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9.0 ASSESSMENT OF POTENTIAL HEALTH EFFECTS

This section of the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application) presents the assessment of health effects. **Section 9.1** describes the health baseline conditions of the proposed Blackwater Gold Project (the Project). The assessment for each Valued Component (VC) includes a description of the rationale and baseline information conducted to select the VC, discussion of potential effects of the Project and proposed mitigation, and an analysis of residual effects significance. The VCs proposed for Human Health include environmental exposures and worker safety and health. **Section 9.3** presents a summary of the health effects assessment results.

9.1 Health Baseline

The human health baseline presents an overview of the health status of the residents and potential labour force in the employment catchment area near the Project location. An overview of baseline conditions for environmental exposures is also presented, based on detailed baseline studies described in **Section 5.1.1.3** (Noise and Vibration) and **Appendix 9.1A** (Environmental Health Baseline Report).

9.1.1 Introduction

Health factors can improve or set back health (Healy and Kerr, 2009). There are many factors known to influence health and well-being (Northern Health, 2012a, b, c, d):

- Good strong start in life;
- Early and enriching experiences;
- Educational opportunities;
- Sufficient and equitable distribution of employment, income, housing, and food;
- Person's interactions with the environment;
- Choices towards certain risk factors and lifestyles;
- Age;
- Sex;
- Genetics; and
- Access to high quality health care services.

The Canadian Institute for Health Information (CIHI) (2013) groups health factors into three interconnected categories:

- Environmental factors;
- Socioeconomic factors, and
- Lifestyle factors.

Environmental factors can be physical or human. Examples of physical environmental factors are air pollution and temperature extremes. Examples of human environmental factors are employment, education, and social support. Socioeconomic factors are recognized to affect health and well-being and include income level, employment, education, and housing (CIHI, 2013). People with higher incomes and better education tend to live longer and healthier lives. This pattern holds across all ages and for virtually all measures of health suggesting a biological dimension of inequality (Wolfe et al., 2012). Socioeconomic status can influence lifestyle factors or lifestyle choices, such as “what we eat, what and how we learn, and where and when we play” (CIHI, 2013).

Based on a community survey, the Canadian Population Health Initiative (CPHI) (2005) estimated that lifestyle factors have a very strong or strong impact on the health of Canadians. These factors include whether a person smokes (80%), a person’s eating habits (72%), and the amount of exercise a person gets (65%) (Healy and Kerr, 2009). In terms of environmental factors, air and water quality (64%) is considered to have a very strong or strong impact on the health of Canadians (CPHI, 2005). CPHI (2005) identified broader socioeconomic factors that have a very strong or strong impact on the health of Canadians: a person’s level of income (33%), availability of quality housing (34%), a person’s level of education (33%), and the safety of communities (35%).

Some health factors, particularly genetic or biological, are factors over which there is little control. For those that can be controlled, such as lifestyle, research clearly demonstrates that individual behaviour change is difficult to achieve (Healy and Kerr, 2009). Evidence shows that Canadians with adequate shelter, a safe and secure food supply, access to education, employment, and sufficient income for basic needs adopt healthier behaviours and have better health (Public Health Agency of Canada, 2008). Achieving behavioural change requires a collective commitment to addressing the needs of the most disadvantaged, improving early childhood development opportunities and education for all, facilitating stronger networks of support, and creating a truly inclusive society (Healy and Kerr, 2009).

9.1.2 Scope of Work

The human health baseline identifies the current state of public health near the Project and, using these statistics, identifies potentially sensitive populations. The human health baseline focuses on permanent, temporary, and seasonal residents near the Project who are potential receptors for environmental exposures, and on the potential labour force in the employment catchment area. Permanent, temporary, and seasonal residents include First Nation and non-First Nation people. However, general health data are not reliable indicators of First Nation health, and monitoring First Nation health is limited by a lack of data (Statistics Canada, 2013a). Data and results for the general population and First Nation people are presented separately.

The term ‘Aboriginal people’ is inclusive of First Nations, Métis, and Inuit, and this section references studies that either focussed on First Nations exclusively or separated the results for First Nations from overall Aboriginal study results. This approach was taken to avoid results of Aboriginal studies that include Métis and Inuit not necessarily being representative of First Nations. The term ‘First Nation’ is used in this section in recognition that the majority of Aboriginal people in the Regional Study Area (RSA) are not Inuit or Métis but are First Nations.

Baseline conditions for environmental exposures are established, referring to **Section 5.1.1.3** (Noise and Vibration) and **Appendix 9.1A** (Environmental Health Baseline Report) (AMEC, 2013). Existing exposures to environmental contaminants were evaluated through a Human Health and Ecological Risk Assessment (HHERA) approach, as described in **Appendix 9.2.2A**.

