate concentration without blasting
387	Grid Receptor	Location of off-property maximum particulate concentration without blasting
5	Critical Receptor	Innu Camp
9	Critical Receptor	Young Naskapi Camp (Pinette Lake)
11	Critical Receptor	Young Naskapi Trailer tent (Triangle Lake)
13	Critical Receptor	Uashat people's camp 2
15	Critical Receptor	Young Naskapi Camp (Howells River)
19	Critical Receptor	Naskapi Cabin
31	Critical Receptor	Innu Cabin
34	Critical Receptor	Naskapi Cabin
36	Critical Receptor	Kawawachikamak (Town)
37	Critical Receptor	Lac John (Town)
38	Critical Receptor	Matimekush (Town)
39	Critical Receptor	Schefferville (Town)
40	Critical Receptor	Workers' Camp

3.3.4.3 Results

Results of the probabilistic risk assessment are presented in Table 3.21 below. Displayed results include the probability of exceeding the de minimis risk level (0.2 for threshold respiratory effects of beryllium and 1E-5 for non-threshold carcinogenic effects). In addition, the probabilistic model estimates the most likely risk estimate should the regulatory benchmarks be exceeded. This is quantified by calculating a conditional tail expectation (CTE), a measure of central tendency of all model realizations greater than a specific probability.

Table 3.21 Probability of Exceeding de minimis levels, and Conditional Tail Expectation for Threshold and Non-threshold Endpoints for Arsenic, Beryllium and Chromium Inhalation

Receptor ID	Beryllium Threshold Respiratory Risks		Lifetime Incremental Cancer Risk via Inhalation				
			Arsenic		Beryllium	Chromium	
	Prob. HQ>0.2	CTE	Prob. ILCR>1e-5	CTE	Prob. ILCR>1e-5	Prob. ILCR>1e-5	CTE
147	0.003	0.29	0.044	3.2E-5	0.000	0.053	4.1E-5
156	0.007	0.26	0.052	3.1E-5	0.000	0.060	4.1E-5
59	0.000	na	0.028	2.2E-5	0.000	0.044	3.1E-5
387	0.001	0.24	0.050	2.5E-5	0.000	0.067	3.5E-5
5	0.000	na	0.000	na	0.000	0.002	1.3E-5

Receptor ID	Beryllium Threshold Respiratory Risks		Lifetime Incremental Cancer Risk via Inhalation				
			Arsenic		Beryllium	Chromium	
	Prob. HQ>0.2	CTE	Prob. ILCR>1e-5	CTE	Prob. ILCR>1e-5	Prob. ILCR>1e-5	CTE
9	0.000	na	0.009	1.8E-5	0.000	0.021	1.9E-5
11	0.000	na	0.002	1.2E-5	0.000	0.005	1.5E-5
13	0.000	na	0.013	1.7E-5	0.000	0.024	2.2E-5
15	0.000	na	0.000	na	0.000	0.000	Na
19	0.000	na	0.000	na	0.000	0.000	Na
31	0.000	na	0.000	na	0.000	0.000	Na
34	0.000	na	0.000	na	0.000	0.005	1.06E-5
36	0.000	na	0.000	na	0.000	0.000	Na
37	0.000	na	0.000	na	0.000	0.000	Na
38	0.000	na	0.000	na	0.000	0.000	Na
39	0.000	na	0.000	na	0.000	0.000	Na
40	0.0003	0.21	0.041	2.5E-5	0.000	0.056	3.2E-5

Notes: The conditional tail expectation (CTE) is the expected value of the output given that it lies above a specified Cumulative Probability. That is, it represents the mean of the worst 100(1 - α)% of outcomes, where α is the specified Cumulative Probability. For example, in the case of arsenic ILCRs at receptor 147, the CTE is the average of all values that lie above the cumulative probability of 0.956.

For the case of potential beryllium respiratory effects, the tabulated results indicate the probability of a significant incremental human health risk(i.e., HQ > 0.2) from cumulative resource extraction activities in the LSA is very low (typically less than 0.1% (i.e., probability <0.001). This is clearly evident in the complementary cumulative distribution functions (CCDF) of predicted HQs for beryllium threshold effects at off property maximal locations (Figure 7). The extremely low probability of HQ > 0.2 is predicted despite the highly conservative assumption of 52 weeks per year exposure and provides confidence that the health risk is negligible. Additionally, in the theoretical scenario where maximum hourly PM_{10} concentrations persist for the chronic exposure duration (a condition not supported by meteorological data) the likely predicted HQ based on the CTE ranges between 0.21 and 0.29 (Table 3.21) a negligible value in light of conservative assumptions.

For the case of cancer risks, in the theoretical scenario where maximum hourly PM_{10} concentrations persist for the chronic exposure duration (a condition not supported by meteorological data) the probability of exceeding the de minimis level is very low (typically <1%). Grid receptor 147 was selected for display (Figure 8) because it is an off-property maximal location during blasting conditions and also has the highest calculated likely ILCRs (CTE). The risk to other receptor locations is inferred to be lower than for grid receptor 147. Figure 9 shows the probability of exceeding the de minimis level of 1E-5 for the three inhalation carcinogens assessed. This figure, clearly indicates that the probability of instantaneous climatic conditions yielding PM_{10}-derived doses equating to ILCRs>1E-5 is unlikely (~5% chance of this occurring). Furthermore, the CTEs provided in Table 3.21 indicate that should this rare condition occur; the likely predicted ILCRs remain between 1E-5 and 1E-4, and are not associated with lifetime exposure. Given the conservative assumptions surrounding exposure duration, these results are considered low and likely to be negligible.

A sensitivity analysis of the predicted ILCRs indicates that P_Air_Blast (the concentration of airborne PM_{10} during blasting conditions) as the greatest contributor to the variance of the predicted ILCRs (Importance measure = 0.376). The predicted hourly P_Air concentrations are modelled based on climate data. Therefore, weather conditions are the driving factor in determining an instantaneous dose.

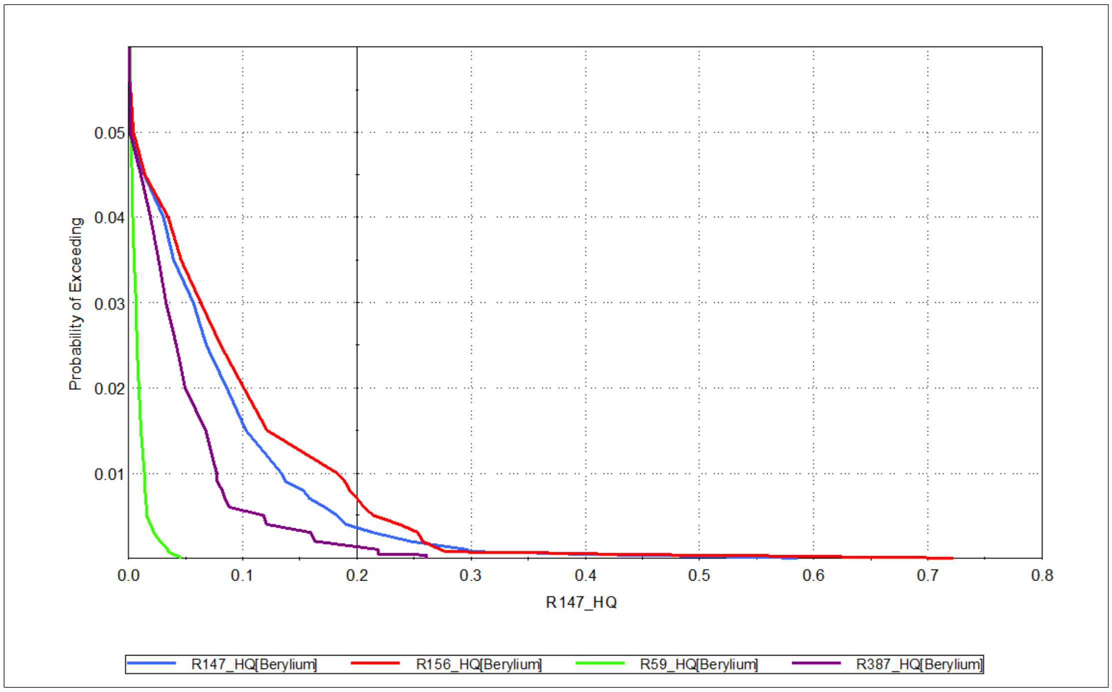


Figure 7 Complementary Cumulative Distribution Function (i.e., Probability of Exceeding a Decision Level) at Off-property Maximum Locations for Threshold Respiratory Effects as a Result of Exposure to Beryllium in PM_{10}, Assuming 52 Weeks Exposure

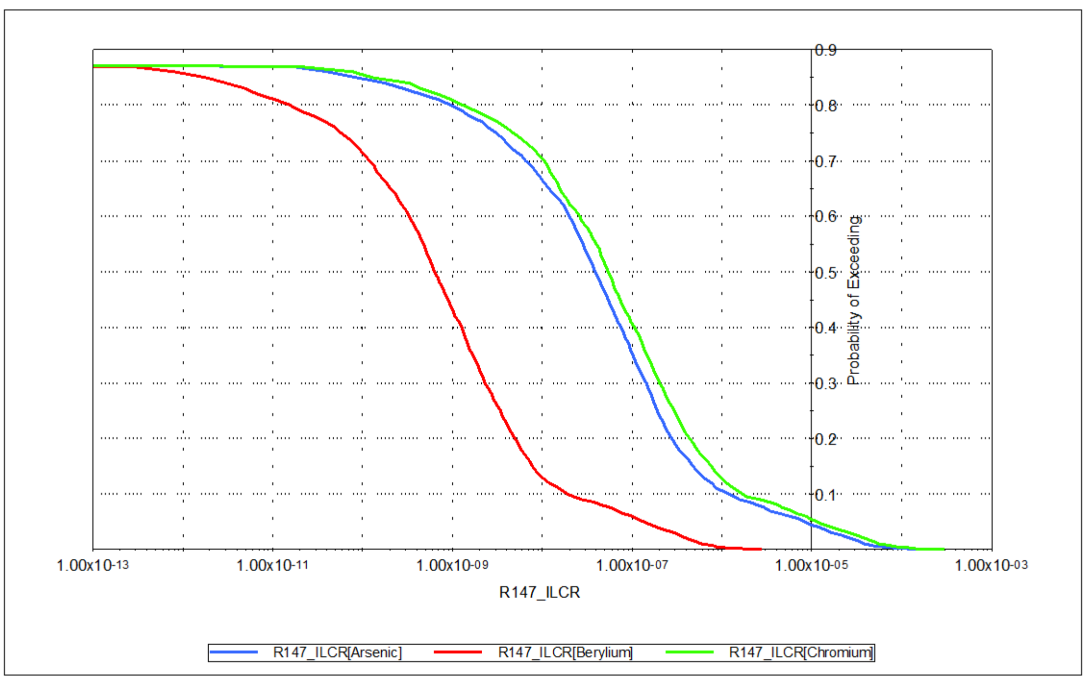


Figure 8 Complementary Cumulative Distribution Function (i.e., Probability of Exceeding a Decision Level) at Off-property Maximum Location 147 for Non-threshold Cancer Risks as a Result of Exposure to Arsenic, Beryllium, and Chromium in PM_{10}, Assuming 52 Weeks Exposure

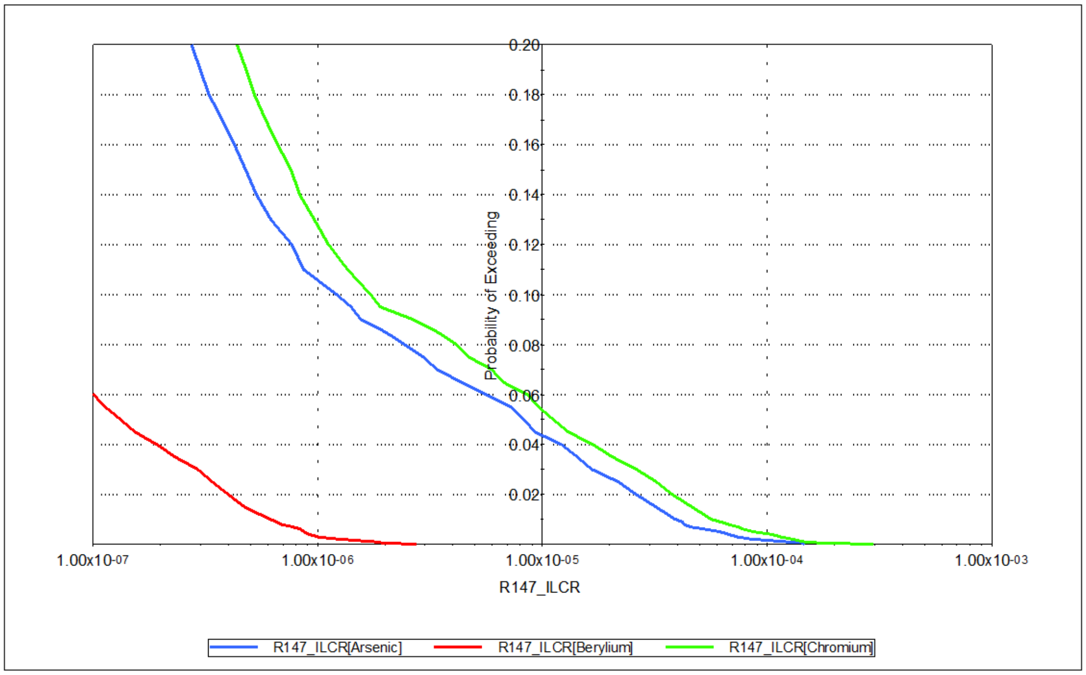


Figure 9 Detailed View of Complementary Cumulative Distribution Function Showing the Probability of Exceeding the de Minimis level at Off-property Maximum Location 147 for Non-threshold Cancer Risks as a Result of Exposure to Arsenic, Beryllium, and Chromium in PM_{10}, Assuming 52 Weeks Exposure

To summarise, the stochastic analysis of fugitive dust exposure and associate health risk indicates:

- Uncontrolled emissions of fugitive dust as a result of cumulative resource extraction activities in the LSA are predicted to have a low probability of resulting in adverse human health effects.
  - Probability threshold risk estimates exceeding the de minimis level are 0.7% for threshold respiratory effects of beryllium.
  - The probability of predicting an ILCR that exceeds 1E-5 ranges from 0 to a maximum of 6.7%
- The magnitude of the most likely predicted risk estimates in the event that meteorological conditions result in exceedance of the de minimis levels remain at levels which are considered to be low and likely to be negligible (i.e., 0.2<HQ<1 and 1E-5<ILCR<1E-4).
- The concentration of PM_{10} during blasting is the primary driver of the probabilistic risk estimates. Site specific monitoring of fugitive dust (PM_{10}) will have the greatest impact of reducing uncertainty around the inhalation risk estimates.

4. Uncertainty Analysis

Throughout the conduct of a quantitative human health risk assessment, the assessor is faced with choices required to calculate exposure estimates and characterize potential risks. These choices relate to assumed exposure point concentrations, exposure duration and frequency, intake rates for human receptors accessing the site, and the toxicity reference values that are used to characterize the risks associated with a certain level of exposure. Details of these uncertainties are presented in Appendix F. Key sources of uncertainty that influence the present risk assessment are discussed briefly below.

Exposure Assessment

The assessment of exposure carries inherent uncertainty that is generally offset by the application of conservative assumptions. The ingestion rates for soil, water and airborne particulates were based on conservative behaviours and human characteristics provided by Health Canada (2010). Ingestion of country food was assumed to be equal to a reasonable upper bound based on literature and project specific data. Highly conservative assumptions concerning site use duration and frequency were applied. No adjustments were made for the bioavailability of PCOCs for uptake through the gastrointestinal tract for environmental media. The above assumptions tend to overestimate exposure, and therefore err on the side of conservatism.

Concentration of Airborne Particulates

The assessment assumes visitors to the LSA are exposed to the 90^{th} percentile of maximum predicted 24-hour PM_{10} concentrations blended between blasting and non-blasting conditions. It is assumed that blasting will occur one day per week throughout the year. The use of the 90^{th} percentile equates to placing a human receptor in very close proximity to the site boundary for a period of 16 weeks per year. Additionally, information in the EIS suggests that reduced frequency of blasting will occur during winter months. All of the above assumptions have the potential to result in an overestimation of inhalation exposure, and therefore err on the side of conservatism.

AECOM have attempted to quantify the uncertainty and variation in expected risk estimates through the use of a probabilistic risk assessment for exposure to airborne particulates under the cumulative activity scenario. The concentration of PM_{10} is the primary driver in dose and risk estimates as a result of inhalation of fugitive dust. The predicted PM_{10} concentrations are based on retrospective weather data, indicating that meteorological conditions at the time of blast are the primary controlling factor for instantaneous dose via particulate inhalation.

Dataset Suitability

Analytical uncertainty is present in every human health risk assessment. The chances of false positive or false negative results are greatest when concentrations in environmental media are close to reportable detection limits. Generally, the overall laboratory dataset is considered to be valid for soil characterization. The datasets for surface water, and particularly plant and wildlife tissues contain a high proportion of values below analytical limits of detection. In these instances, food web models were used to estimate tissue concentrations. This approach, while preferable to arbitrary substitution, carries with it its own uncertainties.

Food Chain Modelling

Directly measured concentrations of contaminants of potential concern were not available for use as exposure point concentrations for all game species considered likely to be consumed under baseline conditions. As well, human health risk estimates in the future project activity and cumulative activity scenarios rely on prediction of tissue quality through food web modeling. Concentrations in tissues were modelled using standard intake equations and receptor characteristics, as well as literature derived transfer factors. The food chain models introduce uncertainty in the risk assessment. The influence of the food web models on the total dose of the human receptors is large. The uncertainty associated with the food web models is compounded by the uncertainty associated with contaminant transfer factors used to estimate the proportion of ingested contaminant that is absorbed and ultimately assimilated into the animal's tissues. This is potentially the largest source of uncertainty to the risk assessment for the predicted future scenarios.

5. Conclusions

Conclusions of the HHRA are drawn based on providing sufficient evidence to answer the key questions developed at the outset of the risk assessment (Section 2.4). Based on the information provided in additional documentation in the EIS (refer to section 1.2) and the quantitative assessment contained herein, the following conclusions can be made.

HH1: What effect will project releases have on water and subsequently human health?

- Under both the Project Operations Scenario and the Cumulative Operations Scenario there is no predicted change in water quality because the mine operation is committed to minimal water discharges with water quality that complies with applicable guidelines. Therefore, there is no anticipated effect on surface water quality or associated health risk from water consumption during traditional land use activities.

HH2: What effect will project releases have on air quality and subsequently human health?

- Under both the Project Operations Scenario and the Cumulative Operations Scenario uncontrolled releases of airborne particulates extending past the property line are predicted to exceed air quality assessment criteria (regulatory guidelines) for short durations, with very limited frequency (<1% of time), and generally only at locations in close proximity to the boundary of the project footprint. The effect on air quality is predicted to yield negligible health risks to aboriginal peoples though both the direct inhalation pathway of dust and indirectly through traditional land uses in the project area.

HH3: What effect will project releases have on soil quality and subsequently human health?

- Under both the Project Operations Scenario and the Cumulative Operations Scenario the predicted effect of releases from the project are likely to yield negligible, or low and likely to be negligible health risk to aboriginal people from incidental soil ingestion during traditional land use activities in the project area. This is based on modelled uptake of soil from the project area influenced by air deposition.

HH4: What effect will project releases have on food quality and subsequently human health?

- Under both the Project Operations Scenario and the Cumulative Operations Scenario, the predicted effect on food quality is likely to yield negligible, or low and likely to be negligible health risk to aboriginal people that consume a large component of traditional country food. This is based on modelled uptake of substances from air deposition into food items such as berries, medicinal tea, and small game. No changes are anticipated in fish or caribou quality, or associated health risk from their consumption, due to (i) minimal water discharges that are managed to comply with water standards, and (ii) a minimal interaction time and diet derived from the mine or surrounding area by caribou.

HH5: What will be the collective effect of changes to water, air, soil and food on human health?

- Under both the Project Operations Scenario and the Cumulative Operations Scenario, the collective effect of predicted changes to water, air, soil, and food are likely to yield negligible, or low and likely to be negligible health risk to aboriginal people visiting the site for traditional land use. This is based on a multi-media exposure assessment for various key substances of interest and the summation of the associated health risks.

Applicability and Inference of Conclusions

- Construction Phase of Project:
  Based on the industrial activities, the evaluated exposure scenarios, and the level of conservatism employed, the predicted health risks summarized above are expected to also apply to the construction phase of the project.
- Decommissioned Project (far future):
  Based on the reduced far future activities following mine decommissioning, evaluated exposure scenarios, and level of conservatism employed, the predicted health risks summarized above are expected to also apply to the far future decommissioned phase of the project.

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Appendix A

Screening for Substances of Interest

Appendix A
Screening of Substances of Interest to Human Health Risk Assessment, Howse Property Project

This document provides the objectives and outcome of a qualitative screening of Substances of Interest (SOI) that may be nominated for further study and input into the Human Health Risk Assessment for Tata Steel Minerals Canada Limited proposed Howse Property Project.

1. Objectives

The specific objective of the screening is to create a broad and inclusive framework for the identification of substances of interest (SOI), defined as substances that meet one of two criteria as follows:

- Substances present in environmental media under baseline conditions at concentrations that are unusual (locally elevated), or;
- Substances with the potential to be present in any compartment of the mine process or lifecycle that may have the ability to alter the current baseline conditions of environmental media by a significant degree.

2. Screening Framework

A broad screening framework (depicted in Figure 1 below) was used to identify substances of interest. The screening framework consists of three broad tracks as follows:

1. Substances whose maximum measured concentration in site media exceed applicable guidelines for metals (Canadian Counsellors of the Ministry of the Environment (CCME), Health Canada Guidelines, or Quebec) and hydrocarbons (CCME and The Atlantic Partners in Risk-Based Corrective Action (RBCA) will be retained as substances of interest. Substances which are in compliance with the aforementioned EQGs will not be retained as substances of interest.
2. A lack of federal or provincial EQGs does not preclude risks to human health. As such, substances for which there are no EQGs will be screened based on site specific background concentrations. Substances whose maximum measured concentration in site media exceed site specific background concentrations will be retained as substances of interest. Substances which are in compliance with site specific background concentrations will not be retained as substances of interest.
3. If no suitable EQG or background data is available, further qualitative assessment based on professional judgement and the precautionary principle is required. Substances will be retained as a SOI if appropriate regulatory bodies (such as Health Canada, US EPA, World Health Organization or others) indicate toxicity, and suitable toxicological data exists upon which to base an assessment. If such information does not exist, and there is concern over magnitude of impact or potential for toxicity additional research may be required.

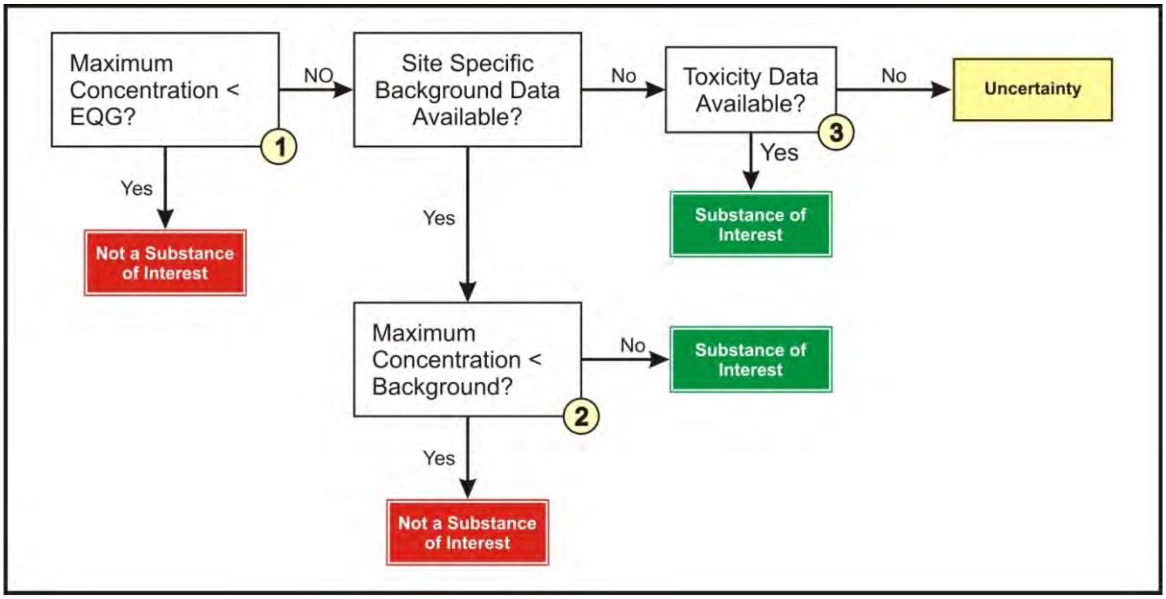

Figure 1 Screening Framework for Identification of Substances of Interest

In order to satisfy the specific objectives of the screening, as stated above, a two phased approach was necessary.

1. Maximum concentrations of elements and hydrocarbons measured in site matrices including soil and surface water were examined. Examination of these baseline matrices will inform the first component of the objective, to identify substances which are at unusual concentration under baseline conditions.
   a. Concentrations of metals measured in soil samples were compared to applicable CCME and Quebec MDDEFP soil quality guidelines.
   b. Concentrations of metals measured in surface water samples were compared to applicable Health Canada and Quebec Drinking Water Guidelines.
2. In order to identify substances which have a potential to alter baseline conditions during the lifecycle of the proposed development, the raw materials that will be introduced to the process will be considered. Concentrations of metals measured in samples of ore, waste rock, and overburden from the Howse property were compared to applicable CCME and Quebec MDDEFP soil quality guidelines. Substances with concentration in ore or waste rock in exceedance of the soil quality guidelines are considered to have the potential to impact baseline conditions for environmental media during the lifecycle of the mine development; and will be retained as substances of interest.
3. The air quality substance of interest screening was conducted by comparing air quality samples for metals and VOCs to air quality standards from Newfoundland/Labrador and Quebec.

3. Substances of Interest

3.1 Soil

The screening framework described above identified 3 substances of interest based on unusual concentrations in the baseline soil dataset. In addition, iron has been nominated due to local enrichment that has made this area the focus of iron mine developments. Contaminants of potential concern based on the soil data therefore include:

- Arsenic
- Manganese
- Mercury
- Iron

3.2 Surface Water

No substances of interest were identified[1] based on the concentrations reported in the baseline surface water data for the study area.

3.3 Ore, Waste Rock and Overburden

In addition, the concentrations of metals in samples of ore and waste rock compared to applicable soil standards identified 10 substances which have the potential to alter baseline conditions, resulting in 7 additional nominated substances of interest. These are:

- Barium
- Lead
- Beryllium
- Molybdenum
- Chromium
- Selenium

It's worth noting that iron was not nominated as a SOI during the above referenced screening despite its natural enrichment in the local area. This is due to its low toxicity, it's an essential trace element for biological activity, and as a consequence it has a correspondingly high soil standard. There are no CCME or Quebec MDDEFP soil quality guidelines for iron; however, iron has been included due to local enrichment that has made this area the focus of iron mine developments. Tabulated maximum concentrations of metals compared to applicable environmental quality guidelines are presented in Table 1 to Table 3.

At the request of CEAA an air quality screening was conducted to applicable air standards which identified 5 additional substances of interest which have the potential to alter baseline conditions. These are:

- Acrolein
- Benzene
- Formaldehyde
- Acetaldehyde
- 1,3-Butadiene

However, the based on the results of the air analysis (Air Dispersion Modeling Report; Appendix 3) these SOI's were compliant with applicable standards and therefore were not nominated for quantitative evaluation in the HHRA.

[1] *Uranium in Pinette Lake was reported on one occasion at 24 µg/L, however all other values reported from Pinette Lake were below limits of detection (<1.0 µg/L). This is an outlier value, and was not considered relevant. Uranium has been stricken as a substance of interest based on surface water baseline data.*

4. Closure

AECOMs screening has identified a total of 16 metals as substances of interest. The screening is designed to provide a broad assessment of substances which warrant more careful study or consideration as the large project unfolds. A substances designation as being "of interest" in no way identifies the probability or magnitude of exposure to any environmental media or potential receptor. These determinations will be made later as part of the formal Human Health Risk Assessment (HHRA).

Table 1. Maximum Concentrations of Metals Measured in Soil from the Howse Property Project Area, as Compared to Applicable Environmental Quality Guidelines

Contaminant	Max. Concentration (mg/kg)	Quebec Soil Standards (mg/kg)			CCME Soil Quality Guidelines (mg/kg)	
		Level A	Level B	Level C	PL	IL
Aluminum	9800	-	-	-	-	-
Antimony	0.5	-	-	-	20	40
Arsenic	17	10	30	50	12	12
Barium	150	245	500	2,000	500	2,000
Beryllium	0.6	-	-	-	4	8
Boron	<2	-	-	-	-	-
Cadmium	0.2	1.5	5	20	10	22
Calcium	<20	-	-	-	-	-
Chromium	22	80	250	800	64	87
Cobalt	9	25	50	300	50	300
Copper	13	100	100	500	63	91
Iron	62000	-	-	-	-	-
Lead	17	30	500	1,000	140	600
Magnesium	2800	-	-	-	-	-
Manganese	1900	1000	1,000	2,200	-	-
Mercury	0.24	0.2	2	10	6.6	50
Molybdenum	3.1	6	10	40	10	40
Nickel	13	100	100	500	50	50
Phosphorus	620					
Potassium	290	-	-	-	-	-
Selenium	0.8	1	3	10	1	3
Silicon	<0.5	-	-	-	-	-
Silver	1	2	20	40	20	40
Sodium	40	-	-	-	-	-
Thallium	<0.1				1	1
Titanium	240	-	-	-	-	-
Thorium	<4					
Tin	<1	5	50	300	50	300
Uranium	NA				23	300
Vanadium	52	-	-	-	130	130
Zinc	47	230	500	1,500	200[a]	360

Quebec Soil Standards: A = Residential/Commercial background levels for inorganic parameters in the Labrador Trough Region. B= Maximum acceptable limit residential, recreational land use. C=Maximum acceptable limit for Non-residential Commercial or Industrial.

CCME Soil Quality Guidelines; PL= = Residential/Park Land, IL = Industrial Lands

a – PL guideline of 200 mg/kg is based on the 1991 interim soil quality criterion. Default value of 500 mg/kg was based on eco contact.

Table 2. Maximum Concentrations of Metals Measured in Surface Water from the Howse Property Project Area, as Compared to Applicable Drinking Water Guidelines*

	Max. Concentration (µg/L)	*MDDELCC (ug/L)	**Health Canada (ug/L)
Aluminum	358	NG	NG
Antimony		6	6
Arsenic	<1	10	10
Barium		1000	1000
Bismuth		NG	NG
Boron		5000	5000
Cadmium	0.152	5	5
Chromium		50	50
Cobalt		NG	NG
Copper	9	1000	NG
Iron	1640	NG	NG
Lead	2	10	10
Lithium		NG	NG
Manganese	135	NG	NG
Mercury	0.04	1	1
Molybdenum	1	NG	NG
Nickel	3.5	NG	NG
Selenium	2	10	50
Silicon		NG	NG
Silver		NG	NG
Sodium	1490	NG	NG
Strontium		NG	NG
Thallium		NG	NG
Titanium		NG	NG
Tin		NG	NG
Uranium	<20	20	20
Vanadium		NG	NG
Zinc	25	NG	NG
Radium (RA 226)	0.018	NG	NG

** Quebec Drinking Water Guidelines - Ministre du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (MDDELCC). Quebec Drinking Water Guidelines exceeded are highlighted in Bold.*

*** Health Canada Drinking Water Guidelines (Maximum Allowable Concentration) exceeded are highlighted with grey shading.*

**** Uranium in Pinette Lake was reported on one occasion at 24 µg/L, however all other values reported from Pinette Lake were below limits of detection (<1.0 µg/L). This is n outlier value, and was not considered relevant. Uranium has been stricken as a substance of interest based on surface water baseline data.*

Table 3. Maximum Concentrations of Metals Measured in Potentially Minable Materials (Ore and Waste Rock), as Compared to Applicable Soil Quality Guidelines*

Substance	Max. Concentration	*Quebec Criteria (Labrador Trough)	**CCME Soil Quality Guideline (PL)
Antimony	1		20
Arsenic	108	10	12
Barium	586	245	500
Berylium	4.6		4
Cadmium	0.4	1.5	10
Cerium	209		
Cesium	3.75		
Chromium	171	80	64
Cobalt	18.9	25	50
Copper	33.1	100	63
Iron (%)	49.5		
Lead	287	30	140
Manganese	3880	1000	
Mercury	100	0.2	6.6
Molybdenum	9.65	6	10
Nickel	39.4	100	50
Selenium	1.3	1	1
Silver	1.34***	0.8	20
Strontium	1600		
Thallium	0.74		1
Tin	2	5	50
Uranium	3.9		23
Vanadium	106		130
Zinc	103	230	200

** Quebec criteria exceedances are highlighted with bold.*

*** CCME Guidelines exceeded are highlighted with grey shading.*

**** Single Outlier Data Point among non detect data. Value not used.*

a – PL guideline of 200 mg/kg is based on the 1991 interim soil quality criterion. Default value of 500 mg/kg was based on eco contact.

Appendix B

Exposure Parameters

- B1: Selection of Dietary Ingestion Rates
- B2: Literature Derived Caribou Tissue Concentrations
- B3: Deterministic Air Particulates (PM_{10}) Estimates

B1. Selection of Dietary Ingestion Rates

Appendix B1
Selection of Country Food Ingestion Rates

Adult Country Food Ingestion Rates

Collection and consumption of traditional country foods is an important cultural and social component of the lives of northern peoples. In addition, country food ingestion can be an important driver in the exposure to environmental contaminants. In consideration of this, AECOM have assessed risks to human health using literature derived country food ingestion rates for northern populations, in conjunction with information gathered through a limited dietary intake survey conducted for the Howse Project (Table 1).

Country food ingestion rates obtained from literature sources were compiled along with estimates made from the dietary intake study. The Naskapi and other northern peoples rely heavily on caribou as a preferred game species. AECOM have elected to ascribe 80% of the game ingestion rate to caribou, and the remaining 20% to small mammals assumed to be collected from the LSA. For adult receptors, the 90th percentile ingestion rate was selected as a reasonable approximation of country food ingestion rates for fish, game and birds.

The available data for berries and Labrador tea was considered insufficient for the calculation of a meaningful 90th percentile; therefore the maximum reported value was used. It is assumed that berries are consumed for 4 months per year. Ingestion of Labrador tea has been assumed to be 0.25 L/day (this is equivalent to ingesting, on average, one cup of tea daily) for adult receptors. It is assumed that 2.91 grams of dry vegetation is required per cup of tea.

Estimation of Country Food Ingestion by Toddlers

The ingestion rates for toddlers of fish, game and birds is assumed to be 50% of the adult ingestion rates as determined from Table 1. These values are in contrast to the standard toddler ingestion rate of wild game (0.085 kg/day) as recommended by health Canada (HC, 2010). The rationale for this adjustment is as follows:

- Per capita ingestion rates were sourced from the U.S. EPA analysis of 2003−2006 NHANES dataset, as reported in Table 11-3 of the US EAP Exposure Factors Handbook (EPA, 2011).
- Based on mean per capita ingestion (g/kg bw/day) of meat, dairy and total fat in edible portions equivalent age groups to health Canada's toddler and adult receptors were calculated to ingest 66 g/day and 134 g/day respectively. Assuming mean per capita ingestion rates, toddlers are seen to consume 49% of the total meat intake relative to an adult receptor.
- Based on the 90th percentile per capita ingestion (g/kg bw/day) of meat, dairy and total fat in edible portions toddler and adult receptors were calculated to ingest 128 and 240 g/day respectively, with toddlers consuming 53% of the total meat intake relative to an adult receptor.

The ingestion rate for berries was scaled in a similar fashion. Per capita ingestion rates of fruit from the NHANES dataset indicate that toddlers consume fruit at a rate that is 1.7 times that of adults. The berry ingestion rate from Table 1 has been scaled accordingly, and converted to dry weight assuming moisture content of 81%. It is assumed that berries are consumed for 4 months per year.

AECOM have assumed that toddlers ingest 1/3 cup of Labrador tea daily.

Table 1. Adult Traditional Food Ingestion Rates (kg/day) and Summary Statistics Used in the Quantitative Human Health Risk Assessment

Source	Community	Fish	Game	Birds	Berries	Vegetation
Health Canada, 2010			0.27			
Richardson, 1997		0.220				
Health Canada, 2007		0.040				
Dewailly et al., 2003	Southern Québecois	0.013				
	James Bay Cree	0.060				
	Nunavik Inuit	0.131				
Godin et al., 2003	Montreal Angers	0.041				
	James Bay Anglers	0.087				
Blanchet & Rochette, 2008	Nunavik Inuit	0.055	0.053	0.028	0.014	
Batal et al., 2005	Denendeh	0.094	0.200	0.019	0.011	0.011
	Yukon	0.093	0.193	0.008	0.011	0.011
Lawn & Harvey, 2004	Kangiqsujuaq, 2002	0.053	0.005	0.054		
Lawn & Harvey, 2003	Kugaaruk,	0.990	0.041			
Lawn & Harvey, 2001	Repulse Bay 1992	0.015	0.188			
	Repulse Bay 1997	0.037	0.097			
	Pond Inlet 1992	0.024	0.241			
	Pond Inlet 1993	0.022	0.202			
	Pond Inlet 1997	0.040	0.171	0.015		
	Repulse Bay 1992	0.031	0.160	0.001		
	Repulse Bay 1997	0.043	0.096	0.000		
	Pond Inlet 1992	0.044	0.246	0.004		
	Pond Inlet 1993	0.017	0.142	0.001		
	Pond Inlet 1997	0.037	0.154	0.001		
Duhaime et al., 2002	Nunavik Inuit	0.038	0.055	0.040	0.017	
Tata Steel	LSA	0.049 [a]	0.02 [b]	0.032 [c]	0.043 [d]	
	Mean	0.095	0.141	0.017	0.019	0.011
	Median	0.042	0.157	0.011	0.014	0.011
	Min.	0.013	0.005	0.000	0.011	0.011
	Max.	0.990	0.270	0.054	**0.043**	**0.011**
	90th %ile	**0.120**	**0.243**	**0.039**	na	na

Notes:

a. . Ingestion rate (kg/day) of game fowl calculated from maximum reported ingestion rate from baseline country food survey results. Country food survey results reported as meals per month. Ingestion rate converted from meals per month to kg/day assuming 150 g/serving from Health Canada (2007) Human Health Risk Assessment of Mercury in Fish and Health Benefits of Fish Consumption. Available at: http://www.hc-sc.gc.ca/fn-an/pubs/mercur/merc_fish_poisson-eng.php#appd

b. Ingestion rate (kg/day) of game fowl calculated from maximum reported ingestion rate from baseline country food survey results. Country food survey results reported as meals per month. Conversion to kg/day assumed 0.163 kg/serving based on EPA (2011) Beef Steak Portion Size (average for men >20 years of age) from Table 11-21.

c. Ingestion rate (kg/day) of game fowl calculated from maximum reported ingestion rate from baseline country food survey results. Country food survey results reported as meals per month. Conversion to kg/day assumed 0.103 kg/serving based on EPA (2011) Chicken and Turkey Portion Size (average for men >20 years of age) from Table 11-21.

d Ingestion rate converted from cups per months (based on maximum reported consumption in the Howse - Baseline Country Food Survey) to kg/day assuming 0.1 kg berry per cup.

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B2. Literature Derived Caribou Tissue Concentrations

Appendix B2
Literature Derived Caribou Tissue Concentrations

Two Aboriginal communities, the Naskapi and the Innu, use the land in the vicinity of the Howse Property for hunting and gathering and both groups place great importance on the health of the caribou herds that visit this area. Based on the analysis conducted for the HHRA caribou tissue concentrations are not likely to be influenced to a large degree by Howse Project Property. Table 1 summarizes findings of the literature review conducted for tissue concentrations of metals in North American caribou herds. The HHRA assumed the majority of the diet to be sourced from caribou muscle tissue and the consumption of organs such as kidneys and liver to represent a small percentage of the diet. Therefore the caribou concentrations brought forward into the HHRA were based on the maximum muscle tissue concentrations of metals found in Table 1.

Table 1. Literature Based Metals Concentrations in Caribou Tissue

Source	Location	Tissue	Pb	Hg	Se	As	Fe
Elkin and Bethke 1995	Nunavut (Bathurst caribou herd)	Kidneys	0.032 (0.01)[a]	0.52 (0.04)[a]			
	Nunavut (Arviat caribou herd)	Kidneys	0.029 (0.01)[a]	2.93 (0.21)[a]			
	Nunavut (Southampton Island caribou herd)	Kidneys	0.0957 (0.02)[a]	2.22 (0.13)[a]			
	Nunavut (Cape Dorset caribou herd)	Kidneys	0.1218 (0.02)[a]	1.25 (0.05)[a]			
	Nunavut (Lake Harbour caribou herd)	Kidneys	0.1363 (0.03)[a]	2.56 (0.25)[a]			
Larter and Nagy 2000	Northwest Territories (Banks Island Peary caribou)	Kidneys	0.2842 (0.18)[a]	1.5747 (0.09)[a]			
	Northwest Territories (Bluenose caribou herd)	Kidneys	0.0609 (0)[a]	3.0305 (0.25)[a]			
Robillard et al. 2002	Northern Quebec (Leaf River Region)	Muscle	0.033 (0.16)[b]	**0.027** (0.01)[b]			
		Kidneys	0.28 (0.09)[b]	1.39 (0.91)[b]			
		Liver	0.89 (0.57)[b]	0.7 (0.41)[b]			
	Northern Quebec (George River - Torngat Mountains Region)	Muscle	0.014 (0.02)[b]	0.019 (0.01)[b]			
		Kidneys	0.2 (0.05)[b]	0.56 (0.19)[b]			
		Liver	0.89 (0.53)[b]	0.38 (0.15)[b]			
O-Hare et al. 2003	Northern Alaska (Point Hope and Cape Thompson)	Liver	0.32 (0.2)[b]			0.07 (0.09)[b]	243.34 (246.04)[b]
	Northern Alaska (Point Hope and Cape Thompson)	Kidneys	0.76 (4.55)[b]			0.12 (0.19)[b]	51.77 (95.87)[b]
	Northern Alaska (Point Hope and Cape Thompson)	Muscle	**0.14** (0.14)[b]			**0.06** (0.06)[b]	**27.55** (62.81)[b]
Aastrup et al. 2000	Greenland (Kangerlussuaq, Akia)	Muscle	0.0045 (0.001)[b]	0.0135 (0.01)[b]	**0.0935** (0.068)[b]		
	Greenland (Kangerlussuaq, Akia)	Liver	0.4255 (0.39)[b]	0.1225 (0.1)[b]	0.21825 (0.16)[b]		
Pollock et al. 2009	Labrador (George River caribou herd)	Kidneys	0.09 (0.06-0.13)[c]	0.66 (0.58-0.75)[c]	1.2 (0.9-1.5)[c]		

Source	Location	Tissue	Pb	Hg	Se	As	Fe
Schuster et al. 2011	Old Crow, Yukon (Porcupine caribou herd)	Muscle		0.003 (0.002)[b]			
		Kidneys		0.36 (0.12)[b]			
		Liver		0.12 (0.07)[b]			

Notes:

a = Standard Error

b= Standard Deviation

c = 95% Confidence Interval

References

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B3. Deterministic Air Particulates (PM_{10}) Estimates

Appendix B3
Deterministic Air Particulates (PM_{10}) Estimates

The predicted intake of contaminants via the halation of fugitive particulates in HHRA is calculated using the standard human exposure equation:

$$Dose_{Particulates} = \frac{C_{particulate} \times P_{Air} \times RAF_{Inh.} \times ET}{BW}$$

which incorporates a measure of the concertation of contaminants (expressed as mg/kg) associated with the particulates of interest ($C_{particulate}$); the concentration of particulate matter (in this case PM10 expressed as kg/m^3) in a volume of air (P_{Air}); the relative absorption factor of inhaled contaminants ($RAF_{Inh.}$), an exposure term (ET), and body weight (BW in kg).

The air particulate concentrations (P_{Air}) selected for the deterministic HHRA are single point estimates. In order to calculate a reasonable upper bound for particulate concentrations within the LSA the predicted maximum 24 hour PM10 concentrations for critical air modeling receptors and off property maximum grid receptors were compiled from the air quality technical report for blast and no-blast conditions under both project and cumulative scenarios.

The deterministic PM10 concentration for project and cumulative scenarios was calculated independently as the blended concentration using the 90^{th} percentile PM_{10} concentration for blast and no-blast conditions assuming blasting occurs one day per week (1/7 = 0.14) as follows:

$$P_{Air} = \left((90th\ \%ile\ PM10_{Blast} \times (0.14)) + (90th\ \%ile\ \mathrm{PM}_{10\,\mathrm{No\ Blast}} \times (0.86)\ )\right)$$

Where:

PAir	=	Reasonable upper bound point estimate of PM10 concentration in air (kg/m^3)
90th %ile $PM_{10\ (Blast)}$	=	Concentration of particulate matter less than 10 µm, in the Blast scenario (kg/m^3)
90th %ile $PM_{10\ (No\ Blast)}$	=	Concentration of Particulate matter less than 10 µm, in the No Blast scenario (kg/m^3)

Cumulative distributions and 90^{th} percentile PM10 concentrations for the blast and no-blast conditions under the project and cumulative scenarios are presented in Figures 1 through 2.

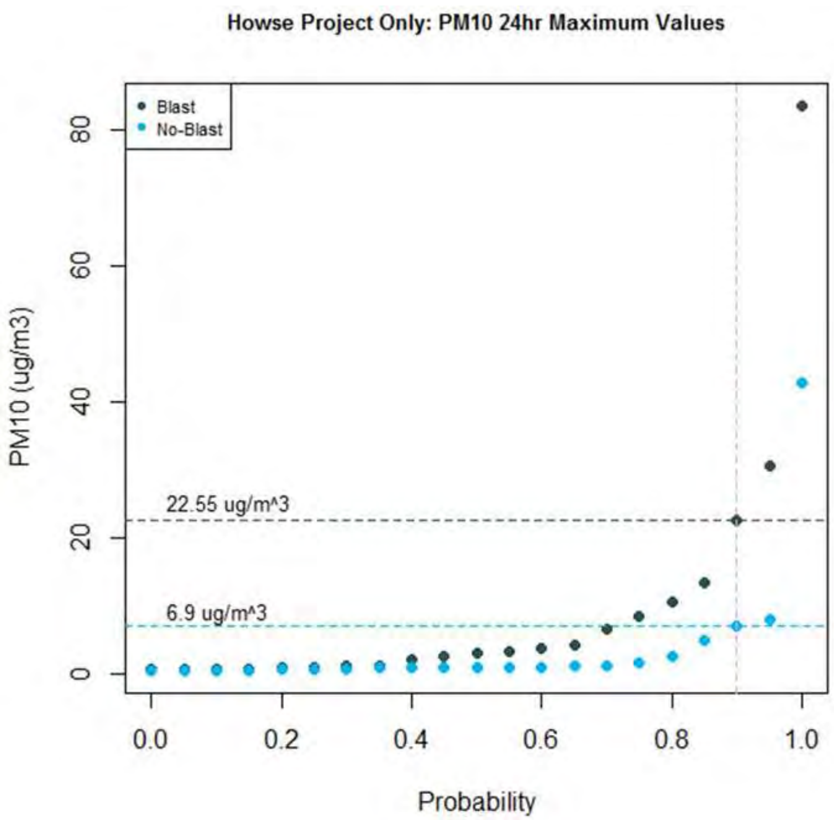

Figure 1. Probability Distribution for PM_{10} under Blast and No-blast Conditions in the Project Scenario

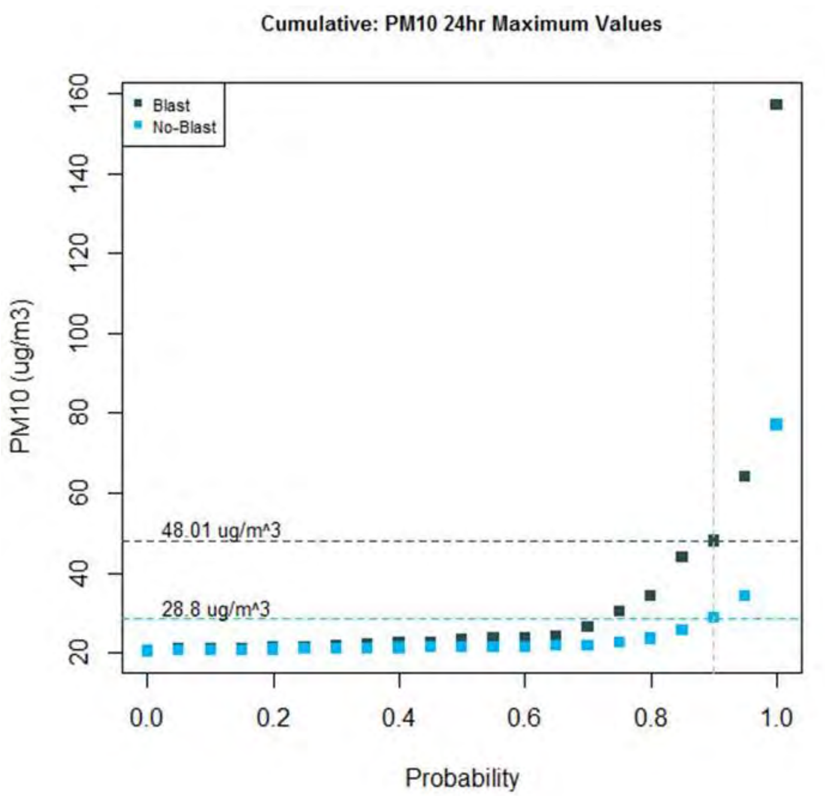

Figure 2. Probability Distribution for PM_{10} under Blast and No-blast Conditions in the Cumulative Scenario

Appendix C

Toxicity Reference Value Summary

Appendix C
Toxicity Reference Value Summary

1. Human Toxicity Reference Values

In accordance CEAA, human health toxicological reference values (TRVs) have been selected primarily from Health Canada (2010). However, in the absence of Health Canada numbers TRVs will be selected from US EPA IRIS. The following brief discussion of the carcinogenic classifications and threshold toxicological effects is required to provide sufficient rationale for the selection of TRVs and method of assessing risk characterization. Individual metal toxicants (Section 1.1) and the inhalation risks from volatile organic carbons (Section 1.2) are discussed separately.

1.1 Metals

Arsenic

Arsenic is a known human carcinogen by both the inhalation and oral exposure routes (CCME 2001, ATSDR 2007a). Increased rates of lung cancer, respiratory irritation, nausea, skin effects, and neurological effects have been reported following inhalation exposure (ATSDR 2007a). Increased lung cancer mortality was observed in multiple human populations (primarily smelter workers) exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. The following non-carcinogenic TRV's were identified for this study:

- Health Canada (2010b) provides oral and inhalation cancer slope factors for arsenic of **1.80** and **27 (per (mg/kg/day))** respectively.
- Health Canada does not provide a non-carcinogenic TRV whereas the US EPA recognizes arsenic as a threshold non-carcinogenic contaminant and recommends an oral RfD of **0.0003 (mg/kg/day).**

Health Canada does provide the following carcinogenic TRV's:

- Provides and oral slope factor of **1.8 mg/kg bw/day.**
- Provides an inhalation slope factor of **27 mg/kg bw/day.**
- Provides an inhalation unit risk of **6.4 mg/m^3.**

The RfD is based primarily on epidemiological studies (applicable to chronic, sub-chronic, and acute exposures) of a Taiwanese population conducted by Tseng 1977 and Tseng et al. 1968, whose drinking water contained elevated concentration of arsenic (0.4-0.6 ppm). The critical effects studied included hyperkeratosis, hyperpigmentation and possible vascular complications. The general symptoms of chronic arsenic poisoning were reported by Hindmarsh and McCurdy 1986 as are weakness, general debility and lassitude, loss of appetite and energy, loss of hair, hoarseness of the voice, loss of weight, and mental abnormalities. Following long-term exposures the most common effects observed include skin, neurological, and vascular disorders.

Following absorption arsenic is initially accumulated in the liver, kidney, lung, spleen, aorta, and skin. With the exception of the skin, clearance from these organs is rapid (ASTDR 2007). The primary target organs for oral and inhalation exposures are the nervous system, skin, cardiovascular system, blood, liver, G.I. System, respiratory system. Typical disorders caused by arsenic exposure include: hyperpigmentation, hyperkeratosis), neurotoxicity, to the central and peripheral nervous system, cardiovascular system disorders, blood disorders such as anemia, leucopenia, liver swelling, gastroenteritis, respiratory system disorders such as rhinitis, laryngitis, tracheobronchitis, pulmonary insufficiency, and nasal septum perforation.

The complex chemistry of arsenic has made it difficult to characterize from a toxicological perspective. Casarett and Doull's (1991) noted no specific interaction between arsenic and other heavy metals. Chronic exposure to arsenic results in neurotoxicity, to the central and peripheral nervous system. Tin has similar target organs/effects, however the dose required to elicit toxicity as a result of tin exposure is extremely high. The interaction between arsenic and tin has therefore been considered insignificant. Arsenic, while having effects on the liver is not recognized as a specific nephrotoxin (Casarett and Doull's, 1991).

Barium

Health Canada (2010b) provides a TDI for Barium of **0.2 mg/kg bw/day.** The USEPA classifies Barium as a Group D compound, not classifiable as to human carcinogenicity. Therefore Health Canada (2010b) does not provide a toxicity reference value for carcinogenic effects.

Human exposure primarily occurs via drinking water, food and air. Chemical related nephropathy, hypertension, reproductive effects have been identified in rat and mice studies (ATSDR 2007b). Barium toxicity depends on the type of barium compound and the solubility of that compound. The solubility of the barium compound a receptor is exposed to is an important factor affecting the potential for absorption and thus development of adverse health effects in humans. However, during dietary exposure the levels of barium absorption may be affected by concentrations of calcium and other minerals in the diet.

The RfD for barium is based primarily on a drinking water study conducted on mice that measured chemical-related nephropathy data which provided the best evidence of a dose-response relationship. The most sensitive target organ resulting from repeated ingestion of soluble barium salts appears to be the kidney. A study by NTP (1994) of chronic and sub chronic drinking water exposures to barium chloride observed mild to severe cases of renal toxicity in F-344/N rats and B6C3F1 mice following. The RfD value provided above was derived using the lower 95% confidence limit for the dose estimated to affect 5% of the population and an uncertainty factor of 300. The uncertainty factor of 300 accounts for variation in susceptibility among humans, the uncertainty associated with extrapolation from laboratory animals to humans, and the uncertainty resulting from limitations in the data base. The overall confidence in the data base used to derive the TRV is medium because it lacks human data that define an adverse effect level but contains adequate dose response information for chronic and sub chronic animal studies conducted in more than one species.

Beryllium

Health Canada (2010b) does not provide a toxicity reference value for Beryllium. The toxicity of inhaled beryllium is well-documented. The acute condition known as berylliosis is caused by inhalation of large doses of beryllium compounds (Constantinidis, 1978). This disease usually develops shortly after exposure and is characterized by rhinitis, pharyngitis, and/or tracheobronchitis, and may progress to severe pulmonary symptoms. Occupational exposure studies have identified that the disease could develop at levels ranging from approximately 2-1000 µg Be/m^3 and therefore the disease is now rarely observed in the United States because of improved industrial hygiene (Zorn et al., 1988; Kriebel et al., 1988b).

The oral toxicity of beryllium is considered to be low. A no-adverse-effect level (NOAEL) for mice was noted in a lifetime bioassay by (Schroeder and Mitchener, 1975a, 1975b) to be 5 ppm beryllium in the drinking water. The NOAEL was converted to 0.54 mg/kg bw/day to derive the USEPA's chronic oral RfD for beryllium of 0.005 mg/kg/day (U.S. EPA, 1991).

Based on sufficient evidence for animals (lung cancer in monkeys and lung tumours in rats) and inadequate evidence for humans exposed to airborne beryllium (lung cancer), beryllium has been classified by the USEPA as (B2) a probable human carcinogen (U.S. EPA, 1991). The USEPA's non threshold TRV's include:

- The unit risk value for inhalation exposure is **0.0024 µg/m^3**
- The inhalation slope factor is **8.4 mg/kg bw/day**
- The unit risk value for oral exposure is **0.00012 µg/L**
- The oral slope factor is **4.3 mg/kg bw/day**

Chromium

Health Canada (2010b) provides a TDI for chromium of **0.001 mg/kg bw/day.** Health Canada has determined that studies conducted on inhalation exposure to chromium and certain chromium compounds provide sufficient evidence for carcinogenicity in humans and animals which includes the following carcinogenic TRV's:

- An inhalation slope factor of **46 mg/kg bw/day**
- Provides an inhalation unit risk of **11 mg/m^3**

Chromium (III) is considered an essential element and therefore trivalent chromium is considered non-toxic. The known harmful effects of chromium to humans are attributed primarily to the hexavalent form which leads to critical health effects such as hepatotoxicity, gastrointestinal irritation or corrosion, and encephalitis. The Health Canada's oral TRV's is based on a weight of evidence approach from drinking water studies of hexavalent chromium ingestion that did not use uncertainty factors. The inhalation cancer slope factor provided by Health Canada was based on a tolerable concentration derived from human epidemiological studies focused on chronic occupational exposure to chromium. The duration of the studies used to derive the inhalation unit risk were reportedly in the range of one to eight years.

Iron

Health Canada does not provide a TRV for iron. The USEPA does not provide an inhalation RfC for iron. Iron is considered an essential trace element; it is an important component of several proteins including enzymes, hemoglobin, and the myoglobin of muscle tissue and in enzymes necessary for oxidative metabolism. Acute iron toxicity effects are well documented, but it is difficult to obtain acute oral toxic doses because they are generally estimated from clinical history in overdose situations. The symptoms of acute iron toxicity include cardiovascular, metabolic, neurological and hepatic alterations as well as gastrointestinal distress. There has been no association between adverse developmental effects and the ingestion of supplemental iron intake during pregnancy. Chronic toxicity of iron has been observed in people with disorders that result in excessive iron absorption, hemoglobin synthesis abnormalities, anemia or frequent blood transfusions.

The USEPA PPTRV does provide an **RfD of 0.7 mg/kg-day** in their Regional Screening Level Summary Table (June, 2015). This value was determined based on a Tolerable Upper Intake Level (UL) for iron of 45 mg Fe/d which is based on gastrointestinal distress as an endpoint in Swedish males and females who were taking an iron supplement (US NAS 2002). The study identified a LOAEL of 60 mg/kg but no NOAEL. A LOAEL of total iron intake (the iron supplement and other sources including diet) was calculated by adding the LOAEL determined in the Swedish study (60 mg/d) to the estimated daily intake of iron from food for Scandinavian men and women (11 mg/d), resulting in a LOAEL of 70 mg/d. This evaluation used an uncertainty factor of 1.5 for extrapolation from a LOAEL to a NOAEL resulting in an upper intake level of 45 mg/d. With an assumed body weight of 70 kg an RfD of 0.64 mg/kg/d was calculated. The resulting US EPA PPTRV was set at 0.7 mg/kg/d.

No classification of iron carcinogenicity could be identified for Health Canada or the USEPA.

Lead

Neither Health Canada nor the US EPA provides TRVs for lead. AECOM has elected to assess inorganic lead based on Wilson and Richardson's (2012) "TDI-equivalent" TRV of **0.0013 mg/kg bw/day**. Wilson and Richardson's TDI-equivalent is based on the observation that a daily lead intake circa 1.3 µg/kg BW/day would be associated with a corresponding 1 mmHg increase in systolic blood pressure, the critical effect in adult receptors. This value is also protective of neurotoxic effects in children as it represents a correlative dose for lead in which is predicted to elicit a blood lead concentration of ~1.4 µg/dL, which is the endpoint used to derive CCME Soils Quality Guidelines for lead protective of human health.

The use of Wilson and Richardson's (2012) TDI-equivalent is further supported by its use in developing the current Director's Interim Standards in British Columbia: Industrial Land Use, Human Health Protection – Intake of Contaminated Soil Standard for Lead, and subsequent adoption following BC CSR Stage 9 Amendments to the Contaminated Sites Regulation (dated January 30, 2014).

Molybdenum

Health Canada (2010b) does not provide a toxicity reference value for carcinogenic effects. The US EPA classification for Molybdenum carcinogenicity is (D) "not classifiable as to carcinogenicity in human" on the basis that existing studies are inadequate to assess the carcinogenicity of molybdenum or molybdenum compounds. The chronic oral Reference Dose (RfD) for molybdenum and molybdenum compounds is **0.005 mg/kg/day**, based on biochemical indices in humans (U.S. EPA IRIS).