The assessment of air quality depends on air dispersion models that are used to evaluate the impacts of the ambient air quality from the corresponding facility or the project assessed. The air dispersion model relies on the completeness, preciseness and/or representativeness of the combination of input data sets. The model is designed to incorporate substantial conservatism in the methods to ensure that potential impacts are not understated. Several assumptions were made to simplify the modeling procedures while increasing the likelihood of overestimating actual concentrations. These assumptions can be found in **Section 5.2.4** (Air Quality Effects Assessment), **Section 5.2.4** and **Appendix 5.2.4A**. Based on the results of the air dispersion modeling, the maximum air emissions are expected during the operations phase. Given that majority of the emissions are expected during this phase, the HHERA model considered the operations phase only, as the main contributor of air emissions.

In the case of surface water quality, a mass balance model was used to produce quantitative water quality predictions at various locations and during all phases of mining, from construction through post-closure. Numerous conservative assumptions were made for the model. A water balance schedule was developed for the mine site and watersheds for input in the mass balance water quality model for the four phases. The results of the water quality parameters modelled and details regarding the conservative assumptions and water balance schedule can be found in the surface water quality effects assessment (**Section 5.3.3**). The modelled results were compared to relevant provincial and federal water quality guidelines (WQGs) and the proposed site-specific water quality objectives. Guidelines and standards for comparison with the model output data were determined by regulations, when applicable, and with respect to the most sensitive receptors in the downstream environment. Due to the installation of water treatment facility, the water quality in receiving streams (after mixing) downstream of the Tailings Storage Facility (TSF) is expected to meet British Columbia (BC) Freshwater Guidelines or site-specific water quality objective and thus, is not expected to result in harmful accumulation and release of metals from downstream surface water or sediments. The HHERA, model takes into account all phases of the Project under worse case conditions (i.e., low flows and higher than expected metals loadings) for predicted surface water quality using the 95%th percentile over the entire lifetime of the Project. Data are collected, presented, and used to indicate the sensitivities of potentially affected populations. This information is used in the human health effects assessment to ascertain whether health could be compromised as a result of the predicted environmental and occupational exposures of the Project.

Exposure to noise and environmental contaminants are reported as part of the human health baseline. The HHERA incorporated evaluations of water, air, soil, and country foods (i.e., vegetation, wild game, and fish) to determine the methods by which humans, including vulnerable populations, might be exposed.

9.1.3 Methods

9.1.3.1 General Health Overview

This human health baseline focuses on general health status, mental well-being, and selected mortality data. Indicators were chosen based on scientific evidence, where that evidence points to sensitivity, or a causal relationship between a potential project-related occupational hazard (e.g., dust) or environmental factor (e.g., air quality), and disease (e.g., respiratory disease). Statistics Canada (2013a) has analyzed the data for statistical significance in the context of the provincial and national averages. Where possible, statistics are described using published information on population health.

For purposes of discussion, local, provincial and national averages are termed significantly different only where statistical significance has been reported between two datasets being compared. Datasets are determined to be 'similar, in general' when there is less than 1.0% difference and no statistically significant difference was reported between two datasets being compared. The terms 'slightly greater' or 'slightly lower' are used when there is more than 1.0% difference but still no statistically significant difference was reported between the two datasets being compared. Where one dataset is identified to be 'slightly' lower or higher, levels of sensitivity are judged to be 'marginal' to reflect the fact that differences in sensitivity may be statistically insignificant. Any conclusion based on a comparison of two averages where there is no statistical significance is given the pretext 'could potentially,' as there is, statistically, some possibility that the comparative order (lesser or greater) is untrue.

9.1.3.2 First Nation Health Overview

In the absence of community-specific health data for the five Cariboo I Electoral Area reserves in the LSA, a general discussion of health based on Canadian and BC studies for First Nation people living on a reserve is presented in this section along with key findings from the Shandro et al. (2012) baseline study conducted in the Stuart Lake / Na'kal Bun area.

9.1.3.3 Noise

Information on the background noise level was obtained by reviewing monitoring results of similar mining projects in the region. This was complemented by a 24-hour background survey within the Project study area.

9.1.3.4 Environmental Contaminants

Risk assessment methods were used to develop a comprehensive understanding of the source of Chemicals of Potential Concern (COPCs), their release mechanisms, their fate and transport mechanisms once released to the environment, and the methods by which sensitive receptors might be exposed.

The selection of COPCs and receptors was based entirely on baseline data collected from various biophysical disciplines, including:

- Hydrology, surface water, and sediment quality;
- Air quality;
- Freshwater aquatics;
- Terrestrial environment;
- Wildlife environment; and
- Human health.