Molybdenum is considered an essential trace element. Molybdenum is an important component of the flavoprotein xanthine oxidase, an enzyme involved in the breakdown of purines to uric acid. Increased serum ceruloplasmin and urinary excretion of copper observed associated with increased molybdenum exposure in human studies indicates that high levels of ingested molybdenum may be associated with potential mineral imbalance (EPA IRIS). Excretion of sufficient quantities of this element may put individuals at risk for the hypochromic microcytic anemia associated with a dietary copper deficiency.

AECOM have assessed molybdenum independently for threshold non-carcinogenic risks only. Considering the absence of evidence for direct injury to obvious target organs/tissues, and molybdenum's antagonistic relationship with copper no assumption of additivity has been made (Casarett and Doull's, 1991).

Manganese

Manganese is considered an essential trace element but Health Canada (2010b) does not consider it to be carcinogenic to humans. However, exposure to elevated concentrations of manganese has been linked with a Parkinson-like neurotoxicity. Health Canada (2010b) provides life stage/body weight specific TRV's for infants to adults based on a Tolerable Daily Intake value derived from human epidemiological studies on food and water ingestion. The following TRV values were selected by AECOM for the risk assessment:

- Adults (0.156 mg/kg/day)

The TRV for manganese was derived using the weight of evidence from human epidemiological and experimental studies. A No Observable Adverse Effects Level (NOAEL) for food ingestion of 11 mg/kg per day was derived in response to parkinsonian-like neurotoxicity and no uncertainty factors were employed for this human test. Age and weight specific TRV's were derived using adjustments to the calculated tolerable upper limits based on life stage and body weight.

Mercury

Health Canada defines a threshold oral TDI for inorganic mercury of **0.0003 mg/kg/day**. This value is based on more than one rat study of oral and subcutaneous exposures looking at nephrotoxicity that indicated a lowest observable adverse effects limit (LOAEL) of 0.3 mg Hg/kg body weight per day. This value had an uncertainty factor of 1000 applied (10 times for use of sub chronic studies, 10 times for interspecies variability, and 10 times for using the LOAEL).

Selenium

Selenium is considered an essential trace element but Health Canada (2010b) does not consider it to be carcinogenic to humans and the USEPA considers it unclassifiable as to human carcinogenicity. Health Canada (2010b) provides life stage/body weight specific TRV's for infants to adults based on a NOAEL value derived from epidemiological studies on diet for infants and children. The adult TRV value for arsenic selected by AECOM for the risk assessment was **0.0057 mg/kg/day.**

The adult TDI provided by Health Canada for selenium is based on biochemical alterations associated with clinical selenosis (EPA IRIS). This is based on epidemiological studies by Yang and Zhou, 1994 and Shearer and Hadjimarkos, 1975. These human dietary studies indicated a NOAEL for adults of 800 µg/day with and uncertainty factor of 2. The NOAEL of 7 µg/kg-d that was derived for children was derived without the use of uncertainty factors. Common clinical and biochemical signs of selenium intoxication included the characteristic "garlic odor" of excess selenium excretion in the breath and urine, thickened and brittle nails, hair and nail loss, lowered hemoglobin levels, mottled teeth, skin lesions and CNS abnormalities.

Health Canada (2010b) does not provide a slope factor for carcinogenic effects. The US EPA classification for selenium carcinogenicity is (D) "not classifiable as to carcinogenicity in humans" based on inadequate human data and inadequate evidence of carcinogenicity in animals.

AECOM have assessed selenium for threshold non-carcinogenic risks only. Selenium forms many insoluble complexes with silver, copper, cadmium and mercury (Casarett and Doull's, 1991). The mechanisms for these interactions are only partially understood, and an assumption of additivity would not be based on verified toxicological understanding. AECOM have therefore assessed selenium independently, with no assumed additivity with other COCs.

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Appendix D

Specific Numerical Modeling

- D1: Soil Deposition and Food Web Modeling
- D2: GoldSim® Multimedia Exposure Model

D1. Soil Deposition and Food Web Modeling

Appendix D1
Soil Deposition and Food Web Modeling

1. Soil Deposition Model

Fugitive dust has been identified as the priority uncontrolled release related to mineral resource extraction activities. Deposition of particulate matter over the lifespan of the proposed project is expected to result in an incremental increase in the concentration of particular elements in surficial soils. In order to predict doses to human receptors via direct soil ingestion, as well as through food web uptake from the soil, the concentrations of COPCs following at the conclusion of the project must be modelled.

Incremental soil concentrations were calculated using protocols provided in the Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities[1]. The incremental change in soil concentrations was calculated as follows:

$$ISC\left(\frac{mg}{kg}\right) = \frac{(Dyd) \times tD}{Zs \times BD}$$

where:
Dyd = dry deposition (mg COPC/m^2/year)
tD = deposition time (16 years)
Zs – soil mixing depth (0.02 m)
BD = bulk density (1500 kg/m^3)

Dry deposition rate for dust (mg TPM/m^2/year) was calculated for blasting and non-blasting conditions using the air dispersion modelling platform CALPUFF (refer to Air Quality Technical Report) for 40 critical receptors located within the LSA and off property grid receptors. Dust fall was multiplied by COPC concentration in dust (mg COPC/kg dust) to estimate dry deposition rate for each COPC.

Soil concentrations were estimated for blast and non-blast conditions, and a weighted average was calculated assuming one day of blasting per week (1/7 ≈ 0.14) throughout the year, and non-blasting conditions for the remaining 6 days per week (6/7≈0.86). This is a conservative simplification of the actual operation in which weekly blasting occurs only in summer, with blasting frequency during winter months reduced to one event per month. Therefore, the incremental soil concentration is calculated as follows:

$$ISC\left(\frac{mg}{kg}\right) = \frac{[(Dyd_{Blast} \times 0.14) + (Dyd_{No-Blast} \times 0.86)] \times tD}{Zs \times BD}$$

where:
Dyd = dry deposition (mg COPC/m^2/year)
tD = deposition time (16 years)
Zs – soil mixing depth (0.02 m)
BD = bulk density (1500 kg/m^3)

The incremental soil concentration for the LSA was assumed to be the 95% Upper tolerance limit of the predicted incremental soil concentrations for the 40 critical receptors plus the off-property maximum location. A tolerance

[1] *US EPA. 2005. Human health risk assessment protocol for hazardous waste combustion facilities, Chapter 5: Estimating media concentrations. Office of Solid Waste and Emergency Response. EPA530-05-006.*

interval is a statistical interval within which, with some confidence level, a specified proportion of a sampled population falls. In this case ACOM have calculated a 95% Upper Tolerance Limit with 90% coverage. That is, a value which will encompass 90% of the population with 95% confidence.

Incremental soil concentrations carried forward into the HHRA for the project and cumulative scenarios are presented in Table 1. Calculated incremental soil concentrations for individual receptor locations are presented in Tables 5 and 6 (located at the back of this appendix).

Table 1. Incremental and Predicted Soil Concentrations (mg/kg) For the Project and Cumulative Scenarios

COPC	Baseline	[COPC] in TPM	Project		Cumulative	
			Incremental	Total	Incremental	Total
Arsenic	10.74	4.8E+1	0.036	10.78	0.115	10.86
Barium	49.26	5.1E+2	0.380	49.6	1.213	50.47
Beryllium	0.37	2.6E+0	0.002	0.372	0.006	0.376
Chromium	0.2	1.4E+2	0.105	0.305	0.337	0.537
Iron	49148	5.5E+5	413.4	49561.4	1319	50467
Lead	17.26	7.4E+1	0.056	17.32	0.177	17.44
Manganese	1177	1.7E+3	1.262	1178.3	4.027	1181
Mercury	0.08	7.0E-2	0.0001	0.0801	0.0002	0.0802
Molybdenum	2.24	4.3E+0	0.0032	2.24	0.0102	2.25
Selenium	0.8	8.0E-1	0.0006	0.801	0.0019	0.802

2. Food Web Modeling

The HHRA requires food web modeling of metals concentrations plant and animal tissues. The equations and detailed inputs for these calculations are provided Sections 1.1 and 1.2, respectively. The HHRA used site specific metals concentrations, However, some environmental data was limited and additional modeling of vegetation (Labrador tea and partridge berry), soil invertebrates, and fish for select metals was also required using soil concentrations and literature derived transfer factors.

2.1 Modeled Concentrations in Hare Tissue

Estimated concentrations of COPCs in the tissue of the Hare were calculated using the following equation:

$$\mathrm{C}_{Hare}=\left(\mathrm{C}_{\mathrm{water}} \times \mathrm{IR}_{\mathrm{water}} + \mathrm{C}_{\mathrm{ter.veg}} \times \mathrm{IR}_{\mathrm{ter.veg}} + \mathrm{C}_{\mathrm{soil.}} \times \mathrm{IR}_{\mathrm{soil}}\right) \times \mathrm{TF}$$

Where:

C_{Hare}	=	Concentration of contaminant in Hare tissue (mg/kg dw)
IR_{water}	=	Water ingestion rate (0.13 L/day)
C_{water}	=	Measured water concentration (mg/L)
IR_{tveg}	=	Ingestion rate of terrestrial vegetation (Labrador Tea) (0.078 kg dw/day)
C_{tveg}	=	Concentration of COPC in terrestrial vegetation (mg/kg dw)
IR_{soil}	=	Soil ingestion rate (0.005 kg/day)
C_{soil}	=	Soil concentration (mg/kg dw)

TF = Feed to Hare Transfer Factor (d/kg (ww)) (See Table 2)

Table 2. Feed to Hare Transfer Factors (d/kg (ww))

Element	Transfer Factor	Source
Arsenic	0.0067	Sample, B. E., et al. "Development and validation of bioaccumulation models for small mammals." Prepared for the US Department of Energy. February (1998).
Barium	0.0451	
Chromium	0.1468	
Iron	0.0121	
Lead	0.1258	
Manganese	0.0053	IAEA, E. Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments. IAEA-TECDOC-1616, IAEA, Vienna, Austria, 2009.
Mercury	0.0731	Sample, B. E., et al. "Development and validation of bioaccumulation models for small mammals." Prepared for the US Department of Energy. February (1998).
Selenium	0.4047	Sample, B. E., et al. "Development and validation of bioaccumulation models for small mammals." Prepared for the US Department of Energy. February (1998).
Beryllium	0.001	Baes, C. F., III, et al, 1984, A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture, ORNL-5786, US. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, TN
Molybdenum	0.006	

2.2 Modeled Concentrations in Spruce Grouse Tissue

Estimated concentrations of COPCs in the tissue of Spruce Grouse were calculated using the following:

$$C_{grouse} = \left(C_{water} \times IR_{water} + [(D1 \times C_{Labtea} \times IR_{Total}) + (D2 \times C_{berry} \times IR_{Total}) + (D3 \times C_{Invert} \times IR_{Total})]\right) \times TF$$

Where:

- C_{grouse} = Concentration of contaminant in bird flesh (mg/kg ww)
- IR_{water} = Water ingestion rate (0.039 L/day)
- C_{water} = Measured water concentration (mg/L)
- IR_{food} = Ingestion rate of food (0.033 kg dw/day)
- C_{food} = Concentration of COPC in food items (Labrador tea, partridge berry, and soil invertebrates) (mg/kg dw)
- D1 = Percentage of diet consumed as Labrador tea (50%)
- D2 = Percentage of diet consumed as partridge berry (30%)
- D3 = Percentage of diet consumed as soil invertebrates (15%)
- $TF_{feed\text{-}to\text{-}grouse}$ = Feed to grouse transfer factor (d/kg (ww)) - (See Table 3)

Table 3. Feed-to-Spruce Grouse Transfer Factors (d/kg (ww))

Element	Transfer Factor	Source
Barium	0.019	IAEA, E. Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments. IAEA-TECDOC-1616, IAEA, Vienna, Austria, 2009.
Manganese	0.019	
Selenium	9.7	

Arsenic	0.83	Recommended Parameter Values for GENII Modeling of Radionuclides in Routine Air and Water Releases. PNNL-21950: Pacific Northwest National Laboratory, 2013.
Beryllium	0.4	
Chromium	0.2	
Iron	1	
Lead	0.8	
Mercury	0.03	
Molybdenum	0.18	

2.3 Calculation of Tissue Concentrations Using Soil and Water Transfer Factors

Additional modeling of vegetation (Labrador tea and partridge berry), soil invertebrates, and fish tissue concentrations were conducted for select metals using the following equations and transfer factors (Table 4).

$$C_{Labrador\ Tea} = \left(C_{\mathrm{Soil}} \times TF_{Veg}\right)$$

$$C_{Partridge\ Berry} = \left(C_{\mathrm{Soil}} \times TF_{berry}\right)$$

$$C_{Invertebrates} = \left(C_{\mathrm{Soil}} \times TF_{Invertebrates}\right)$$

$$C_{fish} = \left(C_{\mathrm{Water}} \times TF_{Fish}\right)$$

Where:

C_{biota}	=	Concentration of contaminant in modeled tissue (mg/kg dw)
$TF_{soil\text{-}to\text{-}tissue}$	=	Soil to terrestrial biota tissue transfer factor (Labrador tea, partridge berry, soil invertebrates)
$TF_{water\text{-}to\text{-}tissue}$	=	Water to fish tissue transfer factor

Table 4. Transfer Factors used for Estimating Tissue Concentrations in Partridge Berry, Labrador Tea, Soil Invertebrates, and Fish

Element	Transfer Factor	Source
Soil-to-Partridge Berry ((mg/kg (ww))/(mg/kg (dw))		
Arsenic	0.036	Appendix C: Screening Level Ecological Risk Assessment Protocol (SLERAP) for Hazardous Waste Combustion Facilities Source: U.S. EPA, 530-D-99-001A - August 1999
Chromium	0.0075	
Barium	0.003	U.S. NRC. Transfer Factors for Contaminant Uptake by Fruit and Nut Trees. PNNL-22975, 2013
Beryllium	0.0015	
Manganese	0.023	
Mercury	0.285	
Lead	0.015	IAEA, E. Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments. IAEA-TECDOC-1616, IAEA, Vienna, Austria, 2009.
Molybdenum	0.5	
Selenium	0.019	
Iron	0.0035	Site specific soil to partridge berry ratio calculated from 2015 collocated soil and vegetation data.
Soil-to-Labrador Tea ((mg/kg (ww))/(mg/kg (dw))		
Arsenic	0.036	Appendix C: Screening Level Ecological Risk Assessment Protocol (SLERAP) for Hazardous Waste Combustion Facilities Source: U.S. EPA, 530-D-99-001A - August 1999
Barium	0.15	
Beryllium	0.01	
Chromium	0.0075	
Lead	0.045	
Selenium	0.016	
Iron	0.0013	IAEA, E. Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments. IAEA-TECDOC-1616, IAEA, Vienna, Austria, 2009.
Manganese	0.41	
Molybdenum	0.58	
Mercury	0.85	Recommended Parameter Values for GENII Modeling of Radionuclides in Routine Air and Water Releases. PNNL-21950: Pacific Northwest National Laboratory, 2013.
Soil-to-Soil Invertebrates ((mg/kg (ww))/(mg/kg (dw))		
Arsenic	0.11	Appendix C: Screening Level Ecological Risk Assessment Protocol (SLERAP) for Hazardous Waste Combustion Facilities Source: U.S. EPA, 530-D-99-001A - August 1999.
Barium	0.22	
Beryllium	0.22	
Chromium	0.01	
Lead	0.03	
Selenium	0.22	
Iron	0.22	Recommended Parameter Values for GENII Modeling of Radionuclides in Routine Air and Water Releases. PNNL-21950: Pacific Northwest National Laboratory, 2013.
Manganese	0.22	
Molybdenum	0.22	
Mercury	0.22	
Water-to-Fish ((mg/kg (ww))/(mg/L))		
Beryllium	10	Appendix C: Screening Level Ecological Risk Assessment Protocol (SLERAP) for Hazardous Waste Combustion Facilities Source: U.S. EPA, 530-D-99-001A - August 1999.
Chromium	4	
Molybdenum	10	A Compendium of Transfer Factors for Agricultural and Animal Products. PNNL-13421: Pacific Northwest National Laboratory, 2003.

Table 5: Incremental Soil Concentrations (mg/kg soil) for 'Howse Only' Scenario

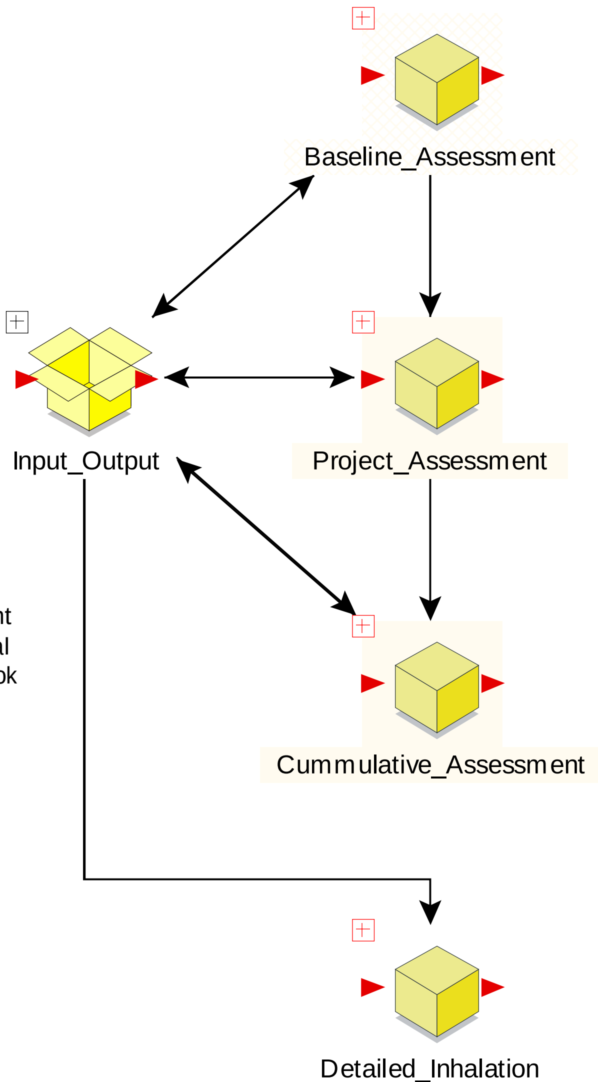
Receptor ID	Location	Dustfall (mg/m2.year)		Arsenic (As) 48.08 (mg/kg dust)			Barium (Ba) 508.72 (mg/kg dust)			Beryllium (Be) 2.62 (mg/kg dust)			Chromium (Cr) 141.16 (mg/kg dust)			Iron (Fe) 553329.46 (mg/kg dust)			Lead (Pb) 74.31 (mg/kg dust)			Manganese (Mn) 1689 (mg/kg dust)			Mercury (Hg) 0.07 (mg/kg dust)			Molybdenum (Mo) 4.28 (mg/kg dust)			Selenium (Se) 0.8 (mg/kg dust)		
		Blast	No-Balst	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total
1	Young Naskapi Camp	92.4	68.6	0.0024	0.0018	0.00185	0.025	0.019	0.020	1.3E-04	9.6E-05	1.0E-04	0.0069541	0.0051619	0.0054307	51.1	20.2	21.3	0.0036608	0.0027173	0.0028588	0.083	0.062	0.065	3.4E-06	2.6E-06	2.7E-06	2.1E-04	1.6E-04	1.6E-04	3.9E-05	2.9E-05	3.1E-05
2	Young Naskapi Camp	88.5	66.0	0.0023	0.0017	0.00178	0.024	0.018	0.019	1.2E-04	9.2E-05	9.7E-05	0.0066652	0.0049708	0.0052249	49.0	19.5	20.5	0.0035087	0.0026167	0.0027505	0.080	0.059	0.063	3.3E-06	2.5E-06	2.6E-06	2.0E-04	1.5E-04	1.6E-04	3.8E-05	2.8E-05	3.0E-05
3	Innu Camp	102.5	76.2	0.0026	0.0020	0.00205	0.028	0.021	0.022	1.4E-04	1.1E-04	1.1E-04	0.00772	0.0057333	0.0060313	56.7	22.5	23.6	0.004064	0.0030182	0.003175	0.092	0.069	0.072	3.8E-06	2.8E-06	3.0E-06	2.3E-04	1.7E-04	1.8E-04	4.4E-05	3.2E-05	3.4E-05
4	Innu Camp	93.4	74.3	0.0024	0.0019	0.00198	0.025	0.020	0.021	1.3E-04	1.0E-04	1.1E-04	0.007028	0.0055925	0.0058079	51.7	21.9	22.8	0.0036997	0.002944	0.0030574	0.084	0.067	0.069	3.5E-06	2.8E-06	2.9E-06	2.1E-04	1.7E-04	1.8E-04	4.0E-05	3.2E-05	3.3E-05
5	Innu Camp	69.8	56.4	0.0018	0.0014	0.00150	0.019	0.015	0.016	9.7E-05	7.9E-05	8.1E-05	0.0052571	0.0042424	0.0043946	38.6	16.6	17.2	0.0027674	0.0022333	0.0023134	0.063	0.051	0.053	2.6E-06	2.1E-06	2.2E-06	1.6E-04	1.3E-04	1.3E-04	3.0E-05	2.4E-05	2.5E-05
6	Innu Camp	72.0	54.3	0.0018	0.0014	0.00146	0.020	0.015	0.015	1.0E-04	7.6E-05	7.9E-05	0.0054202	0.0040878	0.0042877	39.8	16.0	16.8	0.0028533	0.0021519	0.0022571	0.065	0.049	0.051	2.7E-06	2.0E-06	2.1E-06	1.6E-04	1.2E-04	1.3E-04	3.1E-05	2.3E-05	2.4E-05
7	Innu Tent	106.3	81.8	0.0027	0.0021	0.00219	0.029	0.022	0.023	1.5E-04	1.1E-04	1.2E-04	0.0080016	0.0061559	0.0064328	58.8	24.1	25.2	0.0042122	0.0032406	0.0033864	0.096	0.074	0.077	4.0E-06	3.1E-06	3.2E-06	2.4E-04	1.9E-04	2.0E-04	4.5E-05	3.5E-05	3.6E-05
8	Innu Tent	44.2	34.6	0.0011	0.0009	0.00092	0.012	0.009	0.010	6.2E-05	4.8E-05	5.0E-05	0.003329	0.0026016	0.0027107	24.5	10.2	10.6	0.0017525	0.0013695	0.001427	0.040	0.031	0.032	1.7E-06	1.3E-06	1.3E-06	1.0E-04	7.9E-05	8.2E-05	1.9E-05	1.5E-05	1.5E-05
9	Young Naskapi Camp (Pinette Lake)	831.1	669.2	0.0213	0.0172	0.01778	0.225	0.182	0.188	1.2E-03	9.3E-04	9.7E-04	0.0625683	0.0503818	0.0522098	459.9	197.5	204.7	0.0329373	0.0265221	0.0274844	0.749	0.603	0.625	3.1E-05	2.5E-05	2.6E-05	1.9E-03	1.5E-03	1.6E-03	3.5E-04	2.9E-04	3.0E-04
10	Young Naskapi Camp	679.6	506.7	0.0174	0.0130	0.01366	0.184	0.137	0.145	9.5E-04	7.1E-04	7.4E-04	0.0511629	0.0381431	0.040096	376.0	149.5	157.2	0.0269333	0.0200794	0.0211074	0.612	0.456	0.480	2.5E-05	1.9E-05	2.0E-05	1.6E-03	1.2E-03	1.2E-03	2.9E-04	2.2E-04	2.3E-04
11	Young Naskapi Trailer tent (Triangle Lake)	477.6	369.4	0.0122	0.0095	0.00989	0.130	0.100	0.105	6.7E-04	5.2E-04	5.4E-04	0.0359541	0.0278084	0.0290302	264.3	109.0	113.8	0.018927	0.014639	0.0152822	0.430	0.333	0.347	1.8E-05	1.4E-05	1.4E-05	1.1E-03	8.4E-04	8.8E-04	2.0E-04	1.6E-04	1.6E-04
12	Young Naskapi Camp	277.4	249.3	0.0071	0.0064	0.00650	0.075	0.068	0.069	3.9E-04	3.5E-04	3.5E-04	0.0208847	0.0187714	0.0190884	153.5	73.6	74.8	0.0109942	0.0098817	0.0100486	0.250	0.225	0.228	1.0E-05	9.3E-06	9.5E-06	6.3E-04	5.7E-04	5.8E-04	1.2E-04	1.1E-04	1.1E-04
13	Uashat people's camp 2	505.5	392.1	0.0130	0.0101	0.01049	0.137	0.106	0.111	7.1E-04	5.5E-04	5.7E-04	0.0380552	0.0295202	0.0308004	279.7	115.7	120.7	0.0200331	0.0155401	0.016214	0.455	0.353	0.369	1.9E-05	1.5E-05	1.5E-05	1.2E-03	9.0E-04	9.3E-04	2.2E-04	1.7E-04	1.7E-04
14	Young Naskapi Camp	31.7	25.8	0.0008	0.0007	0.00068	0.009	0.007	0.007	4.4E-05	3.6E-05	3.7E-05	0.0023855	0.0019428	0.0020092	17.5	7.6	7.9	0.0012558	0.0010227	0.0010577	0.029	0.023	0.024	1.2E-06	9.6E-07	1.0E-06	7.2E-05	5.9E-05	6.1E-05	1.4E-05	1.1E-05	1.1E-05
15	Young Naskapi Camp (Howells River)	67.5	61.7	0.0017	0.0016	0.00160	0.018	0.017	0.017	9.4E-05	8.6E-05	8.7E-05	0.0050793	0.0046424	0.0047079	37.3	18.2	18.5	0.0026738	0.0024439	0.0024784	0.061	0.056	0.056	2.5E-06	2.3E-06	2.3E-06	1.5E-04	1.4E-04	1.4E-04	2.9E-05	2.6E-05	2.7E-05
16	Uashat - Mani-Utenam Camp	353.0	300.6	0.0090	0.0077	0.00791	0.096	0.082	0.084	4.9E-04	4.2E-04	4.3E-04	0.0265715	0.0226313	0.0232223	195.3	88.7	91.0	0.0139878	0.0119136	0.0122248	0.318	0.271	0.278	1.3E-05	1.1E-05	1.2E-05	8.1E-04	6.9E-04	7.0E-04	1.5E-04	1.3E-04	1.3E-04
17	Uashat - Mani-Utenam Camp	190.2	149.7	0.0049	0.0038	0.00399	0.052	0.041	0.042	2.7E-04	2.1E-04	2.2E-04	0.0143194	0.011271	0.0117283	105.2	44.2	46.0	0.0075381	0.0059333	0.006174	0.171	0.135	0.140	7.1E-06	5.6E-06	5.8E-06	4.3E-04	3.4E-04	3.6E-04	8.1E-05	6.4E-05	6.6E-05
18	Uashat - Mani-Utenam Camp (Inukshuk Lake)	699.9	669.2	0.0179	0.0172	0.01728	0.190	0.182	0.183	9.8E-04	9.3E-04	9.4E-04	0.0526895	0.0503794	0.0507259	387.3	197.5	198.8	0.0277369	0.0265208	0.0267033	0.630	0.603	0.607	2.6E-05	2.5E-05	2.5E-05	1.6E-03	1.5E-03	1.5E-03	3.0E-04	2.9E-04	2.9E-04
19	Naskapi Cabin	47.4	40.4	0.0012	0.0010	0.00106	0.013	0.011	0.011	6.6E-05	5.6E-05	5.8E-05	0.0035714	0.0030437	0.0031228	26.2	11.9	12.2	0.0018801	0.0016022	0.0016439	0.043	0.036	0.037	1.8E-06	1.5E-06	1.5E-06	1.1E-04	9.2E-05	9.5E-05	2.0E-05	1.7E-05	1.8E-05
20	Naskapi Cabin	57.5	48.6	0.0015	0.0012	0.00128	0.016	0.013	0.014	8.0E-05	6.8E-05	7.0E-05	0.0043304	0.0036576	0.0037585	31.8	14.3	14.7	0.0022796	0.0019254	0.0019786	0.052	0.044	0.045	2.1E-06	1.8E-06	1.9E-06	1.3E-04	1.1E-04	1.1E-04	2.5E-05	2.1E-05	2.1E-05
21	Bustard - Observation and hunting site	37.5	32.2	0.0010	0.0008	0.00085	0.010	0.009	0.009	5.2E-05	4.5E-05	4.6E-05	0.0028207	0.0024264	0.0024855	20.7	9.5	9.7	0.0014849	0.0012773	0.0013084	0.034	0.029	0.030	1.4E-06	1.2E-06	1.2E-06	8.6E-05	7.4E-05	7.5E-05	1.6E-05	1.4E-05	1.4E-05
22	Bustard - Observation and hunting site	89.5	66.3	0.0023	0.0017	0.00179	0.024	0.018	0.019	1.2E-04	9.2E-05	9.7E-05	0.0067347	0.004989	0.0052509	49.5	19.6	20.6	0.0035453	0.0026263	0.0027642	0.081	0.060	0.063	3.3E-06	2.5E-06	2.6E-06	2.0E-04	1.5E-04	1.6E-04	3.8E-05	2.8E-05	3.0E-05
23	Picking site (berries / tea)	239.2	204.0	0.0061	0.0052	0.00537	0.065	0.055	0.057	3.3E-04	2.8E-04	2.9E-04	0.0180108	0.0153574	0.0157554	132.4	60.2	61.8	0.0094813	0.0080845	0.008294	0.216	0.184	0.189	8.9E-06	7.6E-06	7.8E-06	5.5E-04	4.7E-04	4.8E-04	1.0E-04	8.7E-05	8.9E-05
24	Irony Mountain	395.5	319.8	0.0101	0.0082	0.00849	0.107	0.087	0.090	5.5E-04	4.5E-04	4.6E-04	0.0297742	0.0240739	0.0249289	218.8	94.4	97.7	0.0156738	0.012673	0.0131231	0.356	0.288	0.298	1.5E-05	1.2E-05	1.2E-05	9.0E-04	7.3E-04	7.6E-04	1.7E-04	1.4E-04	1.4E-04
25	Innu Cabin	47.3	41.4	0.0012	0.0011	0.00108	0.013	0.011	0.011	6.6E-05	5.8E-05	5.9E-05	0.0035577	0.0031175	0.0031835	26.1	12.2	12.5	0.0018728	0.0016411	0.0016759	0.043	0.037	0.038	1.8E-06	1.5E-06	1.6E-06	1.1E-04	9.5E-05	9.7E-05	2.0E-05	1.8E-05	1.8E-05
26	Innu Cabin	39.3	33.5	0.0010	0.0009	0.00088	0.011	0.009	0.009	5.5E-05	4.7E-05	4.8E-05	0.0029563	0.0025249	0.0025896	21.7	9.9	10.2	0.0015563	0.0013292	0.0013632	0.035	0.030	0.031	1.5E-06	1.3E-06	1.3E-06	9.0E-05	7.7E-05	7.9E-05	1.7E-05	1.4E-05	1.5E-05
27	Innu Cabin	33.9	28.1	0.0009	0.0007	0.00074	0.009	0.008	0.008	4.7E-05	3.9E-05	4.0E-05	0.002551	0.0021128	0.0021785	18.7	8.3	8.5	0.0013429	0.0011122	0.0011468	0.031	0.025	0.026	1.3E-06	1.0E-06	1.1E-06	7.7E-05	6.4E-05	6.6E-05	1.4E-05	1.2E-05	1.2E-05
28	Innu Cabin	31.1	24.7	0.0008	0.0006	0.00066	0.008	0.007	0.007	4.3E-05	3.4E-05	3.6E-05	0.0023417	0.0018579	0.0019305	17.2	7.3	7.6	0.0012327	0.0009781	0.0010163	0.028	0.022	0.023	1.2E-06	9.2E-07	9.6E-07	7.1E-05	5.6E-05	5.9E-05	1.3E-05	1.1E-05	1.1E-05
29	Innu Cabin	33.8	26.5	0.0009	0.0007	0.00071	0.009	0.007	0.007	4.7E-05	3.7E-05	3.8E-05	0.0025479	0.0019919	0.0020753	18.7	7.8	8.1	0.0013413	0.0010486	0.0010925	0.030	0.024	0.025	1.3E-06	9.9E-07	1.0E-06	7.7E-05	6.0E-05	6.3E-05	1.4E-05	1.1E-05	1.2E-05
30	Innu Cabin	28.7	22.2	0.0007	0.0006	0.00059	0.008	0.006	0.006	4.0E-05	3.1E-05	3.2E-05	0.0021576	0.0016713	0.0017442	15.9	6.6	6.8	0.0011358	0.0008798	0.0009182	0.026	0.020	0.021	1.1E-06	8.3E-07	8.6E-07	6.5E-05	5.1E-05	5.3E-05	1.2E-05	9.5E-06	9.9E-06
31	Innu Cabin	33.4	27.1	0.0009	0.0007	0.00072	0.009	0.007	0.008	4.7E-05	3.8E-05	3.9E-05	0.0025145	0.0020402	0.0021113	18.5	8.0	8.3	0.0013237	0.001074	0.0011115	0.030	0.024	0.025	1.2E-06	1.0E-06	1.0E-06	7.6E-05	6.2E-05	6.4E-05	1.4E-05	1.2E-05	1.2E-05
32	Innu Cabin	24.6	21.7	0.0006	0.0006	0.00057	0.007	0.006	0.006	3.4E-05	3.0E-05	3.1E-05	0.001853	0.0016342	0.0016671	13.6	6.4	6.5	0.0009755	0.0008603	0.0008776	0.022	0.020	0.020	9.2E-07	8.1E-07	8.3E-07	5.6E-05	5.0E-05	5.1E-05	1.1E-05	9.3E-06	9.4E-06
33	Naskapi Cabin	56.8	44.5	0.0015	0.0011	0.00119	0.015	0.012	0.013	7.9E-05	6.2E-05	6.5E-05	0.004273	0.0033509	0.0034892	31.4	13.1	13.7	0.0022494	0.001764	0.0018368	0.051	0.040	0.042	2.1E-06	1.7E-06	1.7E-06	1.3E-04	1.0E-04	1.1E-04	2.4E-05	1.9E-05	2.0E-05
34	Naskapi Cabin	109.0	85.0	0.0028	0.0022	0.00227	0.030	0.023	0.024	1.5E-04	1.2E-04	1.2E-04	0.0082032	0.0063983	0.0066691	60.3	25.1	26.1	0.0043183	0.0033682	0.0035107	0.098	0.077	0.080	4.1E-06	3.2E-06	3.3E-06	2.5E-04	1.9E-04	2.0E-04	4.6E-05	3.6E-05	3.8E-05
35	Naskapi Cabin	77.4	55.5	0.0020	0.0014	0.00151	0.021	0.015	0.016	1.1E-04	7.7E-05	8.2E-05	0.0058278	0.0041778	0.0044253	42.8	16.4	17.3	0.0030679	0.0021993	0.0023296	0.070	0.050	0.053	2.9E-06	2.1E-06	2.2E-06	1.8E-04	1.3E-04	1.3E-04	3.3E-05	2.4E-05	2.5E-05
36	Kawawachikamak (Town)	7.8	6.6	0.0002	0.0002	0.00017	0.002	0.002	0.002	1.1E-05	9.2E-06	9.4E-06	0.0005835	0.0004952	0.0005084	4.3	1.9	2.0	0.0003072	0.0002607	0.0002676	0.007	0.006	0.006	2.9E-07	2.5E-07	2.5E-07	1.8E-05	1.5E-05	1.5E-05	3.3E-06	2.8E-06	2.9E-06
37	Lac John (Town)	8.7	7.2	0.0002	0.0002	0.00019	0.002	0.002	0.002	1.2E-05	1.0E-05	1.0E-05	0.0006537	0.0005436	0.0005601	4.8	2.1	2.2	0.0003441	0.0002862	0.0002949	0.008	0.007	0.007	3.2E-07	2.7E-07	2.8E-07	2.0E-05	1.6E-05	1.7E-05	3.7E-06	3.1E-06	3.2E-06
38	Matimekush (Town)	11.2	9.6	0.0003	0.0002	0.00025	0.003	0.003	0.003	1.6E-05	1.3E-05	1.4E-05	0.0008423	0.0007202	0.0007385	6.2	2.8	2.9	0.0004434	0.0003791	0.0003888	0.010	0.009	0.009	4.2E-07	3.6E-07	3.7E-07	2.6E-05	2.2E-05	2.2E-05	4.8E-06	4.1E-06	4.2E-06
39	Schefferville (Town)	12.6	10.7	0.0003	0.0003	0.00028	0.003	0.003	0.003	1.8E-05	1.5E-05	1.5E-05	0.0009491	0.0008058	0.0008273	7.0	3.2	3.2	0.0004996	0.0004242	0.0004355	0.011	0.010	0.010	4.7E-07	4.0E-07	4.1E-07	2.9E-05	2.4E-05	2.5E-05	5.4E-06	4.6E-06	4.7E-06
40	Workers' Camp	993.9	978.3	0.0255	0.0251	0.02514	0.270	0.265	0.266	1.4E-03	1.4E-03	1.4E-03	0.0748236	0.0736532	0.0738287	549.9	288.7	289.4	0.0393888	0.0387727	0.0388651	0.895	0.881	0.883	3.7E-05	3.7E-05	3.7E-05	2.3E-03	2.2E-03	2.2E-03	4.2E-04	4.2E-04	4.2E-04
	"Off-Property Limit" Maximum	3191.4	2743.9	0.0818	0.0704	0.07207	0.866	0.744	0.763	4.5E-03	3.8E-03	3.9E-03	0.2402637	0.2065675	0.2116219	1765.9	809.7	829.5	0.1264802	0.1087417	0.1114025	2.875	2.472	2.532	1.2E-04	1.0E-04	1.0E-04	7.3E-03	6.3E-03	6.4E-03	1.4E-03	1.2E-03	1.2E-03

Table 6: Incremental Soil Concentrations (mg/kg soil) for the Cumulative Scenario

Receptor ID	Location	Dustfall (mg/m2.year)		Arsenic (As)			Barium (Ba)			Beryllium (Be)			Chromium (Cr)			Iron (Fe)			Lead (Pb)			Manganese (Mn)			Mercury (Hg)			Molybdenum (Mo)			Selenium (Se)		
				48.08 (mg/kg dust)			508.72 (mg/kg dust)			2.62 (mg/kg dust)			141.16 (mg/kg dust)			553329.46 (mg/kg dust)			74.31 (mg/kg dust)			1689 (mg/kg dust)			0.07 (mg/kg dust)			4.28 (mg/kg dust)			0.8 (mg/kg dust)		
		Blast	No-Balst	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total	Blast Dyd	No-Blast Dyd	Total
1	Young Naskapi Camp	2445	2418	0.0627	0.0620	0.06210	0.663	0.656	0.657	3.4E-03	3.4E-03	3.4E-03	0.18407	0.18204	0.18234	1352.9	713.6	714.8	0.0969	0.09583	0.09599	2.202	2.178	2.182	9.1E-05	9.0E-05	9.0E-05	5.6E-03	5.5E-03	5.5E-03	1.0E-03	1.0E-03	1.0E-03
2	Young Naskapi Camp	2440	2414	0.0626	0.0619	0.06200	0.662	0.655	0.656	3.4E-03	3.4E-03	3.4E-03	0.1837	0.18177	0.18206	1350.2	712.5	713.6	0.0967	0.09569	0.09584	2.198	2.175	2.178	9.1E-05	9.0E-05	9.0E-05	5.6E-03	5.5E-03	5.5E-03	1.0E-03	1.0E-03	1.0E-03
3	Innu Camp	2459	2430	0.0631	0.0623	0.06241	0.667	0.659	0.660	3.4E-03	3.4E-03	3.4E-03	0.18514	0.18291	0.18324	1360.8	717.0	718.3	0.09746	0.09629	0.09646	2.215	2.189	2.193	9.2E-05	9.1E-05	9.1E-05	5.6E-03	5.5E-03	5.6E-03	1.0E-03	1.0E-03	1.0E-03
4	Innu Camp	2452	2430	0.0629	0.0623	0.06239	0.665	0.659	0.660	3.4E-03	3.4E-03	3.4E-03	0.1846	0.18293	0.18318	1356.8	717.1	718.1	0.09718	0.0963	0.09643	2.209	2.189	2.192	9.2E-05	9.1E-05	9.1E-05	5.6E-03	5.5E-03	5.6E-03	1.0E-03	1.0E-03	1.0E-03
5	Innu Camp	2424	2408	0.0621	0.0617	0.06179	0.658	0.653	0.654	3.4E-03	3.4E-03	3.4E-03	0.18246	0.18125	0.18143	1341.1	710.5	711.2	0.09605	0.09541	0.09551	2.183	2.169	2.171	9.0E-05	9.0E-05	9.0E-05	5.5E-03	5.5E-03	5.5E-03	1.0E-03	1.0E-03	1.0E-03
6	Innu Camp	2419	2398	0.0620	0.0615	0.06158	0.656	0.651	0.652	3.4E-03	3.3E-03	3.4E-03	0.18211	0.18057	0.1808	1338.5	707.8	708.7	0.09587	0.09505	0.09518	2.179	2.161	2.163	9.0E-05	9.0E-05	9.0E-05	5.5E-03	5.5E-03	5.5E-03	1.0E-03	1.0E-03	1.0E-03
7	Innu Tent	2470	2442	0.0633	0.0626	0.06271	0.670	0.662	0.664	3.4E-03	3.4E-03	3.4E-03	0.18595	0.18382	0.18414	1366.7	720.6	721.8	0.09789	0.09676	0.09693	2.225	2.199	2.203	9.2E-05	9.1E-05	9.1E-05	5.6E-03	5.6E-03	5.6E-03	1.1E-03	1.0E-03	1.0E-03
8	Innu Tent	2380	2368	0.0610	0.0607	0.06076	0.646	0.642	0.643	3.3E-03	3.3E-03	3.3E-03	0.1792	0.17827	0.17841	1317.1	698.8	699.4	0.09433	0.09385	0.09392	2.144	2.133	2.135	8.9E-05	8.8E-05	8.8E-05	5.4E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
9	Young Naskapi Camp (Pinette Lake)	3350	3179	0.0859	0.0815	0.08216	0.909	0.862	0.869	4.7E-03	4.4E-03	4.5E-03	0.25217	0.2393	0.24123	1853.4	938.0	945.6	0.13275	0.12597	0.12699	3.017	2.863	2.886	1.3E-04	1.2E-04	1.2E-04	7.6E-03	7.3E-03	7.3E-03	1.4E-03	1.4E-03	1.4E-03
10	Young Naskapi Camp	3156	2976	0.0809	0.0763	0.07699	0.856	0.807	0.815	4.4E-03	4.2E-03	4.2E-03	0.23761	0.22402	0.22606	1746.4	878.1	886.1	0.12508	0.11793	0.119	2.843	2.680	2.705	1.2E-04	1.1E-04	1.1E-04	7.2E-03	6.8E-03	6.9E-03	1.3E-03	1.3E-03	1.3E-03
11	Young Naskapi Trailer tent (Triangle Lake)	2975	2857	0.0763	0.0733	0.07372	0.807	0.775	0.780	4.2E-03	4.0E-03	4.0E-03	0.224	0.21511	0.21645	1646.4	843.2	848.5	0.11792	0.11324	0.11394	2.680	2.574	2.590	1.1E-04	1.1E-04	1.1E-04	6.8E-03	6.5E-03	6.6E-03	1.3E-03	1.2E-03	1.2E-03
12	Young Naskapi Camp	2762	2723	0.0708	0.0698	0.06998	0.749	0.739	0.741	3.9E-03	3.8E-03	3.8E-03	0.20796	0.20504	0.20547	1528.5	803.7	805.4	0.10948	0.10794	0.10817	2.488	2.453	2.459	1.0E-04	1.0E-04	1.0E-04	6.3E-03	6.2E-03	6.2E-03	1.2E-03	1.2E-03	1.2E-03
13	Uashat people's camp 2	2971	2870	0.0762	0.0736	0.07398	0.806	0.779	0.783	4.1E-03	4.0E-03	4.0E-03	0.2237	0.21607	0.21721	1644.2	847.0	851.5	0.11776	0.11374	0.11434	2.677	2.585	2.599	1.1E-04	1.1E-04	1.1E-04	6.8E-03	6.6E-03	6.6E-03	1.3E-03	1.2E-03	1.2E-03
14	Young Naskapi Camp	2358	2351	0.0605	0.0603	0.06031	0.640	0.638	0.638	3.3E-03	3.3E-03	3.3E-03	0.17753	0.17699	0.17707	1304.8	693.8	694.1	0.09346	0.09317	0.09321	2.124	2.118	2.119	8.8E-05	8.8E-05	8.8E-05	5.4E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
15	Young Naskapi Camp (Howells River)	2434	2420	0.0624	0.0620	0.06210	0.660	0.657	0.657	3.4E-03	3.4E-03	3.4E-03	0.18325	0.18217	0.18233	1346.9	714.1	714.7	0.09647	0.0959	0.09598	2.193	2.180	2.182	9.1E-05	9.0E-05	9.0E-05	5.6E-03	5.5E-03	5.5E-03	1.0E-03	1.0E-03	1.0E-03
16	Uashat - Mani-Utenam Camp	3554	3493	0.0911	0.0896	0.08980	0.964	0.948	0.950	5.0E-03	4.9E-03	4.9E-03	0.26756	0.26297	0.26366	1966.6	1030.8	1033.5	0.14085	0.13843	0.13879	3.201	3.147	3.155	1.3E-04	1.3E-04	1.3E-04	8.1E-03	8.0E-03	8.0E-03	1.5E-03	1.5E-03	1.5E-03
17	Uashat - Mani-Utenam Camp	2599	2540	0.0667	0.0651	0.06536	0.705	0.689	0.692	3.6E-03	3.5E-03	3.6E-03	0.19569	0.19123	0.1919	1438.3	749.6	752.2	0.10302	0.10067	0.10102	2.342	2.288	2.296	9.7E-05	9.5E-05	9.5E-05	5.9E-03	5.8E-03	5.8E-03	1.1E-03	1.1E-03	1.1E-03
18	Uashat - Mani-Utenam Camp (Inukshuk Lake)	3654	3588	0.0937	0.0920	0.09224	0.991	0.973	0.976	5.1E-03	5.0E-03	5.0E-03	0.27505	0.2701	0.27084	2021.6	1058.8	1061.7	0.14479	0.14218	0.14258	3.291	3.232	3.241	1.4E-04	1.3E-04	1.3E-04	8.3E-03	8.2E-03	8.2E-03	1.6E-03	1.5E-03	1.5E-03
19	Naskapi Cabin	2403	2382	0.0616	0.0611	0.06115	0.652	0.646	0.647	3.4E-03	3.3E-03	3.3E-03	0.18093	0.17929	0.17954	1329.8	702.8	703.8	0.09524	0.09438	0.09451	2.165	2.145	2.148	9.0E-05	8.9E-05	8.9E-05	5.5E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
20	Naskapi Cabin	2422	2396	0.0621	0.0614	0.06152	0.657	0.650	0.651	3.4E-03	3.3E-03	3.3E-03	0.18233	0.18035	0.18064	1340.1	706.9	708.1	0.09598	0.09494	0.09509	2.182	2.158	2.161	9.0E-05	8.9E-05	9.0E-05	5.5E-03	5.5E-03	5.5E-03	1.0E-03	1.0E-03	1.0E-03
21	Bustard - Observation and hunting site	2374	2367	0.0609	0.0607	0.06072	0.644	0.642	0.643	3.3E-03	3.3E-03	3.3E-03	0.17872	0.17822	0.17829	1313.5	698.6	698.9	0.09408	0.09382	0.09386	2.138	2.132	2.133	8.9E-05	8.8E-05	8.8E-05	5.4E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
22	Bustard - Observation and hunting site	2442	2416	0.0626	0.0619	0.06204	0.663	0.655	0.656	3.4E-03	3.4E-03	3.4E-03	0.18385	0.18186	0.18216	1351.3	712.9	714.0	0.09678	0.09573	0.09589	2.200	2.176	2.180	9.1E-05	9.0E-05	9.0E-05	5.6E-03	5.5E-03	5.5E-03	1.0E-03	1.0E-03	1.0E-03
23	Picking site (berries / tea)	3342	3309	0.0857	0.0848	0.08497	0.907	0.898	0.899	4.7E-03	4.6E-03	4.6E-03	0.25159	0.24912	0.24949	1849.2	976.5	978.0	0.13244	0.13114	0.13134	3.010	2.981	2.985	1.2E-04	1.2E-04	1.2E-04	7.6E-03	7.6E-03	7.6E-03	1.4E-03	1.4E-03	1.4E-03
24	Irony Mountain	2844	2767	0.0729	0.0710	0.07125	0.772	0.751	0.754	4.0E-03	3.9E-03	3.9E-03	0.21408	0.20833	0.20919	1573.4	816.6	820.0	0.11269	0.10967	0.11012	2.562	2.493	2.503	1.1E-04	1.0E-04	1.0E-04	6.5E-03	6.3E-03	6.3E-03	1.2E-03	1.2E-03	1.2E-03
25	Innu Cabin	2404	2383	0.0616	0.0611	0.06119	0.652	0.647	0.647	3.4E-03	3.3E-03	3.3E-03	0.18101	0.17942	0.17966	1330.4	703.3	704.3	0.09529	0.09445	0.09458	2.166	2.147	2.150	9.0E-05	8.9E-05	8.9E-05	5.5E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
26	Innu Cabin	2389	2369	0.0612	0.0607	0.06082	0.648	0.643	0.644	3.3E-03	3.3E-03	3.3E-03	0.17982	0.17835	0.17857	1321.7	699.1	700.0	0.09466	0.09389	0.094	2.152	2.134	2.137	8.9E-05	8.8E-05	8.9E-05	5.5E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
27	Innu Cabin	2376	2359	0.0609	0.0605	0.06054	0.645	0.640	0.641	3.3E-03	3.3E-03	3.3E-03	0.17885	0.17756	0.17775	1314.5	696.0	696.8	0.09415	0.09347	0.09357	2.140	2.125	2.127	8.9E-05	8.8E-05	8.8E-05	5.4E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
28	Innu Cabin	2367	2352	0.0607	0.0603	0.06036	0.642	0.638	0.639	3.3E-03	3.3E-03	3.3E-03	0.17822	0.17704	0.17721	1309.9	694.0	694.7	0.09382	0.0932	0.09329	2.132	2.118	2.120	8.8E-05	8.8E-05	8.8E-05	5.4E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
29	Innu Cabin	2371	2355	0.0608	0.0604	0.06045	0.643	0.639	0.640	3.3E-03	3.3E-03	3.3E-03	0.17852	0.1773	0.17748	1312.1	695.0	695.7	0.09398	0.09333	0.09343	2.136	2.121	2.124	8.9E-05	8.8E-05	8.8E-05	5.4E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
30	Innu Cabin	2362	2347	0.0606	0.0602	0.06023	0.641	0.637	0.637	3.3E-03	3.3E-03	3.3E-03	0.17781	0.17669	0.17685	1306.9	692.6	693.3	0.0936	0.09301	0.0931	2.128	2.114	2.116	8.8E-05	8.8E-05	8.8E-05	5.4E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
31	Innu Cabin	2376	2357	0.0609	0.0604	0.06051	0.645	0.640	0.640	3.3E-03	3.3E-03	3.3E-03	0.17888	0.17745	0.17766	1314.7	695.6	696.4	0.09416	0.09341	0.09353	2.140	2.123	2.126	8.9E-05	8.8E-05	8.8E-05	5.4E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
32	Innu Cabin	2356	2347	0.0604	0.0602	0.06021	0.639	0.637	0.637	3.3E-03	3.3E-03	3.3E-03	0.1774	0.17667	0.17678	1303.9	692.5	693.0	0.09339	0.093	0.09306	2.123	2.114	2.115	8.8E-05	8.8E-05	8.8E-05	5.4E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
33	Naskapi Cabin	2400	2381	0.0615	0.0611	0.06113	0.651	0.646	0.647	3.3E-03	3.3E-03	3.3E-03	0.18068	0.17927	0.17948	1328.0	702.7	703.6	0.09511	0.09437	0.09448	2.162	2.145	2.148	9.0E-05	8.9E-05	8.9E-05	5.5E-03	5.4E-03	5.4E-03	1.0E-03	1.0E-03	1.0E-03
34	Naskapi Cabin	2470	2439	0.0633	0.0625	0.06266	0.670	0.662	0.663	3.4E-03	3.4E-03	3.4E-03	0.18595	0.18364	0.18399	1366.8	719.9	721.2	0.09789	0.09667	0.09686	2.225	2.197	2.201	9.2E-05	9.1E-05	9.1E-05	5.6E-03	5.6E-03	5.6E-03	1.1E-03	1.0E-03	1.0E-03
35	Naskapi Cabin	2416	2399	0.0620	0.0615	0.06158	0.656	0.651	0.652	3.4E-03	3.3E-03	3.4E-03	0.18192	0.18061	0.18081	1337.1	708.0	708.8	0.09577	0.09508	0.09518	2.177	2.161	2.163	9.0E-05	9.0E-05	9.0E-05	5.5E-03	5.5E-03	5.5E-03	1.0E-03	1.0E-03	1.0E-03
36	Kawawachikamak (Town)	2317	2314	0.0594	0.0593	0.05934	0.629	0.628	0.628	3.2E-03	3.2E-03	3.2E-03	0.17441	0.17421	0.17424	1281.9	682.9	683.0	0.09181	0.09171	0.09172	2.087	2.084	2.085	8.6E-05	8.6E-05	8.6E-05	5.3E-03	5.3E-03	5.3E-03	9.9E-04	9.9E-04	9.9E-04
37	Lac John (Town)	2320	2316	0.0595	0.0594	0.05940	0.629	0.628	0.629	3.2E-03	3.2E-03	3.2E-03	0.17463	0.17436	0.1744	1283.5	683.5	683.6	0.09193	0.09178	0.09181	2.090	2.086	2.087	8.7E-05	8.6E-05	8.6E-05	5.3E-03	5.3E-03	5.3E-03	9.9E-04	9.9E-04	9.9E-04
38	Matimekush (Town)	2325	2321	0.0596	0.0595	0.05952	0.631	0.630	0.630	3.2E-03	3.2E-03	3.2E-03	0.17505	0.1747	0.17475	1286.6	684.8	685.0	0.09215	0.09197	0.09199	2.095	2.090	2.091	8.7E-05	8.7E-05	8.7E-05	5.3E-03	5.3E-03	5.3E-03	9.9E-04	9.9E-04	9.9E-04
39	Schefferville (Town)	2328	2323	0.0597	0.0596	0.05958	0.632	0.630	0.630	3.2E-03	3.2E-03	3.2E-03	0.17528	0.17489	0.17494	1288.3	685.5	685.8	0.09227	0.09206	0.09209	2.097	2.093	2.093	8.7E-05	8.7E-05	8.7E-05	5.3E-03	5.3E-03	5.3E-03	9.9E-04	9.9E-04	9.9E-04
40	Workers' Camp	4619	4444	0.1184	0.1140	0.11463	1.253	1.206	1.213	6.4E-03	6.2E-03	6.2E-03	0.34777	0.33458	0.33656	2556.1	1311.5	1319.3	0.18307	0.17613	0.17717	4.161	4.003	4.027	1.7E-04	1.7E-04	1.7E-04	1.1E-02	1.0E-02	1.0E-02	2.0E-03	1.9E-03	1.9E-03
	"Off-Property Limit" Maximum	9183	9096	0.2355	0.2332	0.23356	2.492	2.468	2.471	1.3E-02	1.3E-02	1.3E-02	0.69133	0.68478	0.68576	5081.3	2684.3	2688.2	0.36393	0.36048	0.361	8.272	8.194	8.205	3.4E-04	3.4E-04	3.4E-04	2.1E-02	2.1E-02	2.1E-02	3.9E-03	3.9E-03	3.9E-03

D2. GoldSim® Multimedia Exposure Model

Appendix D
GoldSim Multi-Media Exposure and Risk Model
Proposed Howse Property Mine Development



1. Baseline Deterministic Assessment
Baseline assessment conducted as banchmark for determination of incremental project and cumulative human health risks.

2. Project Deterministic Assessment
Project + baseline deterministic assessment of adult and toddler receptors. Exposure point concentrations influenced by fugitive dust and subsequent soil deposition. Exposure assumes 16 weeks per year in project area with remaining 36 weeks in local communities.

3. Cumulative Deterministic Assessment
Mechanics and exposure duration assumptions for the cumulative deterministic risk assessment are identical to the project scenario deterministic assessment. Only exposure point conentrations vary based on increased particulate dispersion adn associated impacts on soil quality and tissue quality. Refer to Model Section 2 for mechanistic details of the calculations.

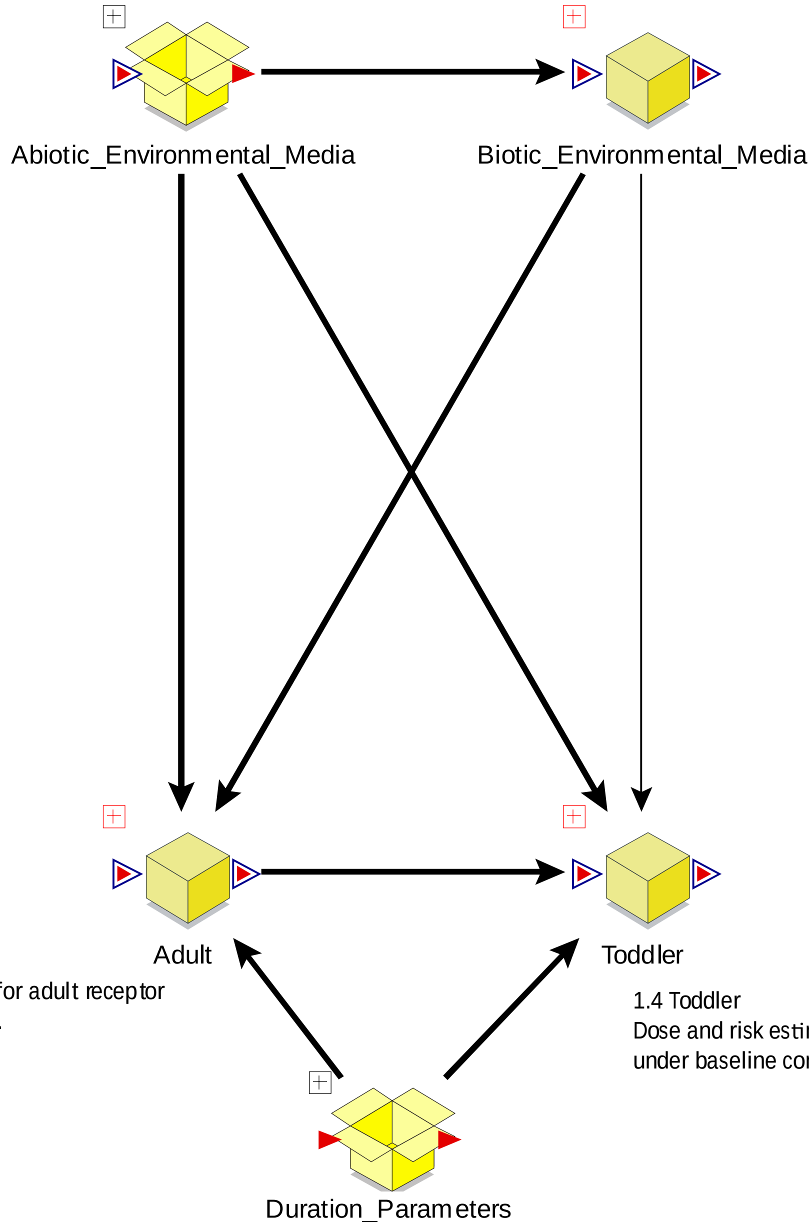
4. Geospatial Probabilistic Inhalation

5. Input/Output Global Container
Contains functions to import and exposrt point estimates to an external Microsoft Excel workbook
.

1 Baseline Assessment

1.1 Abiotic Environmental Concentrations
Baseline measured or assumed concentrations of COPCs in soil, airborne particulates, surface water which influence which influence plant adn animal tissue concentrations, and result in direct human exposure.

1.2 Biotic Environmental Concentration
Measured or predicted concentrations of COPCs in plant and animal tissues consumed by human receptors.

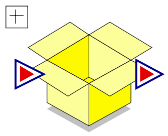


1.3 Adult Receptor
Dose and risk estimation for adult receptor under baseline conditions.

1.4 Toddler
Dose and risk estimation for toddler receptor under baseline conditions.

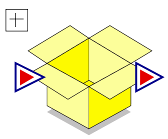
1.5 Duration Parameters
Duration parameters (days/week, weeks/year, etc.) used for baseline assessment.