HHERA involved integrating information from each of the disciplines outlined above; a conservative scenario risk assessment was then completed. Methods for data collection and analysis and sampling locations, along with sample figures, are further described in **Appendix 9.1A**. Risks were assessed using the most conservative information available from each of the disciplines. If risks were acceptable for the conservative scenario, risks for all other lesser exposure scenarios would also be acceptable.

9.1.3.5 Information Sources

The health status of potentially affected populations in the employment catchment area was derived from data published for BC, Health Service Delivery Areas (HSDAs), and Local Health Areas (LHAs) by BC Vital Statistics Agency (2011) and Statistics Canada (2013a). Data are reported at the least-aggregated level available; preference was given to data reported at the LHA level.

Health agency, authorities', and area websites were used to identify publications describing health trends, and inequities between subpopulations within the local health areas, BC, and Canada.

Data for First Nation health were collected from national and local sources (Health Canada, 2005, 2009) and a recent baseline study (Shandro et al., 2012) in the Stuart Lake / Na'kal Bun area. The Shandro study area is within the service area for the Nechako LHA. Information on provision of First Nation health services or health concerns within First Nation communities in the study area is based on desktop research and interviews.

9.1.3.6 Spatial Boundaries

Potentially affected populations include residents and the potential labour force in the employment catchment area, and in the area that will be directly or indirectly affected by mine construction or operation. Those potentially affected include First Nation and non-First Nation populations. Collectively, these are defined as the Human Health Study Area (HHSA) and are also defined as the Socioeconomic Regional Study Area (SERSA) (**Figure 9.1-1**). The boundary of the SERSA reflects the statistical reporting units used by Statistics Canada and the Government of BC. The boundaries do not coincide with health regions, either HSDAs or LHAs (**Figure 9.1-2**).

To capture potential local effects, the HHSA was divided into two study areas:

- The LSA is identical to that of the social and economic baselines, and comprises primarily of Bulkley-Nechako Regional District Electoral Areas (RDEA) D and F, the Village of Fraser Lake, the District of Vanderhoof, and 11 populated Indian Reserves.
- The RSA is identical to that of the social and economic baselines, comprises The RSA comprises the Fraser-Fort George RDEA C, the Bulkley-Nechako RDEAs C and B, the City of Prince George, the Village of Burns Lake, the District of Fort St. James, and 12 populated Indian reserves.

Communities within the HHSA are serviced by the following four LHAs (**Figure 9.1-2**):

- Quesnel LHA 28, providing services to the five Cariboo I Electoral Area communities in the LSA;
- Burns Lake LHA 55, providing services to communities in the LSA and RSA;
- Nechako LHA 56, providing services to communities in the RSA; and
- Prince George LHA 57, providing services to communities in the RSA.

All four of the LHAs relevant to the study area are located in the Northern Interior HSDA. The Northern Interior HSDA is serviced by the Northern Health Authority (NHA).

For environmental exposure VC, potential sources for the release of project-related COPCs include air emissions and liquid effluent emissions (i.e., run-off, surface water, and sediment discharged into the surrounding environment). However, the surface water quality assessment has indicated that the water quality in receiving streams (after mixing) downstream of the TSF is expected to meet BC Freshwater Guidelines or site-specific water quality objectives. Therefore, this is not expected to result in harmful accumulation and release of metals from downstream surface water. As a result, the remaining significant source for the release of COPCs is through air emissions.

Since the major source for the release of COPCs is via air emissions, originated at the mine site, the environmental exposures VC is largely based on the modelling domain considered for the air quality assessment (i.e. Air Quality study area) as illustrated in **Figure 9.1-3**. Potential effects on human receptors located in cross proximity to the air quality study area boundary are also discussed in the assessment.

9.1.3.7 Temporal Boundaries

Every effort has been made to collect the most recent data publicly available (Statistics Canada, 2013a, b), to best represent current health status and sensitivities within the HHSA at the time of the Application.

The HHERA model considers the operations phase of the Project as the period where worse case conditions would occur, since the major source for release of COPC is via air emissions. The potential effects during the other phases of the Project (i.e., construction, closure, and post-closure) are expected to be of lower magnitude; therefore the air quality for these phases was not modelled.