1.1 Abiotic Environmental Concentrations



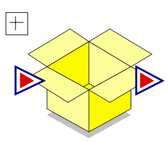
COPC_Water

1.1.1 Water
Baseline exposure point concentrations for surface water.



COPC_Soil

1.1.2 Soil
Baseline exposure point concentrations for soil.

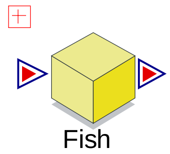


COPC_Particulate

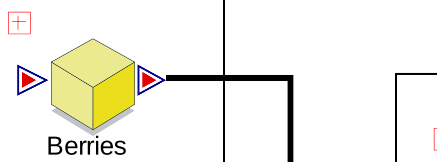
1.1.3 Airborne Particulates
Exposure point coinentrations for airborne particulates

1.2 Biotic Environmental Concentrations

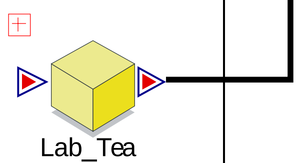
1.2.1 Fish Tissue
Maximum measured concetrations if COPCs in fish tissue. Where COPC <LOD, tissue concentrations is modelled using water-to-fish transfer feactors.



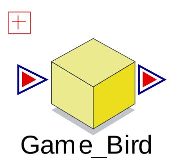
1.2.2 Berries
UCL95 of measured COPC concentration in partridgeberry. Where [COPC] <LOD, tissue concentrations were modelled using soil-to-berry transfer factors.



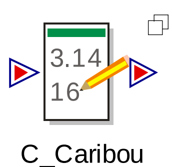
1.2.3 Labrador Tea
Exposure point concentration of labrador tea tissue as UCL95 of measured [COPC]. Where [COPC} <LOD tissue concentrations modelled using soil-to-vegetation transfer factors.

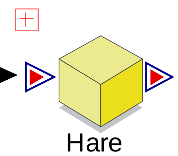


1.2.4 Game Bird
Maximum [COPC] measured in spruce grouse collected from the LSA.



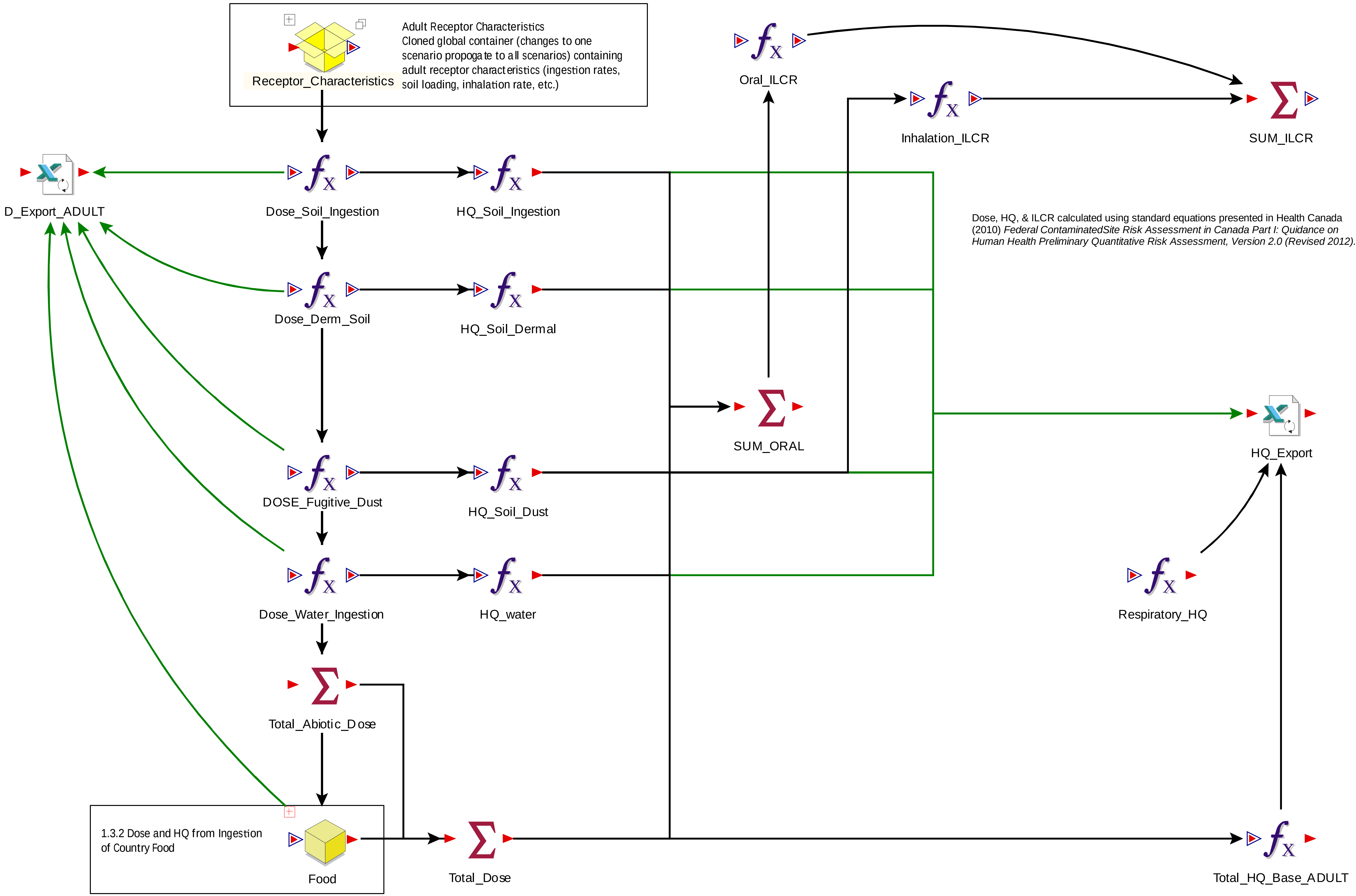
1.2.5 Caribou
Average [COPC] in muscle tissue derived from literature sources (See Appendix B2).





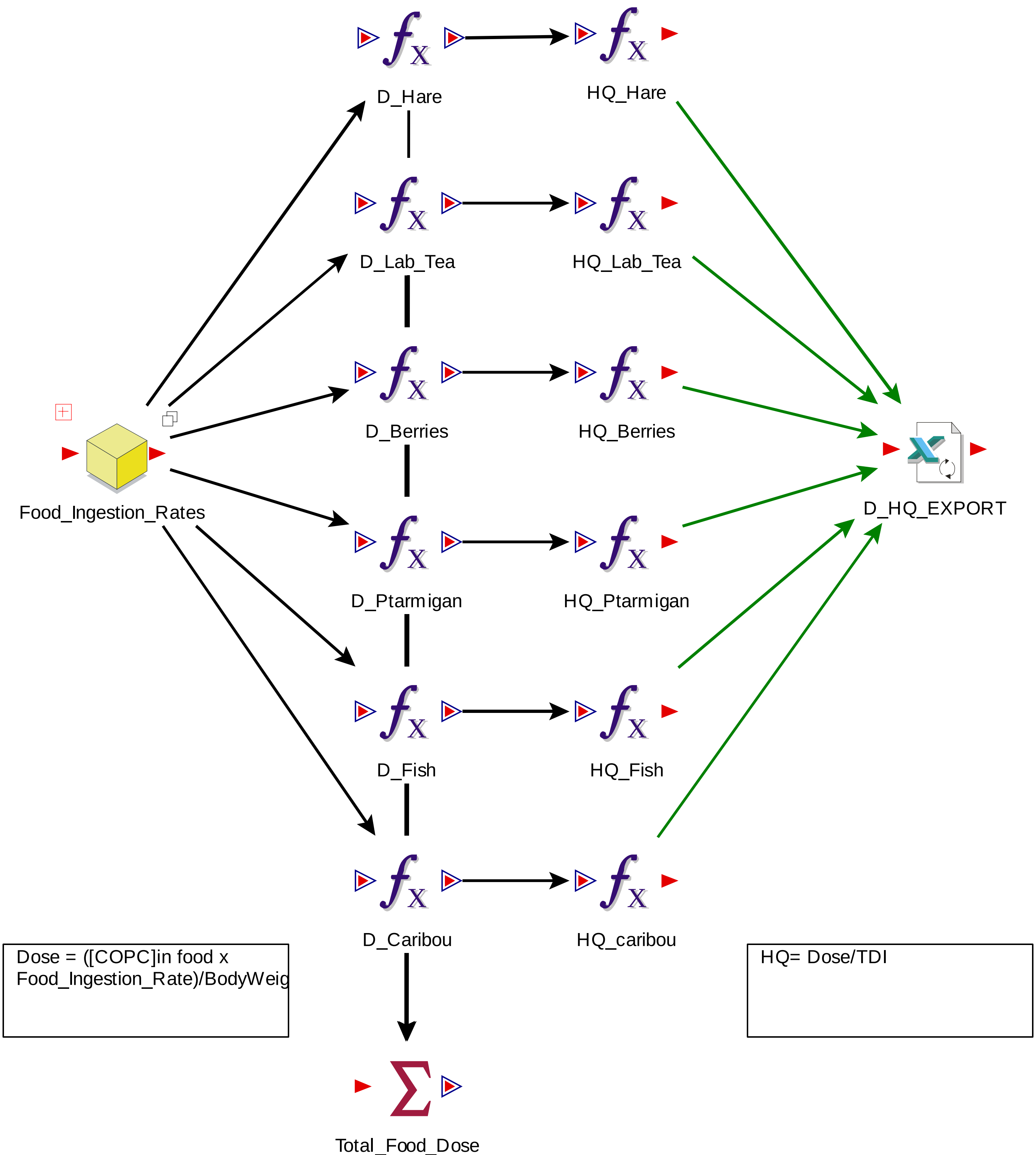
1.2.6 Hare
Snowshoe hare used as surrogate for small terrestrial game. Modelled [COPC] based on FCSAP receptor characteristics and site specific exposure point concentrtions.

1.3 Adult Receptor - Dose and Risk Estimates under Baseline Conditions



Dose, HQ, & ILCR calculated using standard equations presented in Health Canada (2010) *Federal ContaminatedSite Risk Assessment in Canada Part I: Quidance on Human Health Preliminary Quantitative Risk Assessment, Version 2.0 (Revised 2012).*

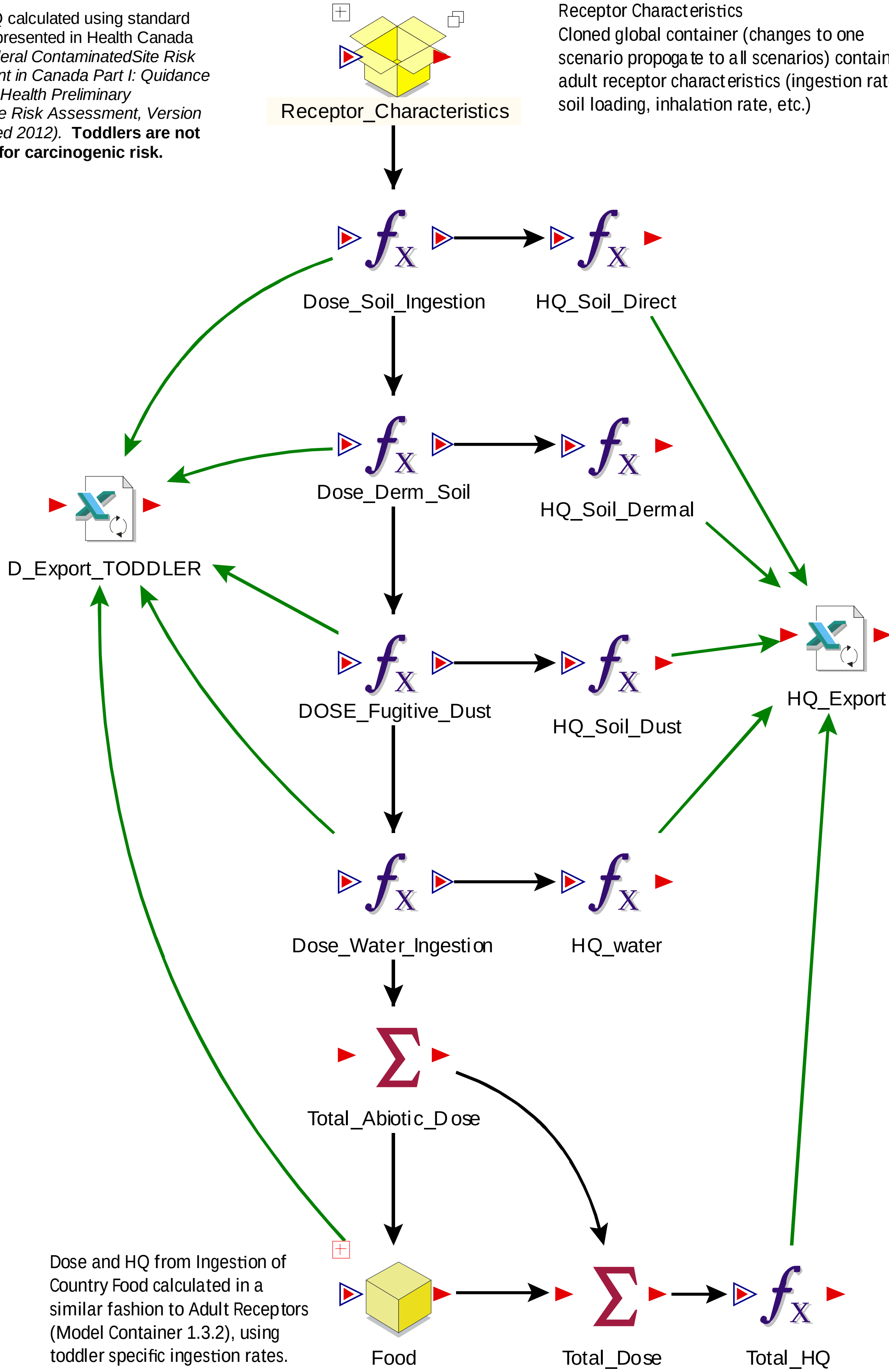
1.3.2 Adult Dose and HQs: Ingestion of Country Food



1.4 Toddler Receptor - Dose and HQs under Baseline Conditions

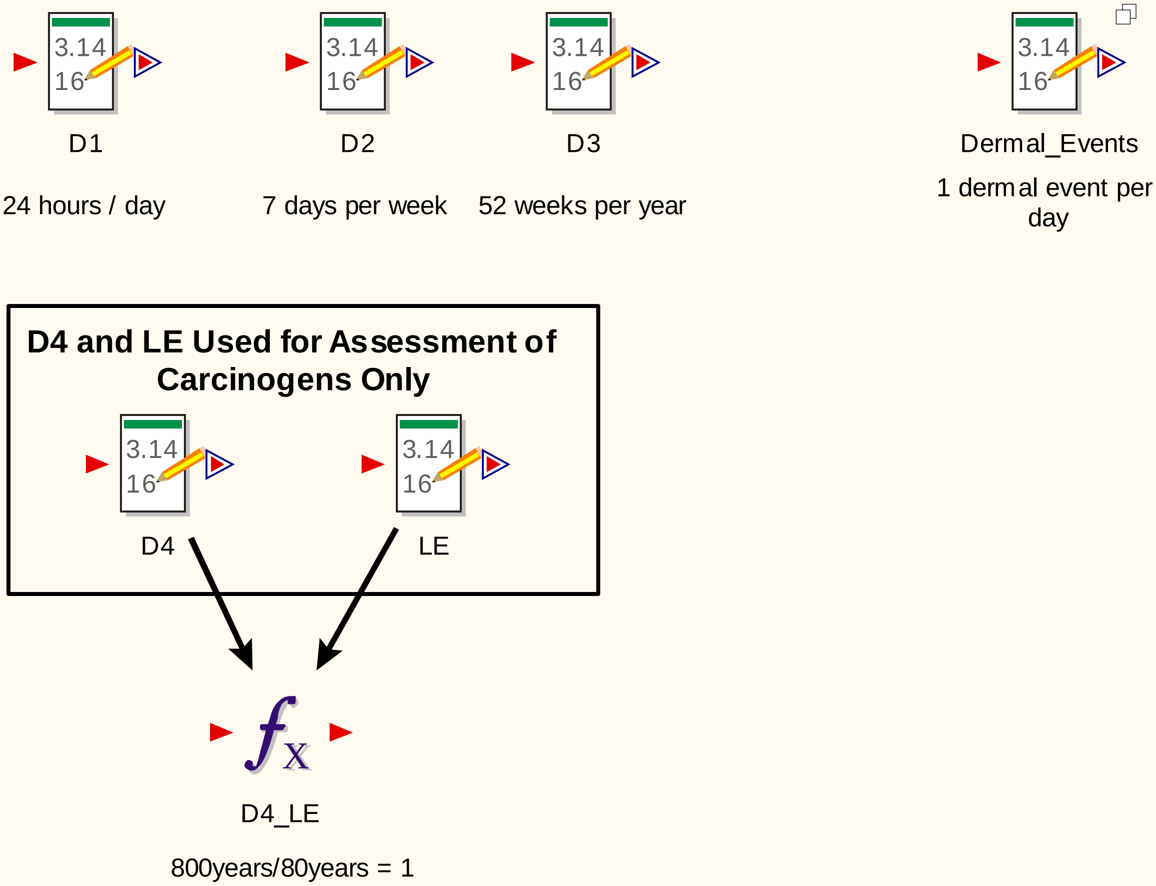
Dose & HQ calculated using standard equations presented in Health Canada (2010) *Federal ContaminatedSite Risk Assessment in Canada Part I: Quidance on Human Health Preliminary Quantitative Risk Assessment, Version 2.0 (Revised 2012).* **Toddlers are not assessed for carcinogenic risk.**

Receptor Characteristics
Cloned global container (changes to one scenario propogate to all scenarios) containing adult receptor characteristics (ingestion rates, soil loading, inhalation rate, etc.)

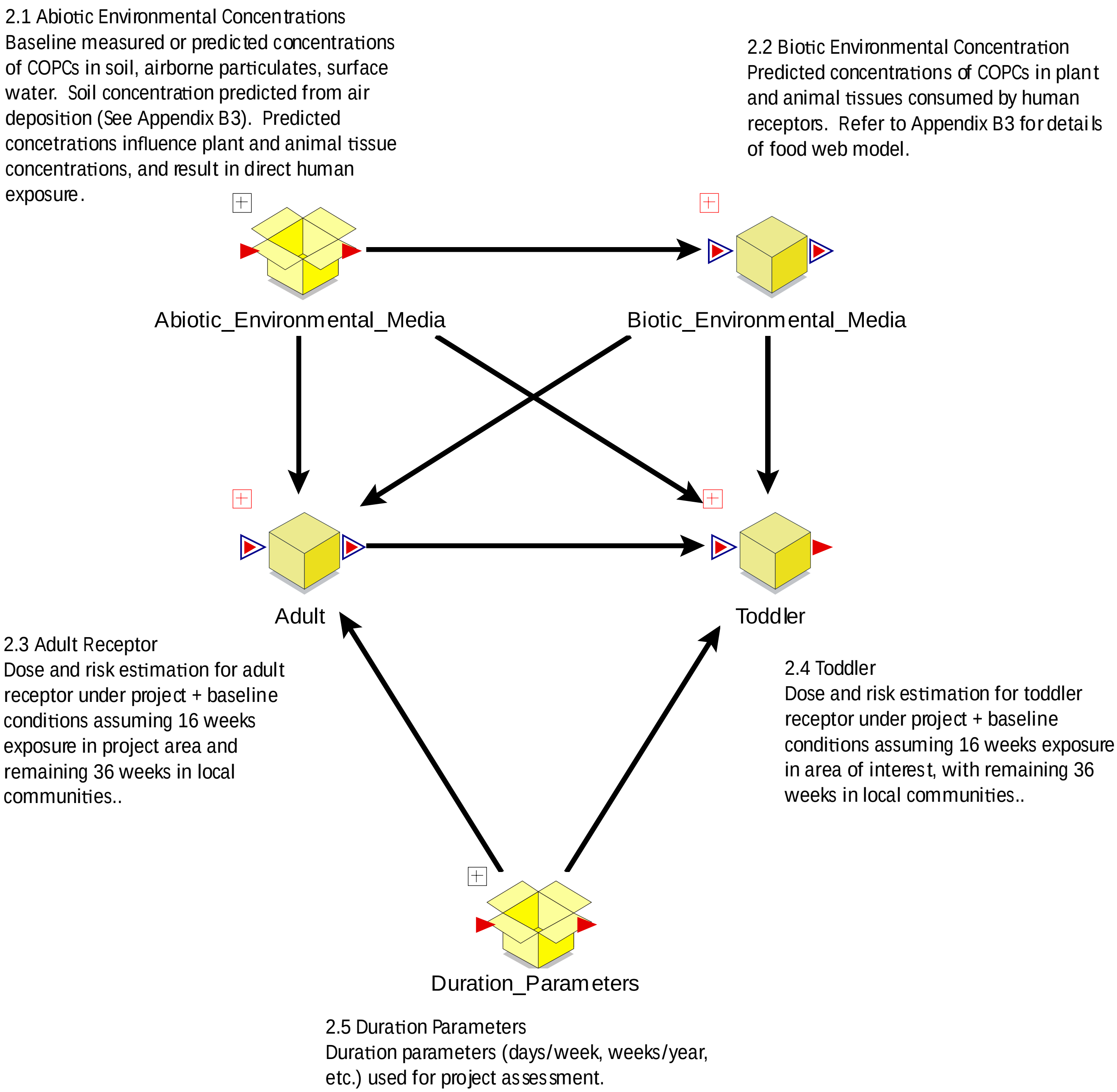


Dose and HQ from Ingestion of Country Food calculated in a similar fashion to Adult Receptors (Model Container 1.3.2), using toddler specific ingestion rates.

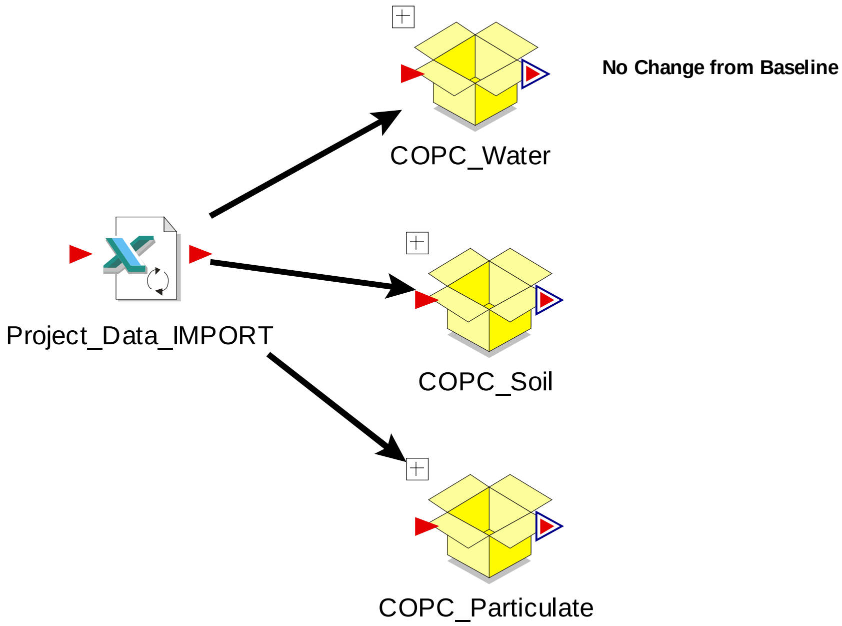
1.5 Duration Parameters



2 Project Deterministic Assessment

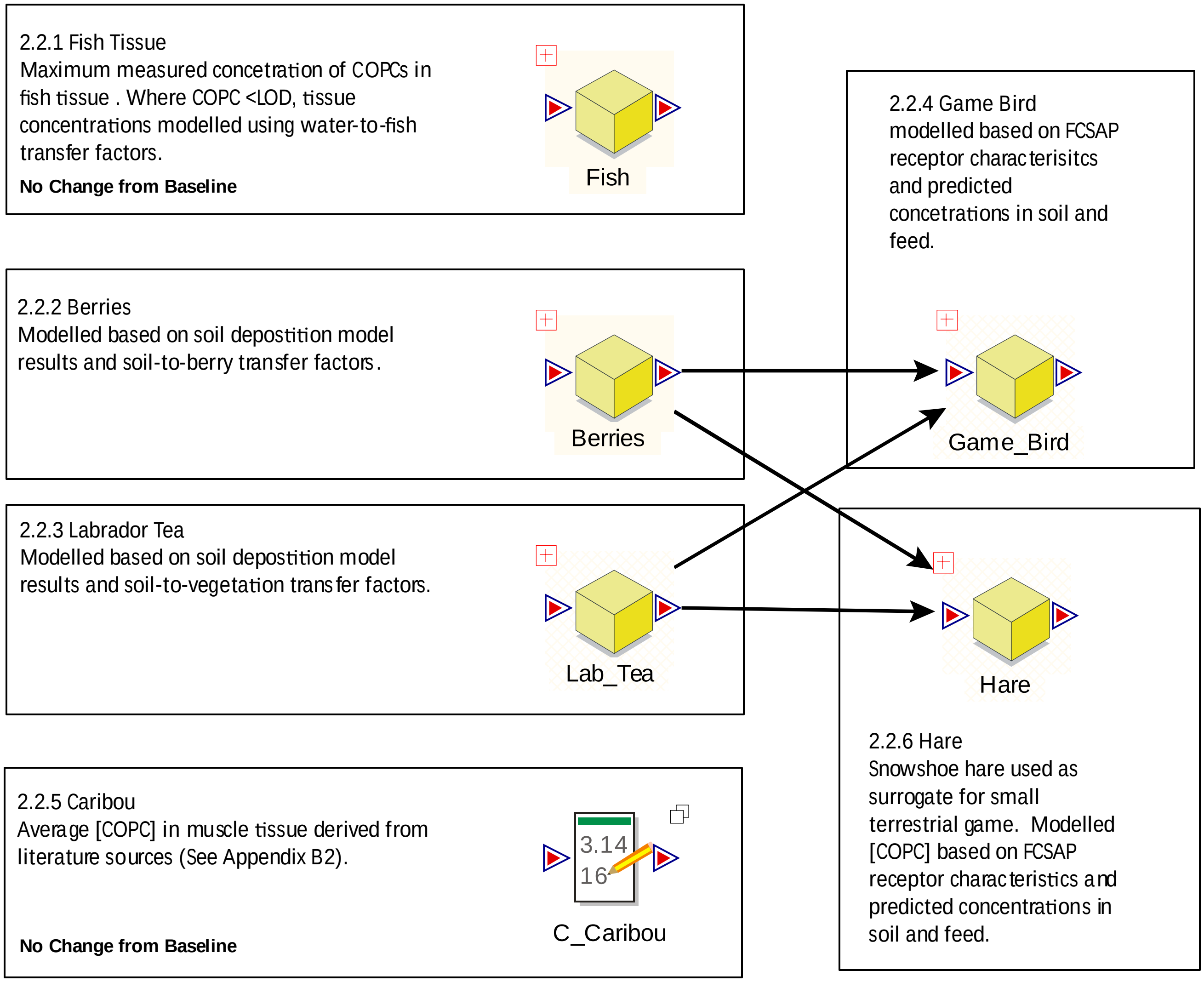


2.1 Abiotic Environmental Concentrations



Baseline measured or predicted concentrations of COPCs in soil, airborne particulates and surface water are imported from an external MS Excel Spreadhseet. (Appendix D2).

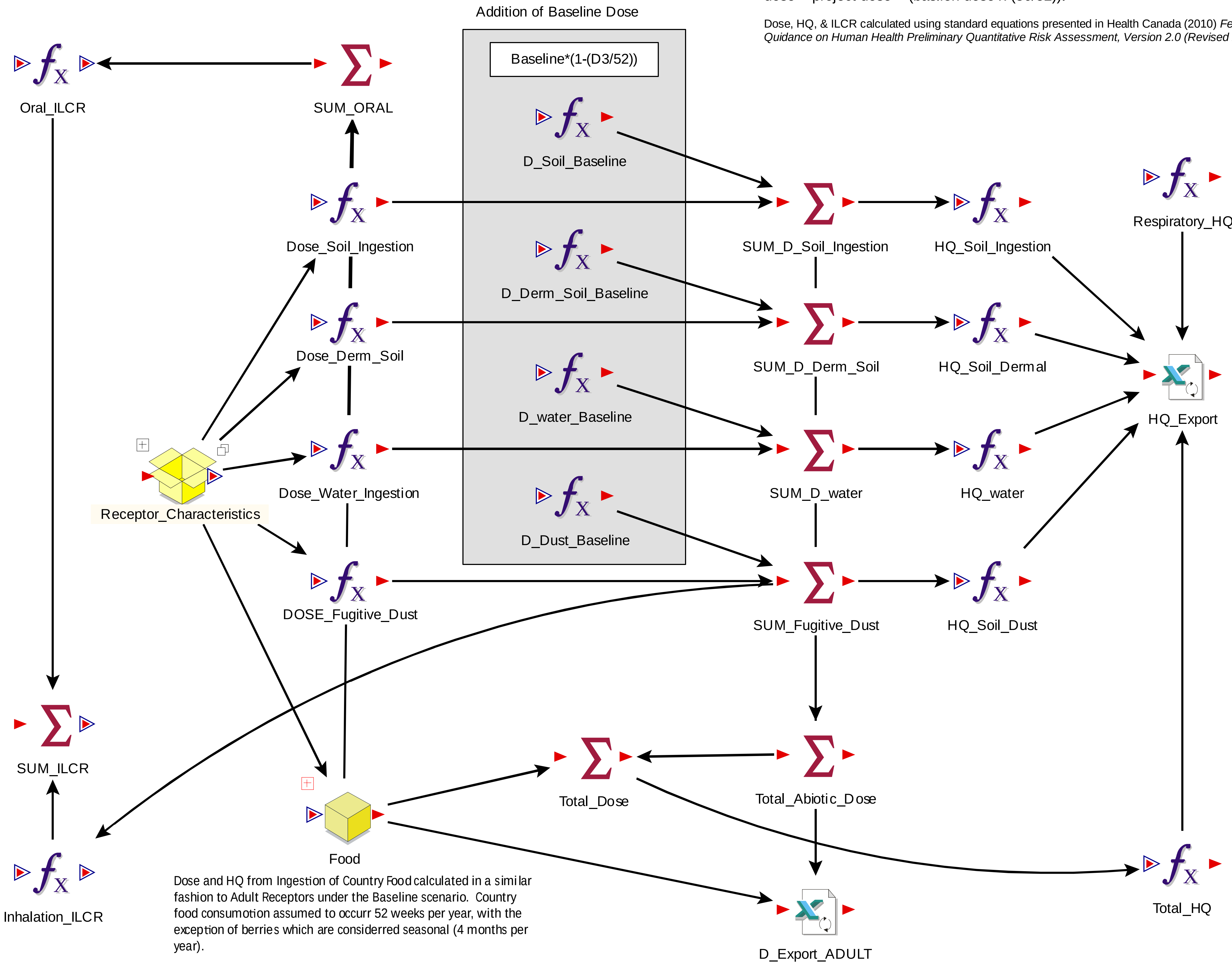
2.2 Biotic Environmental Concentrations



2.3 Adult Receptor Deterministic Project + Baseline

Dose and risk estimation for adult receptor under project + baseline conditions assuming 16 weeks exposure in project area and remaining 36 weeks in local communities. Calculated dose assumes 16 weeks occupance in the project area. Total dose = project dose + (baslien dose x (36/52)).

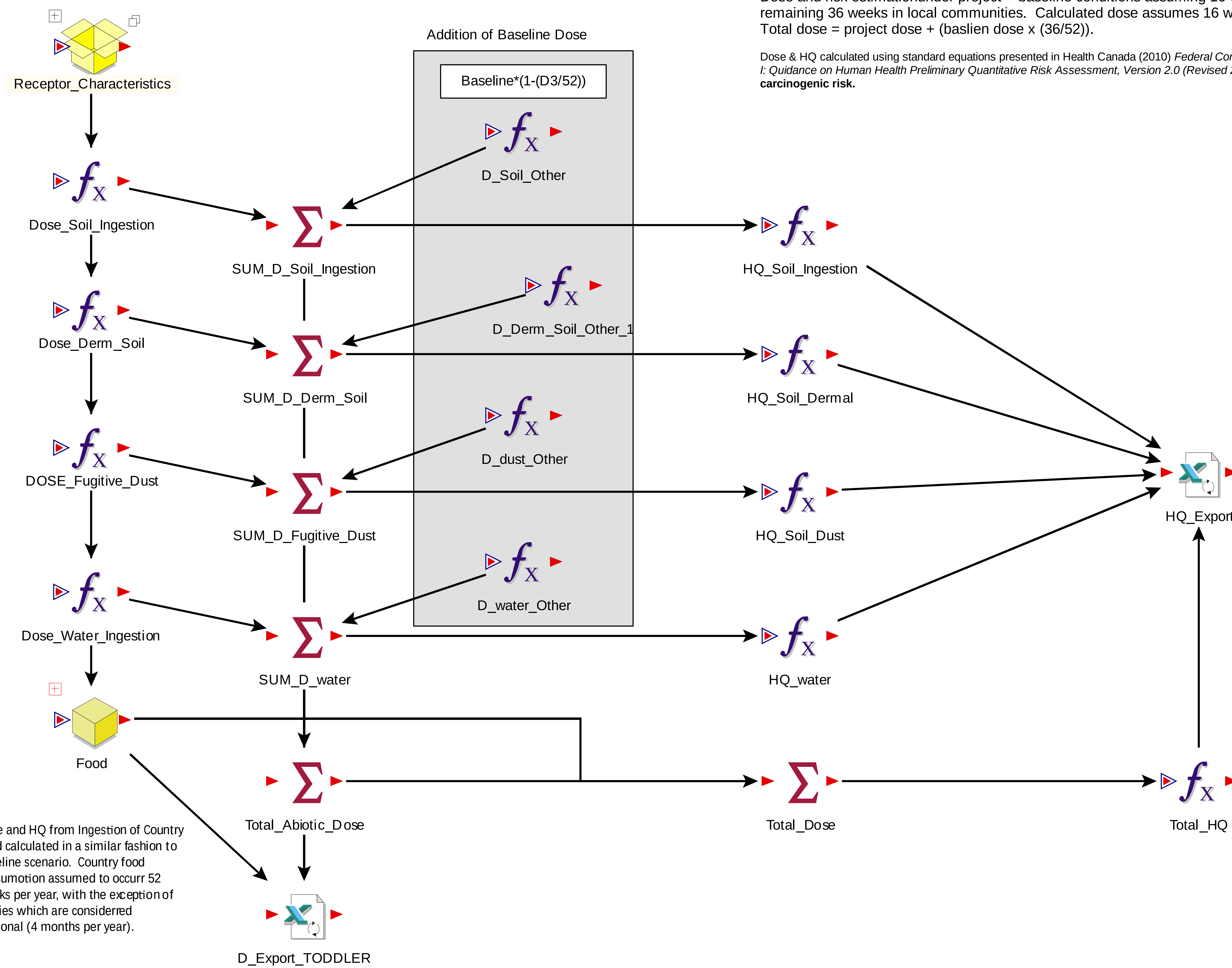
Dose, HQ, & ILCR calculated using standard equations presented in Health Canada (2010) *Federal ContaminatedSite Risk Assessment in Canada Part I: Quidance on Human Health Preliminary Quantitative Risk Assessment, Version 2.0 (Revised 2012).*



2.4 Toddler Project + Baseline Deterministic Assessment

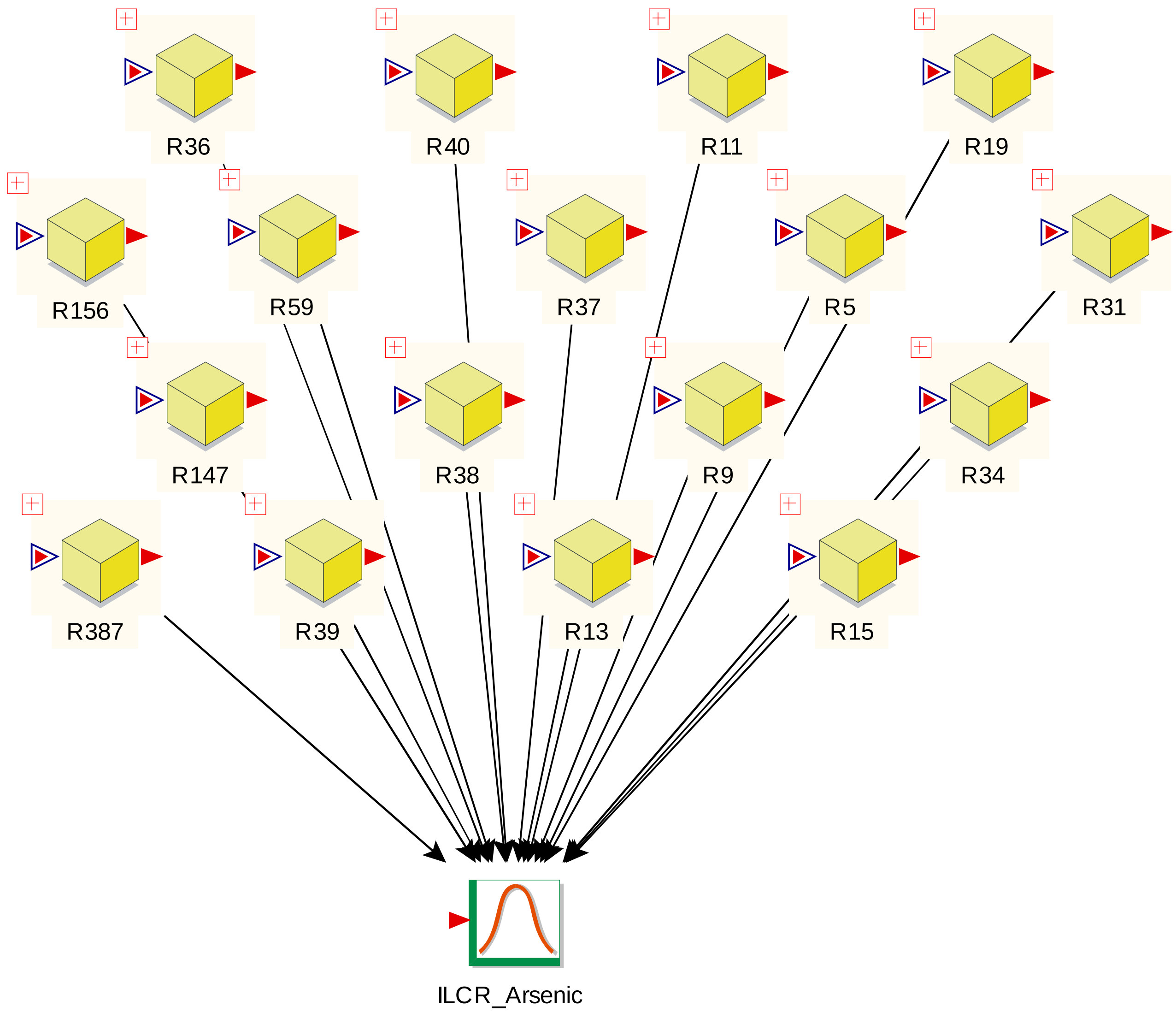
Dose and risk estimationunder project + baseline conditions assuming 16 weeks exposure in project area and remaining 36 weeks in local communities. Calculated dose assumes 16 weeks occupance in the project area. Total dose = project dose + (baslien dose x (36/52)).

Dose & HQ calculated using standard equations presented in Health Canada (2010) *Federal ContaminatedSite Risk Assessment in Canada Part I: Quidance on Human Health Preliminary Quantitative Risk Assessment, Version 2.0 (Revised 2012).* **Toddlers are not assessed for carcinogenic risk.**



Dose and HQ from Ingestion of Country Food calculated in a similar fashion to baseline scenario. Country food consumotion assumed to occurr 52 weeks per year, with the exception of berries which are considered seasonal (4 months per year).

4. Geospatial Probabilistic Inhalation

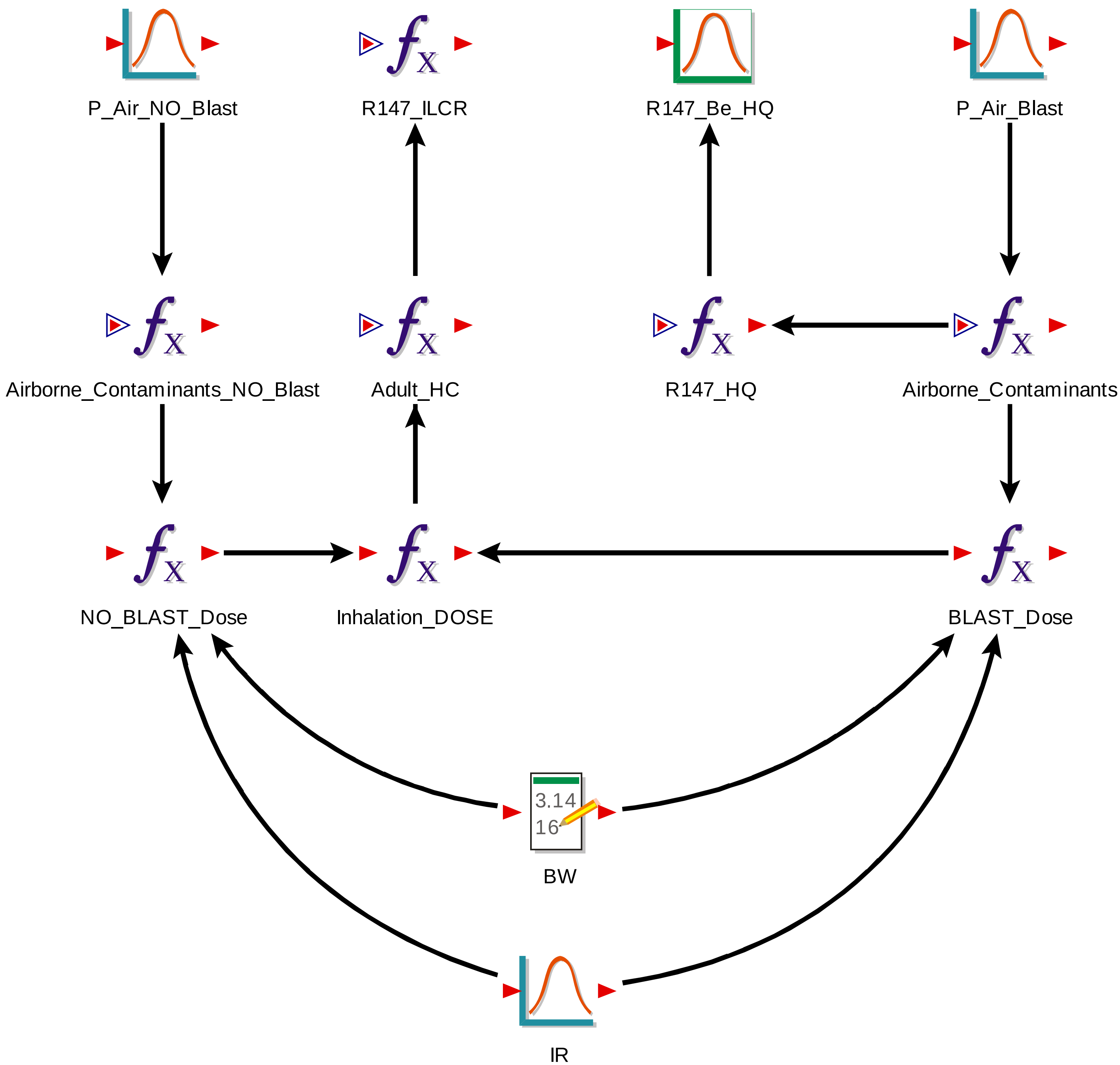


ID	Name	UTM Coordinates
147	Grid 147 off property max location with blast	625.4565 , 6083.702
156	Grid 156 off property max location with blast	625.6801 , 6083.313
59	Grid 59 off property max location without blast	622.2434, 6085.730
387	Grid 387 off property max location without blast	618.5496 , 6086.562
5	Innu Camp	614.85 , 6087.33
9	Young Naskapi Camp (Pinette Lake)	620.46 , 6084.82
11	Young Naskapi Trailer tent (Triangle Lake)	618.09 , 6088.32
13	Uashat people's camp 2	617.80 , 6087.04
15	Young Naskapi Camp (Howells River)	622.30 , 6077.86
19	Naskapi Cabin	631.68 , 6080.09
31	Innu Cabin	633.13 , 6080.34
34	Naskapi Cabin	616.69 , 6084.22
36	Kawawachikamak (Town)	643.50 , 6082.13
37	Lac John (Town)	642.39 , 6076.24
38	Matimekush (Town)	640.80 , 6075.60
39	Schefferville (Town)	640.60 , 6075.00
40	Workers' Camp	624.47 , 6082.77

4.1 Example Probabilistic Framework

Dose and risk estimation for adult receptors via the inhalation of fugitive dust under cumulative scenario. Calculated dose assumes 52 weeks exposure. Chemistry of particulates is drawn from a stochastic element (log-normal probability distribution) for the individual COPCs. This element is contained within model container #5 (Input_Output). Stochastic inputs also include particulate concentrations during blast and no-blast conditions, as well as receptor inhalation rate.

Dose, HQ, & ILCR calculated using standard equations presented in Health Canada (2010) *Federal ContaminatedSite Risk Assessment in Canada Part I: Quidance on Human Health Preliminary Quantitative Risk Assessment, Version 2.0 (Revised 2012).*



Appendix E

Environmental Chemistry

- E1. Statistical Summary
- E2. Human Health Risk Assessment Data Tables

E1. Statistical Summary

Appendix E1
Summary Statistics for Environmental Concentration Data

This Appendix outlines the workflow process for computation of summary statistics, including 95% Upper Confidence Limits of the mean (UCL95) for environmental concentration data with and without non-detect. Summary statistics were computed using the US Environmental Protection Agencies' statistical platform ProUCL Version 4.1. This workflow was developed based on a review of relevant literature, and guidance delivered by Dr. Dennis Helsel [1,2]. The flowchart included as Figure 1 shows the workflow process. The rationale for selection of statistical procedures is described in the text below. Text specific to portion of the flowchart are signified by corresponding numbers, (ι) for example.

Calculating an upper confidence limit on environmental data that does not have ND values is largely influenced by the number of observations (n) and the skewness of the data. For data sets where the number of observations is less than twenty (n<20) bootstrap re-sampling techniques are unlikely to capture the breadth of the sample population shape, and are likely to return inaccurate estimates of the UCL. Under these circumstances either a normal or gamma distribution is assumed based on the strongest goodness of fit statistic provided by ProUCL (i.e. larger R-squared value). ProUCL does not include suitable methods for computation of 95% UCLs based on lognormal distributions, so non-normal (i.e. skewed) distributions are assumed to resemble a gamma distribution. Based on the selected distribution the 95% Student's-t UCL or 95% Adjusted Gamma UCL was carried forward for normal and gamma distributions respectively (ι). For datasets without non-detect values and a sample size of n≥20 bootstrap re-sampling techniques are the best way to compute a UCL95 from skewed data (Helsel, 2012). The Bias Corrected Accelerated Bootstrap (BCA) intervals are recommended for general use, especially for non-parametric problems[3]. The BCA bootstrap technique adjusts for skewness and provides a confidence limit of the mean that that should exceed the true population mean in 95% of cases (i.e. 95% coverage). Under these circumstances (φ) the 95% BCA Bootstrap UCL was used.

In the past, regulatory guidance in environmental sciences supported the use of substitution methods for handing data below reportable limits of detection (ND values). Substitution methods introduce invasive data resulting in poor estimates and incorrect statistical tests (Helsel, 2012). Substitution methods do not provide adequate coverage for UCLs computed on censored data, even when censoring levels are as low as 10% [4] and based on this study the US EPA have stated that "*it is strongly recommended to avoid the use of the DL/2 method….even when the percentage of NDs if as low as 5-10%*"[5]. Accordingly, AECOM did not use substitution methods in this statistical analysis.

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[1] Course presented January 19th 2012 to the Society of Contaminated Sites Approved Professionals of British Columbia titled *Environmental Statistics Using ProUCL.*

[2] Course presented November 29th 2012 titled *Practical Statistics for Contaminated Site Studies* through GeoEnviroLogic Professional Development.

[3] B. Efron and R. J. Tibshirani, An Introduction to the Bootstrap, Boca Raton, FL: CRC Press, 1994..

[4] Singh, A., Maichle, R., and Lee, S. 2006. On the Computation of a 95% Upper Confidence Limit of the Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations. EPA/600/R-06/022, March 2006. Available at: http://www.epa.gov/osp/hstl/tsc/softwaredocs.htm

[5] USEPA 2012 ProUCL Version 4.1 User Guide (Draft). EPA/600/r-07/041. US Environmental Protection Agency, Office of Research and Development, Washington, DC. Available at http:// http://www.epa.gov/osp/hstl/tsc/ProUCL_v4.1_user.pdf.

Two non-substitution methods for handling non-detects are include in ProUCL; (a) the Kaplan-Meier procedure (KM), and; (b) Robust Regression on Order Statistics (ROS).

a. Kaplan-Meier: The KM procedure is a nonparametric method thereby not requiring transformations or assumptions of distribution, and is the standard in medical and industrial statistics for estimating a mean of censored data(6). KM was determined to be the most reliable method for computing the 95% upper confidence limit on the mean (UCL95) of concentration data(4). The KM method was not developed for use where a single censoring value (i.e. one reportable detection limit) exists in the population. In this case the KM estimates of the mean will be equal to the mean based on DL substitution. Datasets with a single censoring level are common for projects of a short duration where a single laboratory has been used. AECOM have used KM methods for datasets with multiple detections limits (κ).
b. Robust Regression on Order Statistics (ROS): The ROS procedure is the most suitable method for datasets with a single detection limit (7). ROS uses regression on a probability plot to estimate distributional parameters, usually in log units. Individual estimates are then predicted from the line, and retransformed back into original units. No transformation of the estimated summary statistics occurs. The imputed values are then used collectively with the detected data to compute summary statistics. This is the preferred method for datasets with a single censoring level (λ).

Calculation of summary statistics, including 95% UCLs, for datasets with NDs is based on the both the number of censoring levels as described above as well as the percentage of the dataset being censored (μ). For datasets where less than 40% of the observations are censored, the BCA method is used. BCA intervals are recommended for general use for datasets where the degree of censoring is low (<40%) however the method breaks down when the degree of censoring is high (≥40%) (4). Under these circumstances the median value, which is used to make the adjustment for skewness, is difficult/impossible to determine (4). Therefore, AECOM have elected to use BCA Bootstrap UCL95s for datasets where the degree of censoring is low (<40%), and 95% Percentile Bootstrap UCLs where 40% or more of the observations are NDs (μ).

[6] Klein and Moeschberger, 2003; as cited in Denis R. Helsel. 2009. Summing Nondetects: Incorporating Low-Level contaminants in Risk Assessment. Integrated Environmental Assessment and Management. Vol.6, No. 3, pp. 361-366.

[7] Helsel D.R. 2005. Nondetects and data analysis: Statistics for censored environmental data. Hoboken (NJ). John Wiley & Sons, 250p.

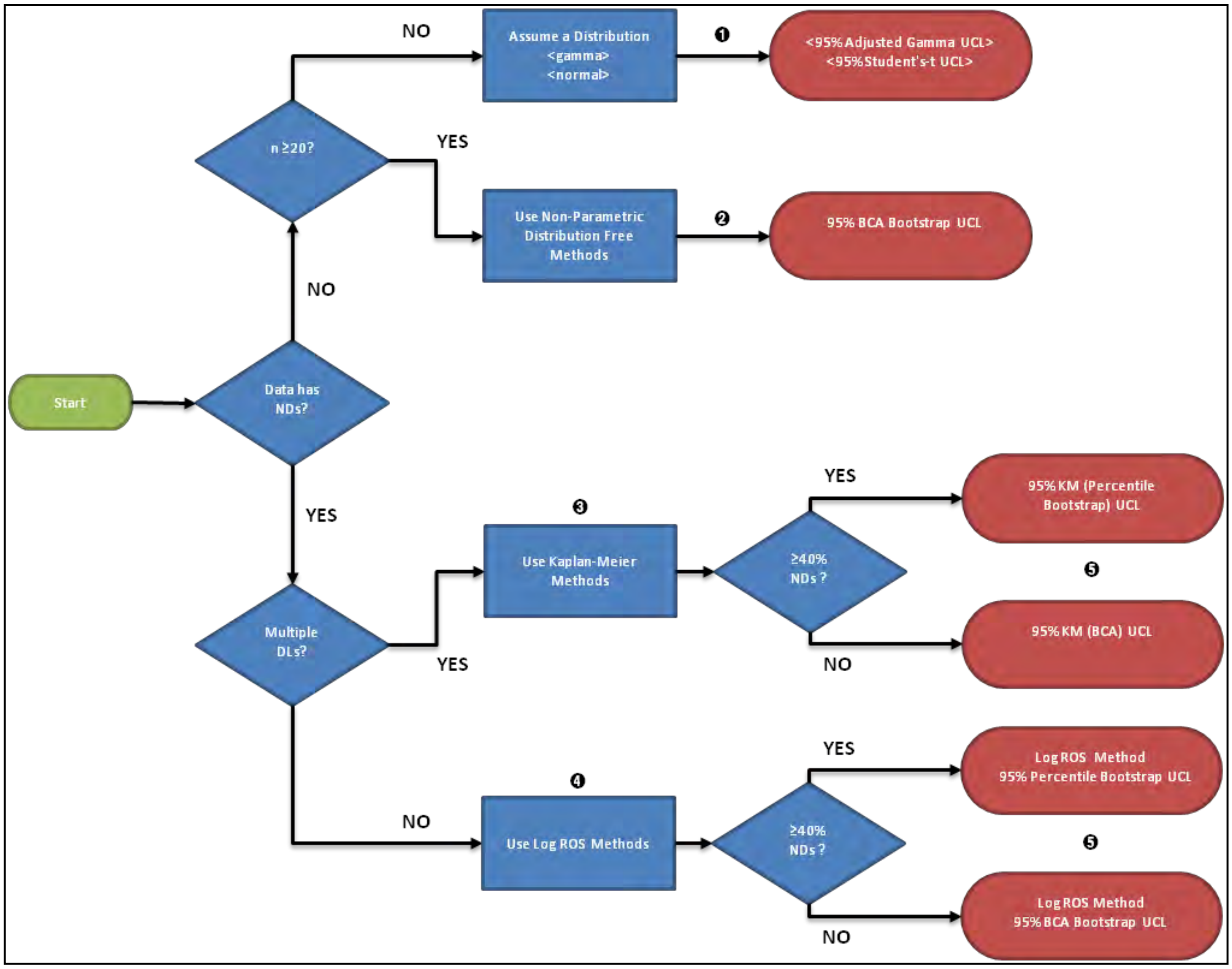

Figure 1: Flowchart showing decision making process for selection of appropriate UCL95s from ProUCL output for environmental concentration data

Table 1: Summary Statistics – All Collocated Soil Samples (mg/kg)

Contaminant	n	n Detected	% ND	n Distinct	n Missing	Max.	Min.	Mean	SD	CV	Skewness	UCL95	Method
Arsenic	31	30	3%	10	0	17	5	10.13	3.099	0.306	-	10.74	6
Barium	31	31	0%	22	0	150	12	36.39	30.82	0.847	2.823	49.26	2
Beryllium	27	26	4%	5	0	0.6	0.2	0.342	0.115	0.336	-	0.37	6
Chromium	31	31	0%	16	0	29	5	17.42	6.015	0.345	-0.508	19.13	2
Iron	31	31	0%	24	0	62000	9600	46052	12518	0.272	-1.328	49148	2
Lead	31	31	0%	16	0	51	2	13.71	8.137	0.594	3.253	17.26	2
Manganese	31	31	0%	27	0	1900	50	1028	516	0.502	0.144	1177	2
Mercury	27	26	4%	10	0	0.24	0.02	0.0612	0.0454	0.742	-	0.0808	6
Molybdenum	31	26	16%	18	0	3.3	0.7	2.146	0.842	0.392	-	2.24	4
Selenium	31	3	90%	2	0	0.8	0.5	0.6	0.134	0.223	-	0.8	Max

Method:
1. 95% Adjusted Gamma UCL
2. 95% BCA Bootstrap UCL
3. 95% KM (Percentile Bootstrap) UCL
4. 95% KM (BCA) UCL
5. Log ROS 95% Percentile Bootstrap UCL
6. Log ROS 95% BCA Bootstrap UCL

Table 2: Summary Statistics – Collocated Partridge Berries Samples

Contaminant	n	n Detected	% ND	n Distinct	n Missing	Max.	Min.	Mean	SD	CV	Skewness	UCL95	Method
Arsenic	12	0	100	0	0	<2.0	-	-	-	-	-	<2.0	Max
Barium	12	12	0%	10	0	23	9	15.83	4.387	0.277	0.173	18.91	1
Beryllium	12	0	100	0	0	<0.1	-	-	-	-	-	<0.1	Max
Chromium	12	0	100	0	0	<1.0	-	-	-	-	-	<1.0	Max
Iron	12	12	0%	11	0	560	54	230.9	178.2	0.772	1.127	374.9	1
Lead	12	0	100	100	0	0	<1.0	-	-	-	-	<1.0	Max
Manganese	12	12	0%	8	0	360	140	293.3	68.14	0.232	-1.479	347	1
Mercury	12	0	100	100	0	0	<0.01	-	-	-	-	<0.01	Max
Molybdenum	12	0	100	100	0	0	<0.5	-	-	-	-	<0.5	Max
Selenium	12	0	100	100	0	0	<0.5	-	-	-	-	<0.5	Max

Method: Locally collected unwashed Partridge Berries.
1. 95% Adjusted Gamma UCL
2. 95% BCA Bootstrap UCL
3. 95% KM (Percentile Bootstrap) UCL
4. 95% KM (BCA) UCL
5. Log ROS 95% Percentile Bootstrap UCL
6. Log ROS 95% BCA Bootstrap UCL

Table 3: Summary Statistics – Collocated Labrador Tea Samples

Contaminant	n	n Detected	% ND	n Distinct	n Missing	Max.	Min.	Mean	SD	CV	Skewness	UCL95	Method
Arsenic	13	0	100	0	0	<2.0	-	-	-	-	-	<2.0	Max
Barium	13	13	13	0%	12	0	78	29	50.69	17.39	0.343	0.418	1
Beryllium	13	0	100	0	0	<0.1	-	-	-	-	-	<0.1	Max
Chromium	13	0	100	0	0	<1.0	-	-	-	-	-	<1.0	Max
Iron	13	13	13	0%	13	0	3200	42	766.5	1005	1.311	1.618	1
Lead	13	0	100	100	0	0	<1.0	-	-	-	-	<1.0	Max
Manganese	13	13	13	0%	11	0	1600	620	1002	298.8	0.298	0.811	1
Mercury	13	0	100	100	0	0	<0.01	-	-	-	-	<0.01	Max
Molybdenum	13	0	100	100	0	0	<0.5	-	-	-	-	<0.5	Max
Selenium	13	0	100	100	0	0	<0.5	-	-	-	-	<0.5	Max

Method: Locally collected unwashed Labrador Tea leaves.
1. 95% Adjusted Gamma UCL
2. 95% BCA Bootstrap UCL
3. 95% KM (Percentile Bootstrap) UCL
4. 95% KM (BCA) UCL
5. Log ROS 95% Percentile Bootstrap UCL
6. Log ROS 95% BCA Bootstrap UCL

Table 4: Summary Statistics – Surface Water from Triangle and Pinette Lake

Contaminant	n	n Detected	% ND	Max.	Method
Arsenic	10	0	100	<0.001	Max
Barium	1	1	0	0.0033	Max
Beryllium	10	0	100	<0.0001	Max
Chromium	10	0	100	<0.001	Max
Iron	10	8	80	1.08	Max
Lead	10	0	100	<0.0005	Max
Manganese	10	10	100	0.104	Max
Mercury	10	0	100	<0.0001	Max
Molybdenum	10	0	100	<0.001	Max
Selenium	10	0	100	<0.003	Max

Method: Maximum for unbalanced data set from Pinette Lake (n=8) and Triangle Lake (n=2)

Table 2: Summary Statistics – Benthic Invertebrates from Triangle and Pinette Lake

Contaminant	n	n Detected	% ND	n Distinct	n Missing	Max.	Min.	Mean	SD	CV	Skewness	UCL95	Method
Arsenic	6	5	17%	5	0	0.61	0.0314	0.212	0.218	1.028	-	0.384	6
Barium	6	6	0%	6	0	8.77	0.245	5.683	3.289	0.579	-0.902	22.3	1
Bismuth	6	1	83%	1	0	0.0149						0.0149	Max
Beryllium	6	0	100%	0	0	<0.6						<0.6	Max
Chromium	6	5	17%	5	0	3.74	0.047	0.872	1.423	1.632	-	2.162	6
Iron	6	6	0%	6	0	4540	160	1147	1704	1.486	2.206	7068	1
Lead	6	6	0%	6	0	1.58	0.0402	0.476	0.555	1.166	2.17	2.186	1
Manganese	6	6	0%	5	0	126	4.36	71.94	49.58	0.689	-0.175	286.7	1
Mercury	6	5	17%	5	0	0.062	0.0082	0.0224	0.0201	0.897	-	0.0411	6
Molybdenum	6	5	17%	5	0	0.32	0.016	0.119	0.106	0.891	-	0.205	6
Selenium	6	5	17%	5	0	0.635	0.134	0.357	0.226	0.633	-	0.499	6

Method:
1. 95% Adjusted Gamma UCL
2. 95% BCA Bootstrap UCL
3. 95% KM (Percentile Bootstrap) UCL
4. 95% KM (BCA) UCL
5. Log ROS 95% Percentile Bootstrap UCL
6. Log ROS 95% BCA Bootstrap UCL

Table 6: Summary Statistics – Fish Collected from Triangle Lake and Pinette Lake

Contaminant	n	n Detected	% ND	Max.	Method
Arsenic	10	5	50	0.0355	Max
Barium	10	4	60	0.093	Max
Beryllium	10	0	100	<0.0020	Max
Chromium	10	0	100	<0.040	Max
Iron	10	10	100	7.2	Max
Lead	10	3	30	0.01	Max
Manganese	10	10	100	0.233	Max
Mercury	10	10	100	0.315	Max
Molybdenum	10	0	100	<0.010	Max
Selenium	10	10	100	1.49	Max

Method: Maximum selected between lake trout (n=5) and brook trout (n=5) collected from Triangle Lake and Pinette Lake.

Table 7: Summary Statistics – Spruce Grouse

Contaminant	n	n Detected	% ND	Max.	Method
Arsenic	3	2	67	0.0123	Max
Barium	3	0	100	<0.020	Max
Beryllium	3	0	100	<0.0020	Max
Chromium	3	0	100	<0.040	Max
Iron	3	3	100	60	Max
Lead	3	3	100	0.341	Max
Manganese	3	3	100	0.63	Max
Mercury	3	1	33	0.0026	Max
Molybdenum	3	3	100	0.017	Max
Selenium	3	3	100	0.388	Max

Method: Maximum selected from locally collected spruce grouse (n=3)

E2. Human Health Risk Assessment Data Tables

Table 1 - Metals Concentration in Fish Tissue Collected From Triangle Lake and Pinette Lake (mg/kg ww)
AECOM
2015

		PI-BROOK1	PI-BROOK2	PI-BROOK3	PI-BROOK4	PI-BROOK5	LAKER 1	LAKER 2	LAKER 2	LAKER 3	LAKER 4	LAKER 5	RDL
		Pinette Lake	Pinette Lake	Pinette Lake	Pinette Lake	Pinette Lake	Triangle Lake	Triangle Lake	Triangle Lake	Triangle Lake	Triangle Lake	Triangle Lake	
Sampling Date		5-Aug-15	5-Aug-15	5-Aug-15	5-Aug-15	5-Aug-15	6-Aug-15	6-Aug-15	6-Aug-15	7-Aug-15	7-Aug-15	7-Aug-15	
Total Metals	**UNITS**												
Total Aluminum	mg/kg	0.31	0.35	<0.20	0.26	<0.20	0.24	<0.20	<0.20	<0.20	<0.20	0.63	0.2
Total Antimony	mg/kg	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.001
Total Arsenic	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0304	0.0338	0.0347	0.0355	0.0254	0.0161	0.005
Total Barium	mg/kg	0.093	0.056	0.073	0.048	0.032	<0.020	<0.020	<0.020	<0.020	<0.020	0.025	0.02
Total Beryllium	mg/kg	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.002
Total Bismuth	mg/kg	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.02
Total Boron	mg/kg	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	0.4
Total Cadmium	mg/kg	0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.002
Total Calcium	mg/kg	118	96.7	143	71.3	93.7	61.7	54.7	54.5	55.8	50.6	77.8	2
Total Chromium	mg/kg	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	0.04
Total Cobalt	mg/kg	0.0043	<0.0040	0.0045	0.0053	0.0047	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	0.004
Total Copper	mg/kg	0.298	0.211	0.28	0.383	0.341	0.215	0.246	0.277	0.222	0.192	0.286	0.01
Total Iron	mg/kg	6	3.8	3.9	7.2	4.7	3.7	2.9	3.5	3	3.9	3.8	2
Total Lead	mg/kg	0.0031	0.0051	<0.0020	<0.0020	0.01	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.002
Total Magnesium	mg/kg	302	299	321	296	326	305	311	310	286	257	264	2
Total Manganese	mg/kg	0.233	0.111	0.142	0.204	0.117	0.068	0.073	0.074	0.061	0.053	0.088	0.02
Total Mercury	mg/kg	0.244	0.0759	0.162	0.102	0.1	0.212	0.229	0.282	0.315	0.239	0.197	0.002
Total Molybdenum	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.01
Total Nickel	mg/kg	0.017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.01
Total Phosphorus	mg/kg	2640	2630	2740	2560	2880	2720	2720	2740	2530	2300	2380	2
Total Potassium	mg/kg	4540	4550	4470	4200	4840	4480	4630	4590	4350	3930	3810	2
Total Selenium	mg/kg	0.316	0.319	0.311	0.306	0.338	1.45	1.38	1.49	1.3	1.26	1.46	0.01
Total Silver	mg/kg	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	0.004
Total Sodium	mg/kg	263	213	253	192	242	285	299	306	299	294	272	2
Total Strontium	mg/kg	0.306	0.258	0.483	0.169	0.258	0.031	<0.020	<0.020	<0.020	<0.020	0.052	0.02
Total Thallium	mg/kg	0.00326	0.00254	0.00196	0.0027	0.00279	0.00108	0.00166	0.00195	0.00181	0.00166	0.00129	0.0004
Total Tin	mg/kg	0.041	0.027	0.023	0.034	0.031	0.024	0.024	<0.020	<0.020	0.029	0.024	0.02
Total Titanium	mg/kg	0.091	0.086	0.082	0.08	0.089	0.077	0.06	0.072	0.065	0.055	<0.050	0.05
Total Uranium	mg/kg	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	0.0004
Total Vanadium	mg/kg	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	0.04
Total Zinc	mg/kg	3.37	3.23	3.42	3.54	3.48	2.8	3.02	3.29	2.57	2.61	3.02	0.04

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate

Table 2 - Metals Concentrations in Benthic Invertebrates (mg/kg ww) from Triangle Lake and Pinette Lake
AECOM
2015

		PI-INV1	RDL	PI-INV2	RDL	PI-INV3	RDL	TR-INV1	RDL	TR-INV2	RDL	TR-INV3	RDL
		Pinette Lake		Pinette Lake		Pinette Lake		Triangle Lake		Triangle Lake		Triangle Lake	
Sampling Date		5-Aug-15		7-Aug-15		7-Aug-15		7-Aug-15		7-Aug-15		7-Aug-15	
Total Metals by ICPMS	**UNITS**												
Total Aluminum	mg/kg	53.4	1	143	6	17.9	0.2	37.8	0.6	248	0.4	1840	4
Total Antimony	mg/kg	0.0157	0.005	<0.030	0.03	0.0012	0.001	0.0158	0.003	0.01	0.002	0.048	0.02
Total Arsenic	mg/kg	0.095	0.025	<0.15	0.15	0.0314	0.005	0.292	0.015	0.188	0.01	0.61	0.1
Total Barium	mg/kg	7.14	0.1	5.43	0.6	0.245	0.02	8.77	0.06	3.79	0.04	8.72	0.4
Total Beryllium	mg/kg	<0.010	0.01	<0.060	0.06	<0.0020	0.002	<0.0060	0.006	0.0149	0.004	<0.040	0.04
Total Bismuth	mg/kg	<0.10	0.1	<0.60	0.6	<0.020	0.02	<0.060	0.06	<0.040	0.04	<0.40	0.4
Total Boron	mg/kg	2.4	2	<12	12	<0.40	0.4	1.5	1.2	5.46	0.8	<8.0	8
Total Cadmium	mg/kg	0.045	0.01	0.152	0.06	0.0213	0.002	0.161	0.006	0.0493	0.004	0.054	0.04
Total Calcium	mg/kg	255	10	336	60	43.4	2	17600	6	451	4	474	40
Total Chromium	mg/kg	<0.20	0.2	<1.2	1.2	0.047	0.04	0.3	0.12	0.725	0.08	3.74	0.8
Total Cobalt	mg/kg	0.18	0.02	0.18	0.12	0.0172	0.004	0.05	0.012	0.373	0.008	0.834	0.08
Total Copper	mg/kg	2.55	0.05	2.68	0.3	2.96	0.01	3.58	0.03	2.53	0.02	5.27	0.2
Total Iron	mg/kg	502	10	287	60	160	2	211	6	1180	4	4540	40
Total Lead	mg/kg	0.375	0.01	0.204	0.06	0.0402	0.002	0.359	0.006	0.297	0.004	1.58	0.04
Total Magnesium	mg/kg	192	10	203	60	60.5	2	321	6	336	4	1440	40
Total Manganese	mg/kg	68.6	0.1	126	0.6	4.36	0.02	29.1	0.06	77.6	0.04	126	0.4
Total Mercury	mg/kg	0.024	0.01	0.062	0.06	0.0125	0.002	0.0082	0.006	0.0135	0.004	<0.040	0.04
Total Molybdenum	mg/kg	0.128	0.05	<0.30	0.3	0.016	0.01	0.079	0.03	0.107	0.02	0.32	0.2
Total Nickel	mg/kg	0.144	0.05	0.44	0.3	0.136	0.01	0.15	0.03	0.622	0.02	2.61	0.2
Total Phosphorus	mg/kg	839	10	1090	60	664	2	2810	6	1020	4	1660	40
Total Potassium	mg/kg	349	10	458	60	187	2	54.9	6	134	4	187	40
Total Selenium	mg/kg	0.162	0.05	<0.30	0.3	0.134	0.01	0.635	0.03	0.523	0.02	0.52	0.2
Total Silver	mg/kg	<0.020	0.02	<0.12	0.12	0.02	0.004	0.411	0.012	0.0114	0.008	<0.080	0.08
Total Sodium	mg/kg	393	10	449	60	79.1	2	138	6	327	4	704	40
Total Strontium	mg/kg	1.71	0.1	3.77	0.6	0.089	0.02	22.5	0.06	0.809	0.04	2.6	0.4
Total Thallium	mg/kg	0.0023	0.002	0.024	0.012	0.0017	0.0004	0.0074	0.0012	0.00294	0.0008	0.0112	0.008
Total Tin	mg/kg	<0.10	0.1	<0.60	0.6	<0.020	0.02	<0.060	0.06	0.042	0.04	<0.40	0.4
Total Titanium	mg/kg	1.22	0.25	2.7	1.5	0.478	0.05	0.92	0.15	4.97	0.1	33.2	1
Total Uranium	mg/kg	0.0097	0.002	0.023	0.012	0.0026	0.0004	0.0198	0.0012	0.0424	0.0008	0.122	0.008
Total Vanadium	mg/kg	<0.20	0.2	<1.2	1.2	<0.040	0.04	<0.12	0.12	0.452	0.08	2.38	0.8
Total Zinc	mg/kg	33.5	0.2	32	1.2	15.8	0.04	15.1	0.12	29.3	0.08	53.9	0.8

RDL = Reportable Detection Limit

Table 3 - Metals Concentrations in Spruce Grouse (mg/kg ww) from the Howse Project Property
AECOM, 2015

	UNITS	H-BS-P-1	H-BS-P-1 (Lab Dup)	RPD	H-BS-P-2	H-BS-P-3	RDL
Sampling Date		26-Aug-15	26-Aug-15		26-Aug-15	26-Aug-15	
Total Metals							
Total Aluminum	mg/kg	0.96	0.7	31.3%	1.03	0.71	0.2
Total Antimony	mg/kg	<0.0010	<0.0010	-	0.0061	0.0188	0.001
Total Arsenic	mg/kg	<0.0050	<0.0050	-	0.0123	0.0111	0.005
Total Barium	mg/kg	<0.020	<0.020	-	<0.020	<0.020	0.02
Total Beryllium	mg/kg	<0.0020	<0.0020	-	<0.0020	<0.0020	0.002
Total Bismuth	mg/kg	<0.020	<0.020	-	<0.020	<0.020	0.02
Total Boron	mg/kg	<0.40	<0.40	-	<0.40	<0.40	0.4
Total Cadmium	mg/kg	0.0029	0.0031	6.7%	0.0042	0.0073	0.002
Total Calcium	mg/kg	40.6	41.6	2.4%	59.2	73.5	2
Total Chromium	mg/kg	<0.040	<0.040	-	<0.040	<0.040	0.04
Total Cobalt	mg/kg	<0.0040	<0.0040	-	<0.0040	<0.0040	0.004
Total Copper	mg/kg	3.28	3.4	3.6%	3.4	3.06	0.01
Total Iron	mg/kg	49.9	53	6.0%	60	49.6	2
Total Lead	mg/kg	0.0047	0.0039	18.6%	0.0553	0.341	0.002
Total Magnesium	mg/kg	299	297	0.7%	318	336	2
Total Manganese	mg/kg	0.556	0.503	10.0%	0.612	0.63	0.02
Total Mercury	mg/kg	<0.0020	<0.0020	-	<0.0020	0.0026	0.002
Total Molybdenum	mg/kg	0.013	0.017	26.7%	0.017	0.013	0.01
Total Nickel	mg/kg	<0.010	<0.010	-	<0.010	<0.010	0.01
Total Phosphorus	mg/kg	2630	2730	3.7%	2900	2970	2
Total Potassium	mg/kg	3060	3130	2.3%	3330	3640	2
Total Selenium	mg/kg	0.273	0.293	7.1%	0.388	0.318	0.01
Total Silver	mg/kg	<0.0040	<0.0040	-	<0.0040	<0.0040	0.004
Total Sodium	mg/kg	555	545	1.8%	673	471	2
Total Strontium	mg/kg	0.096	0.097	1.0%	0.088	0.192	0.02
Total Thallium	mg/kg	<0.00040	<0.00040	-	<0.00040	<0.00040	0.0004
Total Tin	mg/kg	0.026	0.032	20.7%	0.035	<0.020	0.02
Total Titanium	mg/kg	0.077	0.084	8.7%	0.07	0.11	0.05
Total Uranium	mg/kg	<0.00040	<0.00040	-	<0.00040	<0.00040	0.0004
Total Vanadium	mg/kg	<0.040	<0.040	-	<0.040	<0.040	0.04
Total Zinc	mg/kg	6.44	6.44	0.0%	6.54	6.58	0.04

RDL = Reportable Detection Limit

Lab-Dup = Laboratory Initiated Duplicate

Table 4 - Petroleum Aromatic Hydrocarbon Concentrations in Labrador Tea (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

		HOWSE PROJECT PROPERTY														
		HOW-LT-1 A	HOW-LT-1 A Lab-Dup	RPD	HOW-LT-1 B	HOW-LT-2 A	HOW-LT-2 B	HOW-LT-2 B Lab-Dup	RPD	HOW-LT-3 A	HOW-LT-3 B	HOW-LT-4 A	HOW-LT-4 B	HOW-LT-5 A	HOW-LT-5 B	HOW-LT-5 C
Sampling Date		26-Jul-15	26-Jul-15		26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15		26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15
% MOISTURE	%	77	77	-	59	75	60	60	-	80	60	80	59	78	67	65
PAH	**Units**															
Acenaphthene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b)fluoranthene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(j)fluoranthene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(k)fluoranthene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(c)phenanthrene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(ghi)perylene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenz(a,h)anthracene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,i)pyrene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)pyrene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,l)pyrene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
7,12-Dimethylbenzanthracene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-cd)pyrene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
3-Methylcholanthrene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Naphthalene	mg/kg	<0.4 (1)	<0.3 (1)	-	<0.2 (1)	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	mg/kg	<0.04	<0.04	-	<0.04	<0.04	<0.04	<0.04	-	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Pyrene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2-Methylnaphthalene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1-Methylnaphthalene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,3-Dimethylnaphthalene	mg/kg	0.2	0.2	-	0.3	<0.2 (1)	<0.1	<0.1	-	<0.3 (1)	<0.1	<0.1	<0.1	<0.3 (1)	<0.5 (1)	<0.6 (1)
2,3,5-Trimethylnaphthalene	mg/kg	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

A - Washed, B - Unwashed, C- Unwashed Replicate

RDL = Reportable Detection Limit

(1) Detection limit raised due to matrix interference.

Table 4 - Petroleum Aromatic Hydrocarbon Concentrations in Labrador Tea (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

		GREENBUSH AREA											
		GB-LT-1 A	GB-LT-1 B	GB-LT-2 A	GB-LT-2 B	GB-LT-3 A	GB-LT-3 B	GB-LT-4 A	GB-LT-4 B	GB-LT-5 A	GB-LT-5 B	GB-LT-5 C	RDL
Sampling Date		26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	
% MOISTURE	%	88	64	88	66	77	63	81	64	85	60	60	N/A
PAH	**Units**												
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Acenaphthylene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Benzo(a)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Benzo(a)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Benzo(b)fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Benzo(j)fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Benzo(k)fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Benzo(c)phenanthrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Benzo(ghi)perylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Chrysene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Dibenz(a,h)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Dibenzo(a,i)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Dibenzo(a,h)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Dibenzo(a,l)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
7,12-Dimethylbenzanthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.3 (1)	<0.3 (1)	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Indeno(1,2,3-cd)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
3-Methylcholanthrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Naphthalene	mg/kg	0.03	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Phenanthrene	mg/kg	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.04
Pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
2-Methylnaphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
1-Methylnaphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
1,3-Dimethylnaphthalene	mg/kg	<0.9 (1)	<0.3 (1)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
2,3,5-Trimethylnaphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1

A - Washed, B - Unwashed, C- Unwashed
RDL = Reportable Detection Limit
(1) Detection limit raised due to matrix in

Table 5 - Metals Concentrations in Labrador Tea (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

		HOWSE PROJECT PROPERTY														
	Units	HOW-LT-1 A	HOW-LT-1 A Lab-Dup	RPD	HOW-LT-1 B	HOW-LT-1 B Lab-Dup	RPD	HOW-LT-2 A	HOW-LT-2 B	HOW-LT-3 A	HOW-LT-3 B	HOW-LT-4 A	HOW-LT-4 B	HOW-LT-5 A	HOW-LT-5 B	HOW-LT-5 C
% MOISTURE	%	77	77		59	59		75	60	80	60	80	59	78	67	65
Sampling Date		26-Jul-15	26-Jul-15		26-Jul-15	26-Jul-15		26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15
METALS																
Aluminum	mg/kg	<20	<20	-	<20	<20	-	31	28	23	26	<20	27	49	<20	23
Antimony	mg/kg	0.7	0.3 (1)	80%	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Silver	mg/kg	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	mg/kg	<2	<2	-	<2	<2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Barium	mg/kg	34	31	9%	29	29	0%	66	70	71	74	46	66	48	32	35
Beryllium	mg/kg	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth	mg/kg	<2	<2	-	<2	<2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Boron	mg/kg	10	10	0%	10	10	0%	14	12	12	11	13	14	16	16	17
Cadmium	mg/kg	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Calcium	mg/kg	2500	2500	0%	2300	2300	0%	3900	4100	4500	4400	3200	4100	5700	4100	4300
Chromium	mg/kg	<1	<1	-	<1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	mg/kg	6	6	0%	6	6	0%	5	4	6	5	6	5	5	6	6
Cobalt	mg/kg	<1	<1	-	<1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tin	mg/kg	1	1	0%	1	1	0%	1	1	1	1	1	1	1	1	1
Iron	mg/kg	43	43	0%	42	41	2%	44	45	150	180	120	190	63	65	68
Lithium	mg/kg	<5	<5	-	<5	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
Magnesium	mg/kg	670	680	1%	650	670	3%	710	680	850	810	880	890	660	760	740
Manganese	mg/kg	700	730	4%	620	660	6%	880	870	1600	1600	1000	1400	1500	880	990
Mercury	mg/kg	<0.010	-	-	<0.010	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Molybdenum	mg/kg	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nickel	mg/kg	0.7	0.7	0%	0.5	0.5	0%	0.8	0.8	0.8	0.7	0.7	0.7	0.8	0.9	0.9
Phosphorus	mg/kg	1800	1800	0%	1800	1900	5%	1700	1500	2100	1900	2200	1700	1700	2400	2200
Potassium	mg/kg	7000	6500	7%	6700	6900	3%	6600	5900	7100	6300	8000	6000	6600	9100	8600
Lead	mg/kg	<1	<1	-	<1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
Selenium	mg/kg	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sodium	mg/kg	<10	<10	-	<10	<10	-	<10	<10	<10	<10	<10	<10	<10	<10	<10
Strontium	mg/kg	<5	<5	-	<5	<5	-	12	13	22	25	7	9	16	9	11
Tellurium	mg/kg	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Thallium	mg/kg	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Thorium	mg/kg	<4	<4	-	<4	<4	-	<4	<4	<4	<4	<4	<4	<4	<4	<4
Titanium	mg/kg	<2	<2	-	<2	<2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Tungsten	mg/kg	<1	<1	-	<1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
Vanadium	mg/kg	<2	<2	-	<2	<2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Zinc	mg/kg	18	18	0%	17	19	11%	19	18	25	22	20	20	25	25	26
Zirconium	mg/kg	<2	<2	-	<2	<2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2

A - Washed, B - Unwashed, C- Unwashed Replicate

RDL = Reportable Detection Limit

Table 5 - Metals Concentrations in Labrador Tea (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

		GREENBUSH AREA											
	Units	GB-LT-1 A	GB-LT-1 B	GB-LT-2 A	GB-LT-2 B	GB-LT-3 A	GB-LT-3 B	GB-LT-4 A	GB-LT-4 B	GB-LT-5 A	GB-LT-5 B	GB-LT-5 C	RDL
% MOISTURE	%	88	64	88	66	77	63	81	64	85	60	60	N/A
Sampling Date		26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	
METALS													
Aluminum	mg/kg	110	120	50	49	190	250	94	89	67	83	98	20
Antimony	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Silver	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2
Barium	mg/kg	42	43	83	78	43	42	42	40	44	38	46	4
Beryllium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Bismuth	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2
Boron	mg/kg	14	13	20	18	15	15	11	11	12	12	13	2
Cadmium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Calcium	mg/kg	3200	3200	4100	3900	3700	3600	4500	3700	4100	3800	4200	20
Chromium	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Copper	mg/kg	6	6	6	7	6	6	6	7	4	4	4	1
Cobalt	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Tin	mg/kg	1	1	1	1	1	1	1	1	1	1	1	1
Iron	mg/kg	1900	2400	430	600	2400	3200	890	1200	620	930	1000	10
Lithium	mg/kg	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5
Magnesium	mg/kg	870	920	760	780	850	810	810	760	750	730	730	5
Manganese	mg/kg	650	640	1200	1100	960	830	930	820	1100	1000	1400	2
Mercury	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.01
Molybdenum	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Nickel	mg/kg	1.2	1.3	1	0.9	1.3	1.2	1	1	0.8	0.9	1	0.5
Phosphorus	mg/kg	2100	2100	1900	2000	1800	1800	1900	1900	1300	1400	1200	20
Potassium	mg/kg	7700	7300	8100	8500	6900	7900	7200	7500	5500	5400	4900	20
Lead	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Selenium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Sodium	mg/kg	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10
Strontium	mg/kg	11	11	5	5	9	8	8	8	10	9	9	5
Tellurium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Thallium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Thorium	mg/kg	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	4
Titanium	mg/kg	<2	<2	<2	<2	3	3	<2	<2	<2	<2	<2	2
Tungsten	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Vanadium	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2
Zinc	mg/kg	23	22	20	19	19	18	22	20	19	18	20	5
Zirconium	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2

A - Washed, B - Unwashed, C-

RDL = Reportable Detection Li

Table 6 - Petroleum Aromatic Hydrocarbon Concentrations in Partridge Berries (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

		HOWSE PROJECT PROPERTY										
	Units	HOW-PB-1 A	HOW-PB-1 B	HOW-PB-2 A	HOW-PB-2 B	HOW-PB-3 A	HOW-PB-3 B	HOW-PB-4 A	HOW-PB-4 B	HOW-PB-5 A	HOW-PB-5 B	HOW-PB-5 C
Sampling Date		30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15
% Moisture	%	89	88	88	85	88	87	90	88	88	88	88
PAH												
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b)fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(j)fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(k)fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(c)phenanthrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(ghi)perylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenz(a,h)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,i)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,l)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
7,12-Dimethylbenzanthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-cd)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
3-Methylcholanthrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	mg/kg	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2-Methylnaphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1-Methylnaphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,3-Dimethylnaphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,3,5-Trimethylnaphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

A - Washed, B - Unwashed, C - Unwashed Replicate
RDL = Reportable Detection Limit

Table 6 - Petroleum Aromatic Hydrocarbon Concentrations in Partridge Berries (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

		GREENBUSH AREA (DI - DUST IMPACTED)															
	Units	**DI-PB-1 A**	**DI-PB-1 B**	**DI-PB-1 B Lab-Dup**	**RPD**	**DI-PB-2 A**	**DI-PB-2 B**	**DI-PB-3 A**	**DI-PB-3 B**	**DI-PB-4 A**	**DI-PB-4 B**	**DI-PB-5 A**	**DI-PB-5 A Lab-Dup**	**RPD**	**DI-PB-5 B**	**DI-PB-5 C**	**RDL**
Sampling Date		30-Aug-15	30-Aug-15	30-Aug-15		30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15		30-Aug-15	30-Aug-15	
% Moisture	%	87	87	87	-	89	88	88	87	88	88	88	88	-	88	88	N/A
PAH																	
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Anthracene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Benzo(a)anthracene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Benzo(a)pyrene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Benzo(b)fluoranthene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Benzo(j)fluoranthene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Benzo(k)fluoranthene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Benzo(c)phenanthrene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Benzo(ghi)perylene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Chrysene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Dibenz(a,h)anthracene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Dibenzo(a,i)pyrene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Dibenzo(a,h)pyrene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Dibenzo(a,l)pyrene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
7,12-Dimethylbenzanthracene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Fluoranthene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Indeno(1,2,3-cd)pyrene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
3-Methylcholanthrene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
Naphthalene	mg/kg	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	0.01
Phenanthrene	mg/kg	<0.04	<0.04	<0.04	-	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	-	<0.04	<0.04	0.04
Pyrene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
2-Methylnaphthalene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
1-Methylnaphthalene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
1,3-Dimethylnaphthalene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1
2,3,5-Trimethylnaphthalene	mg/kg	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.1

A - Washed, B - Unwashed, C - Unwashed

RDL = Reportable Detection Limit

Table 7 - Metal Concentrations in Partridge Berries (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

		HOWSE PROJECT PROPERTY											
		HOW-PB-1 A	HOW-PB-1A Lab-Dup	HOW-PB-1 B	HOW-PB-2 A	HOW-PB-2 B	HOW-PB-3 A	HOW-PB-3 B	HOW-PB-4 A	HOW-PB-4 B	HOW-PB-5 A	HOW-PB-5 B	HOW-PB-5 C
Sampling Date		30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15
% Moisture	%	89	89	88	88	85	88	87	90	88	88	88	88
METALS	**Units**												
Aluminum	mg/kg	26	26	39	33	74	23	30	<20	22	43	66	26
Antimony	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Silver	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Barium	mg/kg	16	14	14	17	21	18	15	13	13	15	17	15
Beryllium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Boron	mg/kg	9	7	7	10	10	8	7	6	7	6	6	5
Cadmium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Calcium	mg/kg	1300	1200	1200	1300	1400	1300	1200	1400	1300	1300	1500	1400
Chromium	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	mg/kg	4	4	4	4	4	4	4	3	3	4	4	4
Cobalt	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tin	mg/kg	1	1	1	1	1	1	1	1	1	1	1	1
Iron	mg/kg	30	27	170	110	530	20	72	29	54	170	170	150
Lithium	mg/kg	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Magnesium	mg/kg	480	450	460	320	340	460	450	410	380	450	540	470
Manganese	mg/kg	320	290	300	170	180	340	330	310	280	320	350	320
Mercury (Hg)	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nickel	mg/kg	0.9	0.9	0.8	1.8	1.9	0.8	0.8	0.7	0.6	0.6	0.8	0.7
Phosphorus	mg/kg	860	850	860	870	820	790	770	780	730	790	950	860
Potassium	mg/kg	5800	5700	5800	4200	4000	5400	5200	5400	5500	5300	5400	5300
Lead	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Selenium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sodium	mg/kg	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Strontium	mg/kg	7	6	6	8	9	6	<5	<5	<5	<5	6	5
Tellurium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Thallium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Thorium	mg/kg	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Titanium	mg/kg	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	2	<2
Tungsten	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Vanadium	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Zinc	mg/kg	9	8	9	10	11	8	8	8	8	9	10	9
Zirconium	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

A - Washed, B - Unwashed, C - Unwashed Replicate

RDL = Reportable Detection Limit

Table 7 - Metal Concentrations in Partridge Berries (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

		GREENBUSH AREA											
		DI-PB-1 A	DI-PB-1 B	DI-PB-2 A	DI-PB-2 B	DI-PB-3 A	DI-PB-3 B	DI-PB-4 A	DI-PB-4 B	DI-PB-5 A	DI-PB-5 B	DI-PB-5 C	RDL
Sampling Date		30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	
% Moisture	%	87	87	89	88	88	87	88	88	88	88	88	N/A
METALS	**Units**												
Aluminum	mg/kg	27	27	<20	<20	42	70	32	47	27	47	41	20
Antimony	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Silver	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2
Barium	mg/kg	22	23	11	11	11	12	10	9	15	20	20	4
Beryllium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Bismuth	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2
Boron	mg/kg	7	7	13	14	12	12	11	9	7	7	7	2
Cadmium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Calcium	mg/kg	1300	1300	920	950	1100	1100	1100	920	1100	1400	1300	20
Chromium	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Copper	mg/kg	5	5	4	4	4	4	3	3	4	4	5	1
Cobalt	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Tin	mg/kg	1	1	1	1	1	1	1	1	1	1	1	1
Iron	mg/kg	51	95	81	120	180	560	230	450	43	190	210	10
Lithium	mg/kg	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5
Magnesium	mg/kg	560	560	420	420	410	400	390	340	420	490	480	5
Manganese	mg/kg	300	300	140	140	360	330	300	280	300	360	350	2
Mercury (Hg)	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.01
Nickel	mg/kg	1.2	1	0.8	1	<0.5	<0.5	0.5	<0.5	0.7	1	1	0.5
Phosphorus	mg/kg	920	820	740	800	830	760	700	590	730	840	840	20
Potassium	mg/kg	5600	5200	6900	6400	6600	5900	4900	4400	5100	5600	4800	20
Lead	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Selenium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Sodium	mg/kg	<10	<10	<10	<10	<10	<10	<10	13	<10	11	<10	10
Strontium	mg/kg	9	9	<5	<5	<5	<5	<5	<5	<5	<5	<5	5
Tellurium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Thallium	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Thorium	mg/kg	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	4
Titanium	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2
Tungsten	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Vanadium	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2
Zinc	mg/kg	8	8	14	14	8	8	8	7	7	9	9	5
Zirconium	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2

A - Washed, B - Unwashed, C - U

RDL = Reportable Detection Lim

Table 9 - Metal Concentrations in Collocated Soil (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

							HOWSE PROJECT PROPERTY													
	Units	RDL	CCME Parkland SGQ HH	A	B	C	HOW-LT-1-S	HOW-LT-2-S	HOW-LT-3-S	HOW-LT-4-S	HOW-LT-5-S	HOW-LT-56 (DUP)-S	HOW-PB-1-S	HOW-PB-1-S Lab-Dup	HOW-PB-1-S Lab-Dup 2	HOW-PB-2-S	HOW-PB-3-S	HOW-PB-4-S	HOW-PB-5-S	HOW-PB-5B (DUP)-S
Sampling Date			mg/kg	mg/kg			26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15
% MOISTURE	%	N/A	-	-	-	-	18	25	31	67	24	20	22	22	22	16	21	31	22	22
METALS																				
Aluminum	mg/kg	20	-	-	-	-	2800	4400	9100	3100	5400	4200	12000	12000	12000	9100	13000	9100	9400	10000
Antimony	mg/kg	0.1	-	-	-	-	0.4	0.5	0.3	0.2	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.5	0.4	0.5
Silver	mg/kg	0.5		**2**	20	40	<0.5	<0.5	1	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	mg/kg	2	12	**10**	30	50	**11**	**14**	**10**	5	**9**	**9**	**13**	**12**	**12**	**11**	**14**	**12**	**10**	**12**
Barium	mg/kg	4	500	**245**	500	2000	20	35	32	33	20	19	28	28	28	40	22	30	130	27
Beryllium	mg/kg	0.1	4	-	-	-	0.2	0.3	0.4	0.2	0.3	0.2	0.4	0.4	0.4	0.5	0.4	0.3	0.4	0.4
Bismuth	mg/kg	2		-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Boron	mg/kg	2		-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Cadmium	mg/kg	0.1	14	**1.5**	5	20	<0.1	0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	0.1	0.2	0.1
Calcium	mg/kg	20		-	-	-	<20	<20	<20	170	<20	<20	88	110	82	150	110	190	250	190
Chromium	mg/kg	1	220	**85**	250	800	11	10	19	6	11	8	24	22	23	23	29	20	18	21
Copper	mg/kg	1	1100	**40**	100	500	5	6	8	4	7	5	15	13	13	28	14	13	16	20
Cobalt	mg/kg	1		**15**	50	300	2	4	7	<1	3	2	11	10	10	11	7	4	7	9
Tin	mg/kg	1		**5**	50	300	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Iron	mg/kg	10		-	-	-	34000	49000	49000	13000	40000	35000	58000	53000	54000	54000	55000	39000	41000	48000
Lithium	mg/kg	5		-	-	-	<5	<5	10	<5	<5	<5	9	9	9	9	10	7	7	9
Magnesium	mg/kg	5		-	-	-	600	490	2000	310	910	480	2500	2100	2200	3300	3000	2400	2700	3000
Manganese	mg/kg	2		**770**	1000	2200	450	**960**	**1000**	50	720	190	1800	1700	1600	1400	1200	470	1900	1300
Molybdenum	mg/kg	0.5		**2**	10	40	**2.5**	**3.1**	**2.2**	0.7	1.8	2	**3.3**	**3**	**3.1**	**2.4**	**2.9**	**3.3**	**2.4**	**2.7**
Gold	mg/kg			-	-	-	<10	<10	<10	<10	<10	<10	-	-	-	-	-	-	-	-
Nickel	mg/kg	0.5		**50**	100	500	4	3.9	10	2.9	5.7	3.8	13	11	12	18	14	11	14	16
Mercury	mg/kg	0.01	6.6	**0.2**	2	10	0.02	0.04	0.1	**0.24**	<0.01	0.02	0.04	0.04	0.03	0.07	0.07	0.08	0.06	0.07
Palladium	mg/kg			-	-	-	<20	<20	<20	<20	<20	<20	-	-	-	-	-	-	-	-
Phosphorus	mg/kg	20		-	-	-	160	270	310	620	210	180	530	530	500	270	390	350	410	390
Platinum	mg/kg			-	-	-	<10	<10	<10	<10	<10	<10	-	-	-	-	-	-	-	-
Potassium	mg/kg	20		-	-	-	240	140	190	210	190	150	340	320	330	370	320	390	290	300
Lead	mg/kg	1	140	**50**	500	1000	5	8	12	10	9	7	19	18	18	13	14	15	18	14
Selenium	mg/kg	0.5	80	**1**	3	10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sodium	mg/kg	10		-	-	-	29	24	25	39	22	21	21	20	21	19	21	22	23	21
Strontium	mg/kg	5		-	-	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tellurium	mg/kg	0.5		-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Thallium	mg/kg	0.1		-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	0.1
Thorium	mg/kg	4		-	-	-	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Titanium	mg/kg	2		-	-	-	240	190	110	45	94	110	120	110	110	230	190	180	170	180
Tungsten	mg/kg	1		-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Uranium	mg/kg		23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	2		-	-	-	45	52	26	12	30	30	38	34	33	26	39	33	25	26
Zinc	mg/kg	5	500	**110**	500	1500	16	20	42	11	19	13	53	46	47	52	46	36	46	51
Zirconium	mg/kg	2		-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

RDL = Reportable Detection Limit

A - Quebec Soil Standards - Residential/Commercial background levels for inorganic parameters in the Labrador Trough Region.

B - Quebec Soil Standards - Maximum acceptable limit residential, recreational land use.

C - Quebec Soil Standards - Maximum acceptable limit for Non-residential Commercial or Industrial.

Table 9 - Metal Concentrations in Collocated Soil (mg/kg dw) from the Howse Project Property and Greenbush Area
AECOM, 2015

							GREENBUSH AREA												
	Units	RDL	CCME Parkland SGQ HH	A	B	C	GB-LT-1-S	GB-LT-2-S	GB-LT-3-S	GB-LT-3-S Lab-Dup	GB-LT-4-S	GB-LT-5-S	GB-LT-56 (DUP)-S	DI-PB-1-S	DI-PB-2-S	DI-PB-3-S	DI-PB-4-S	DI-PB-5-S	DI-PB-5B (DUP)-S
Sampling Date			mg/kg		mg/kg		26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	26-Jul-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15	30-Aug-15
% MOISTURE	%	N/A	-	-	-	-	26	20	24	24	32	32	27	21	20	18	25	15	14
METALS																			
Aluminum	mg/kg	20	-	-	-	-	7400	6800	4300	4400	4300	8600	9800	9000	6200	1500	8600	9300	7500
Antimony	mg/kg	0.1	-	-	-	-	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	<0.1	<0.1	0.3	0.3	0.3
Silver	mg/kg	0.5		**2**	20	40	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	mg/kg	2	12	**10**	30	50	**10**	**17**	**9**	**9**	**10**	**11**	**11**	**10**	5	<2	**9**	**9**	**7**
Barium	mg/kg	4	500	**245**	500	2000	24	30	12	14	150	22	31	21	65	19	31	79	20
Beryllium	mg/kg	0.1	4	-	-	-	0.4	0.3	0.2	0.2	0.3	0.5	0.6	0.3	0.3	<0.1	0.3	0.4	0.3
Bismuth	mg/kg	2		-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Boron	mg/kg	2		-	-	-	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2	<2
Cadmium	mg/kg	0.1	14	**1.5**	5	20	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Calcium	mg/kg	20		-	-	-	<20	<20	<20	<20	22	<20	68	180	2100	130	98	77	86
Chromium	mg/kg	1	220	**85**	250	800	21	19	12	13	10	19	22	20	11	5	16	23	20
Copper	mg/kg	1	1100	**40**	100	500	10	8	4	5	4	10	13	10	5	3	6	17	12
Cobalt	mg/kg	1		**15**	50	300	5	7	4	4	7	7	9	6	4	1	5	10	6
Tin	mg/kg	1		**5**	50	300	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Iron	mg/kg	10		-	-	-	62000	58000	60000	61000	53000	57000	53000	56000	44000	9600	50000	48000	42000
Lithium	mg/kg	5		-	-	-	7	7	<5	<5	<5	10	12	6	<5	<5	5	9	7
Magnesium	mg/kg	5		-	-	-	2000	1600	830	790	380	2000	2800	2100	1400	200	1300	2500	2200
Manganese	mg/kg	2		**770**	1000	2200	710	1900	**790**	**780**	1800	1200	1500	**850**	**920**	310	700	1600	540
Molybdenum	mg/kg	0.5		**2**	10	40	2	**2.7**	1.2	1.3	1.6	**2.2**	2	1.9	0.8	<0.5	1.7	1.6	1.4
Gold	mg/kg			-	-	-	<10	<10	<10	<10	<10	<10	<10	-	-	-	-	-	-
Nickel	mg/kg	0.5		**50**	100	500	11	7.9	5.2	4.9	4.9	10	13	11	6	1.7	6.5	15	11
Mercury	mg/kg	0.01	6.6	**0.2**	2	10	0.04	0.04	0.04	0.05	0.12	0.08	0.1	0.05	0.03	0.02	0.03	0.06	0.05
Palladium	mg/kg			-	-	-	<20	<20	<20	<20	<20	<20	<20	-	-	-	-	-	-
Phosphorus	mg/kg	20		-	-	-	280	300	330	350	500	280	270	320	280	130	370	240	230
Platinum	mg/kg			-	-	-	<10	<10	<10	<10	<10	<10	<10	-	-	-	-	-	-
Potassium	mg/kg	20		-	-	-	290	290	230	230	190	250	270	320	200	130	260	340	300
Lead	mg/kg	1	140	**50**	500	1000	12	17	9	9	14	14	13	11	8	2	11	**51**	10
Selenium	mg/kg	0.5	80	**1**	3	10	<0.5	<0.5	<0.5	<0.5	0.8	0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sodium	mg/kg	10		-	-	-	23	25	21	18	22	26	40	21	12	41	16	17	15
Strontium	mg/kg	5		-	-	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tellurium	mg/kg	0.5		-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Thallium	mg/kg	0.1		-	-	-	<0.1	0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Thorium	mg/kg	4		-	-	-	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Titanium	mg/kg	2		-	-	-	120	130	99	120	63	95	87	150	44	47	90	130	150
Tungsten	mg/kg	1		-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Uranium	mg/kg		23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	2		-	-	-	40	50	30	30	36	32	34	29	27	13	34	27	25
Zinc	mg/kg	5	500	**110**	500	1500	34	39	17	16	17	40	47	31	15	7	25	35	28
Zirconium	mg/kg	2		-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

RDL = Reportable Detection Limit

A - Quebec Soil Standards - Residential/Commercial background levels for inorganic parameters in the Labrador Trough Region.

B - Quebec Soil Standards - Maximum acceptable limit residential, recreational land use.

C - Quebec Soil Standards - Maximum acceptable limit for Non-residential Commercial or Industrial.

Table 10 - Metal Concentrations in Howse Local Study Area Surface Water (ug/L)
AECOM, 2015

Parameter	Unit	Health Canada DWG[1]	Quebec DWG[2]	Pinette Lake											
				29-Sep-14	20-Aug-14	14-Jul-14	10-Jun-14	9-Oct-13	14-Aug-13	9-Jun-13	10-Sep-08	10-Jun-13	27-Jul-11	27-Jul-11	8-Aug-12
Aluminum	µg/L	–	–	17	13	12	17	17	32	17	118	53	10	10	70
Antimony		6	6	–	–	–	–	–	–	–	–	–	–	–	–
Arsenic	µg/L	10	10	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	<1.0	<2
Barium		1000	1000	–	–	–	–	–	<0.002	–	–	–	–	–	–
Beryllium		–	–	–	–	–	–	–	<0.002	–	–	–	–	–	–
Bismuth		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Boron		5000	5000	–	–	–	–	–	–	–	–	–	–	–	–
Cadmium	µg/L	5	5	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.129	<0.20	<0.2	<0.20	<1
Calcium	µg/L	–	–	<500	<500	<500	<300	<500	<500	<300	569	<300	2	2	1.9
Chromium		50	50	–	–	–	–	–	<0.005	–	–	–	–	–	–
Cobalt		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Copper	µg/L	1000	–	<1.0	<1.0	<1.0	<0.50	<1.0	1.9	<0.50	1	<0.50	<0.5	<0.50	<3.0
Iron	µg/L	–	–	<60	84	62	<100	200	140	140	1080	<100	<100	<100	100
Lead	µg/L	10	10	<0.50	<0.50	<0.50	<0.10	<0.50	<0.50	<0.10	<1.0	<0.10	<0.1	<0.10	<1.0
Magnesium	µg/L	–	–	210	190	200	180	220	220	200	291	170	2	2	1.4
Manganese	µg/L	–	–	3.6	3	2.3	6.5	12	8	22	104	4.7	1	1	12
Mercury	µg/L	1	1	<0.01	<0.01	<0.1	<0.1	<0.1	<0.1	–	<0.02	–	<0.1	<0.1	<0.1
Molybdenum	µg/L	–	–	<1.0	<1.0	<1.0	<0.05	<1.0	<1.0	<0.05	<2	<0.50	<0.5	<0.50	<30
Nickel	µg/L	–	–	<2.0	<2.0	<2.0	<1.0	<2.0	<2.0	<1.0	<1	<1.0	<1	<1.0	<10
Phosphorus		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Potassium	µg/L	–	–	<500	<500	<500	<100	<500	<500	<100	56	<100	330	330	<200
Radium (RA 226)	Becquerel/L	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Selenium	µg/L	50	10	<3.0	<3.0	<3.0	<1.0	<3.0	<3.0	<1.0	<1.0	<1.0	<1	<1.0	<1
Silicon		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Silver		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sodium	µg/L	–	–	700	<500	<500	410	720	540	390	820	–	820	820	300
Strontium		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thallium		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tin		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Titanium		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Uranium	µg/L	20	20	<1.0	<1.0	<1.0	<1.0	24	–	–	<1.0	–	<0.02	<20	<20
Vanadium		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Zinc	µg/L	–	–	<7.0	11	<7.0	<5.0	<7.0	<7.0	<5.0	6	<5.0	<5	<5.0	<5
Zirconium		–	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Health Canada Drinking Water Guidelines (Maximum Allowable Concentration)

2 - Quebec Drinking Water Guidelines - Ministre du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (MDDELCC).

Table 10 - Metal Concentrations in Howse Local Study Area Surface Water (ug/L)
AECOM, 2015

Parameter	Unit	Health Canada	Goodream Creek						Triangle Lake	Burnetta Creek	DS03-14
		DWG[1]	14-Aug-13	9-Oct-13	23-Oct-13	10-Jun-14	14-Jul-14	29-Sep-14	2-Sep-13	3-Sep-13	10-Sep-08
Aluminum	µg/L	–	76	<10	33	75	38	120	18	130	57
Antimony		6	–	–	–	–	–	–	–	–	–
Arsenic	µg/L	10	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Barium		1000	–	–	–	–	–	–	–	–	–
Beryllium		–	–	–	–	–	–	–	–	–	–
Bismuth		–	–	–	–	–	–	–	–	–	–
Boron		5000	–	–	–	–	–	–	–	–	–
Cadmium	µg/L	5	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.2	0.129
Calcium	µg/L	–	<500	2300	<500	450	<500	<500	2700	<500	685
Chromium		50	–	–	–	–	–	–	–	–	–
Cobalt		–	–	–	–	–	–	–	–	–	–
Copper	µg/L	1000	1	<1.0	<1.0	<0.50	<1.0	<1.0	<1.0	<1.0	4
Iron	µg/L	–	160	<60	240	<100	66	310	75	220	1640
Lead	µg/L	10	<0.50	<0.50	<0.50	<0.10	<0.50	<0.50	<0.50	<0.50	<1.0
Magnesium	µg/L	–	<100	1300	230	180	220	210	2300	290	195
Manganese	µg/L	–	33	3.2	7.3	4.2	1.9	18	6.5	23	64
Mercury	µg/L	1	<0.1	<0.1	<0.10	<0.1	<0.1	<0.01	<0.10	<0.10	<0.02
Molybdenum	µg/L	–	1	<1.0	<1.0	<0.50	<1.0	<1.0	<1.0	<1.0	<2
Nickel	µg/L	–	3.5	<2.0	<2.0	1.2	<2.0	<2.0	<2.0	<2.0	<1
Phosphorus		–	–	–	–	–	–	–	–	–	–
Potassium	µg/L	–	<500	<500	–	<100	<500	<500	<500	<500	20
Radium (RA 226)	Becquerel/L	–	–	–	0.002	–	–	–	–	–	–
Selenium	µg/L	50	<3.0	<3.0	<3.0	<1.0	<3.0	<3.0	<3.0	<3.0	<1.0
Silicon		–	–	–	–	–	–	–	–	–	–
Silver		–	–	–	–	–	–	–	–	–	–
Sodium	µg/L	–	–	–	610	–	–	–	580	<500	<500
Strontium		–	–	–	–	–	–	–	–	–	–
Thallium		–	–	–	–	–	–	–	–	–	–
Tin		–	–	–	–	–	–	–	–	–	–
Titanium		–	–	–	–	–	–	–	–	–	–
Uranium	µg/L	20	–	<10	–	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vanadium		–	–	–	–	–	–	–	–	–	–
Zinc	µg/L	–	<7.0	11	<7.0	25	<7.0	7.3	<7.0	<7.0	8
Zirconium		–	–	–	–	–	–	–	–	–	–

1 - Health Canada Drinking Water Guidelines (Maximum Allowa Concentration)

2 - Quebec Drinking Water Guidelines - Ministre du Développen de l'Environnement et de la Lutte contre les changements clima (MDDELCC).

Table 11 - Metals Concentrations in Sediment (mg/kg ww) from Pinette Lake and Triange Lake
AECOM, 2015

		HOS 1	HOS 2	HOS 3	HOS 4	HOS 5	TR-S1	TR-S2	TR-S3	TR-S4	TR-S5	RDL
Sampling Date		5-Aug-15	5-Aug-15	5-Aug-15	5-Aug-15	5-Aug-15	5-Aug-15	5-Aug-15	5-Aug-15	5-Aug-15	5-Aug-15	
Physical Properties	**UNITS**											
Soluble (2:1) pH	pH	5.34 (1)	5.82 (1)	5.70 (1)	5.40 (2)	5.31 (1)	5.21	5.55	5.50	5.47	5.26	N/A
Total Metals by ICPMS												
Total Aluminum (Al)	mg/kg	14600	12100	12000	12200	12400	13400	13400	15500	14800	16200	100
Total Antimony (Sb)	mg/kg	0.41	0.47	0.46	0.43	0.49	0.52	0.41	0.57	0.55	0.6	0.1
Total Arsenic (As)	mg/kg	3.8	3.19	3.09	3.06	5.44	10	7.52	7.7	7.75	9.5	0.5
Total Barium (Ba)	mg/kg	43.3	41.3	41.5	59.4	62.4	112	93.8	88.6	83.5	110	0.1
Total Beryllium (Be)	mg/kg	0.68	0.68	0.82	0.64	0.93	0.99	0.94	1.08	1.09	1.12	0.4
Total Bismuth (Bi)	mg/kg	0.16	0.12	0.12	0.19	0.1	0.15	0.14	0.18	0.16	0.17	0.1
Total Cadmium (Cd)	mg/kg	0.592	1.58	1.67	0.938	2.1	1.01	0.916	1.09	1	0.8	0.05
Total Calcium (Ca)	mg/kg	703	740	873	1230	1260	1430	1510	1520	1370	1380	100
Total Chromium (Cr)	mg/kg	26.4	20.2	20.3	20.7	22.8	26.5	25.5	29	27.6	30.3	1
Total Cobalt (Co)	mg/kg	3.83	3.43	3.52	3.69	4.58	13.6	11.5	12.4	11.8	14.4	0.3
Total Copper (Cu)	mg/kg	25.2	19.5	20.1	24.1	50.9	23	22.1	25.7	24.7	27.7	0.5
Total Iron (Fe)	mg/kg	33100	20600	21000	21500	22800	75500	54400	57100	52100	79900	100
Total Lead (Pb)	mg/kg	14	11.3	11.7	18.8	9.12	15.5	13.5	16.2	14.4	15.4	0.1
Total Magnesium (Mg)	mg/kg	2980	2450	2500	2210	2160	4310	3760	4460	4110	4410	100
Total Manganese (Mn)	mg/kg	153	161	163	224	143	870	538	343	299	857	0.2
Total Mercury (Hg)	mg/kg	0.115	0.074	0.065	0.112	0.129	0.091	0.113	0.117	0.116	0.137	0.05
Total Molybdenum (Mo)	mg/kg	2.59	2.82	2.86	2.59	3.65	1.87	1.43	1.77	1.6	1.94	0.1
Total Nickel (Ni)	mg/kg	21	19	19.6	19	36.7	27.3	26	28.4	29	28.2	0.8
Total Phosphorus (P)	mg/kg	1090	728	747	749	682	637	477	497	471	984	10
Total Potassium (K)	mg/kg	1050	741	688	942	798	1200	1370	1500	1450	1520	100
Total Selenium (Se)	mg/kg	0.97	0.86	0.78	1.02	1.78	2.23	2.61	2.74	2.65	3.19	0.5
Total Silver (Ag)	mg/kg	0.788	0.662	0.661	0.737	0.835	0.236	0.291	0.307	0.314	0.413	0.05
Total Sodium (Na)	mg/kg	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	100
Total Strontium (Sr)	mg/kg	6.46	7.37	7.37	9.04	11.6	4.97	5	5.61	5.33	5.61	0.1
Total Thallium (Tl)	mg/kg	0.113	0.07	0.073	0.089	0.126	0.157	0.135	0.18	0.174	0.159	0.05
Total Tin (Sn)	mg/kg	0.34	0.29	0.27	0.51	0.22	0.34	0.31	0.4	0.34	0.3	0.1
Total Titanium (Ti)	mg/kg	150	118	107	108	94.8	250	220	260	255	246	1
Total Vanadium (V)	mg/kg	25.5	19.6	19.2	21.1	18.1	30.8	29.2	33.8	31.7	34.3	2
Total Zinc (Zn)	mg/kg	102	137	141	102	326	134	153	159	150	143	1
Total Zirconium (Zr)	mg/kg	<0.50	<0.50	<0.50	<0.50	0.8	2.85	1.66	2.12	1.92	2.67	0.5

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Due to insufficient sample water:soil extraction ratio has changed from 2:1 to 4:1 in order to analyse sample.
(2) Due to insufficient sample water:soil extraction ratio has changed from 2:1 to 5:1 in order to analyse sample.

Appendix F

Uncertainty Analysis

Appendix F
Uncertainty Analysis

Parameters for which uncertainties have been identified, the sensitivity of risk estimates, and the potential degree and influence of these uncertainties is presented in Table 1. Uncertainties are assessed relative to their influence on the baseline, project, or cumulative scenario (or a combination thereof). Parameters which are addressed in the probabilistic risk assessment are discussed relative to the cumulative scenario.

Table 1: Summary of Key Uncertainties in the HHRA and Implications for Estimates

<table>
<tr><th>Parameter</th><th>Baseline</th><th>Project</th><th>Cumulative</th></tr>
<tr><td>Country Food Ingestion Rates</td><td colspan="3">AECOM have assumed the 90th percentile of compiled country food ingestion rates collected from the Howse Country Food Survey, as well as literature sources for northern Canadian peoples.
Ingestion rates were available for country food categories which appropriately capture the likely spectrum of country foods collected from the LSA.
Ingestion rates for toddler receptors were scaled from adult ingestion rates based on per capita (mg/kg bw/day) ingestion rates for equivalent age groups.

Sensitivity of risk estimates: High - Ingestion of country foods is a primary controlling parameter of the predicted dose under all exposure scenarios.
Degree of Uncertainty: Moderate - Literature derived ingestion rates for northern peoples of Quebec and Labrador have been integrated into our assessment. It is the AECOM's position that this provides a decreased level of uncertainty relative to the use of the Health Canada (2010a) PQRA default ingestion rates for Aboriginal and Indigenous populations.</td></tr>
<tr><td>Proportion of Diet Originating from the Area of Interest</td><td colspan="3">AECOM have allowed for 100% of fish, small game, and game fowl to be sourced from the area of interest to satisfy daily ingestion rates for the entire year. This is considered to be a highly conservative assumption, as it is considered unlikely that an individual or family group would collect a years' worth of country foods from one location year after year. This is considered adequately protective of those individuals that may collect a high proportion of their country foods from the area of interest.

Sensitivity of risk estimates: Moderate - Ingestion of country foods is a primary controlling parameter of the predicted dose under all exposure scenarios.
Degree of Uncertainty: High - The available site specific dietary use survey provides insufficient evidence to adjust ingestion rates for food derived from areas other than the project area. AECOM have therefore relied on a conservative assumption of 100% of country foods.</td></tr>
<tr><td>Game Species - Relative Time in Affected Zone</td><td colspan="3">Fish, small game, and game fowl are assumed to spend 100% of their tim e in the affected area.
Caribou tissue quality is assumed to not be influenced by the project area due minimal interaction time and diet derived from the mine or surrounding area by caribou.

Sensitivity of risk estimates: Low - Ingestion of country foods is a primary controlling parameter of the predicted dose under all exposure scenarios, however caribou (not influenced by the site) represent a significant portion of the traditional diet..
Degree of Uncertainty: Low - The small mammals and game fowl species modelled have reasonable small home ranges relative to the LSA. 100% time on site is assumed to accurately capture the expected exposure time for these species. Caribou are known to be migratory species with very large home ranges. Literature derived tissues provide the lowest uncertainty, integrating exposures over the animals life and home range.</td></tr>
<tr><td>Toxicity Reference Values</td><td colspan="3">TRVs were sourced from recommended sources. Sources for TRVs in order of preference were
• Health Canada
• US EPA IRIS

Sensitivity of Risk Estimates: High - Toxicity reference values are a principal controlling parameter in the calculation of risk estimates.
Degree of Uncertainty: Low - TRVs were sourced from the most up-to date recommended sources. Risks are unlikely to be over or under-estimated.</td></tr>
</table>

Parameter	Baseline	Project	Cumulative
Soil Exposure Point Concentrations	UCLM95 of Site Specific Soil Data **Sensitivity of Risk Estimates: Low** - Soil does not exert significant influence on the predicted risk estimates. **Degree of Uncertainty: Low -** Site specific information. Risk estimates are unlikely to be over or under-estimated.	Soil concentration modelled based on scenario specific maximum annual dust fall and particulate chemistry. Upper tolerance limit of the predicted soil concentrations at 41 receptor locations selected as representative of the LSA. **Sensitivity of Risk Estimates: Low** - Soil direct contact and food web transfer of COPCs do not exert significant influence on the predicted risk estimates. **Degree of Uncertainty: Low** - Conservative upper bounds of modeled results were selected as exposure point concentrations. Risk estimates are unlikely to be over or under-estimated.	
Fish Exposure Point Concentrations	Maximum concentration measured in fish tissue from Pinette or Triangle Lake. **Sensitivity of Risk Estimates: High** - Fish consumption is the driving factor for risk estimates of some COPCs (eg. Hg). **Degree of Uncertainty: Moderate** - Risk estimates as a result of fish ingestion are likely to be over-predicted, particularly in consideration of the fact that the HHRA assumes 100% of fish is sourced from these two small lakes.		
Caribou Exposure Point Concentrations	Average concentration in muscle tissue calculated from meta-analysis of reported tissue concentrations from literature sources. Caribou are known to be migratory species with very large home ranges. Literature derived tissues provide the lowest uncertainty, integrating exposures over the animals life and home range. **Sensitivity of Risk Estimates: High** - Caribou ingestion is significant contributor to the calculated dose. **Degree of Uncertainty: Low -** Literature derived tissue concentrations from multiple studies.		
Project Influenced Game Exposure Point Concentrations	Maximum measured concentrations of COPCs in Spruce Grouse collected from the LSA. Tissue quality for Hare modelled based on baseline soil, and food web transfer using literature derived transfer factors from reputable sources (See Appendix D1).	Tissue quality modelled based on soil deposition model, and food web transfer using literature derived transfer factors. Transfer factors sourced from recommended, reputable sources (See Appendix D1). **Sensitivity of Risk Estimates: High -** Ingestion of country food is a primary driver of risk estimates. **Degree of Uncertainty - High** - Prediction of tissue from transfer factors contains a high degree of uncertainty. There is a possibility for over or under-estimation of risks.	
Particulate Chemistry	Dust assumed to be composed of surficial soil. Chemistry assumed to be equal to UCLM95 of surficial soil from LSA. **Sensitivity of Risk Estimates: Low** **Degree of Uncertainty: Low** - Particulate chemistry derived from site specific soil data. Predicted risks are unlikely to be over or under-estimated.	Dust assumed to be composed of mined ore. Chemistry assumed to be equal to UCLM95 of drill core dataset. **Sensitivity of Risk Estimates: Moderate** - - Particulate inhalation is not a significant contributor to overall dose, but is considered the only uncontrolled release media from the site. **Degree of Uncertainty: Low** - Particulate chemistry derived from drill core data for the material to be mined. ***Probabilistic Cumulative Assessment***: Log-normal probability distributions for each COPC included as stochastic elements. Variability of rock chemistry propagated through assessment. Sensitivity analysis indicates moderate contribution of dust chemistry (importance score <0.1).	

Parameter	Baseline	Project	Cumulative
Fugitive Dust	Assumed to be Quebec regional background PM10 concentration (4 ug/m3). **Sensitivity of Risk Estimates: Low** - Particulate inhalation not a significant contributor to baseline dose. **Degree of Uncertainty: Low** - Risk estimates unlikely to be over-predicted.	Assumed to be equal to 90^{th} percentile of the maximum 24-hour predicted PM10 concentration at 41 receptor locations, assuming blasting occurs 1 day per week. **Sensitivity of Risk Estimates: High** - the overall dose is not heavily influenced by particulate inhalation, but particulate concentration (PM10) exerts a high degree of influence on the dose associated with the inhalation route of exposure. **Degree of uncertainty: Low** - PM10 concentration derived from detailed particulate dispersion models conducted for a retrospective period of 5 years. ***Probabilistic Cumulative Assessment***: Cumulative probability distributions for each receptor location derived from hourly predicted PM10 concentrations over 5 year period. Variability of meteorological conditions and predicted PM10 concentration propagated through assessment. Sensitivity analysis indicates major influence of PM10 on predicted risk estimates (Importance Score <0.38).	