9.1.3.8 Administrative Boundaries

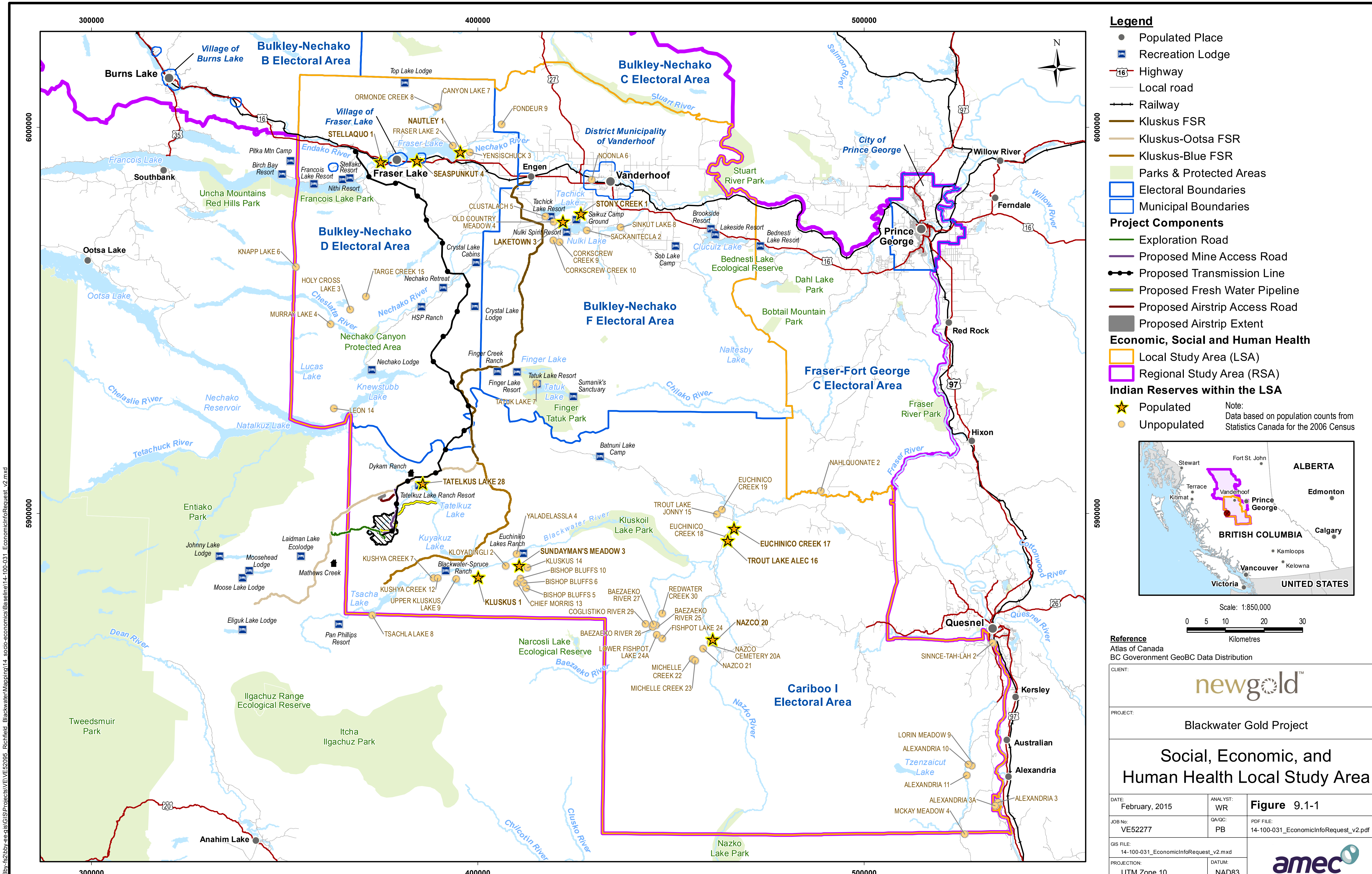
No administrative boundaries were considered for the environmental exposure VC.

9.1.3.9 Technical Boundaries

The technical boundaries for the environmental exposure VC are limited by the boundaries of other VCs (i.e., air quality, surface water quality and laboratory analysis). The HHERA model inputs are dependent on the input results and methodologies of other disciplines.

9.1.3.10 Results/Discussion

General health, mental health, and mortality data are presented and discussed in the context of the province and the nation overall. While the general data include those collected from First Nation persons, First Nation people do not share the same level of health as other Canadians (Health Canada, 2003a, 2013a). As such, it is inappropriate to employ general health data in representing the health status of First Nation persons. The term ‘First Nations’ is used where data have been collected from First Nation populations only, and does not include Métis or Inuit health.



Social, Economic, and Human Health Local Study Area

Figure 9.1-1

CLIENT:	newgold
PROJECT:	Blackwater Gold Project
DATE:	February, 2015
ANALYST:	WR
JOB No:	VE52277
QA/QC:	PB
PDF FILE:	14-100-031_EconomicInfoRequest_v2.pdf
GIS FILE:	14-100-031_EconomicInfoRequest_v2.mxd
PROJECTION:	UTM Zone 10
DATUM:	NAD83

amec

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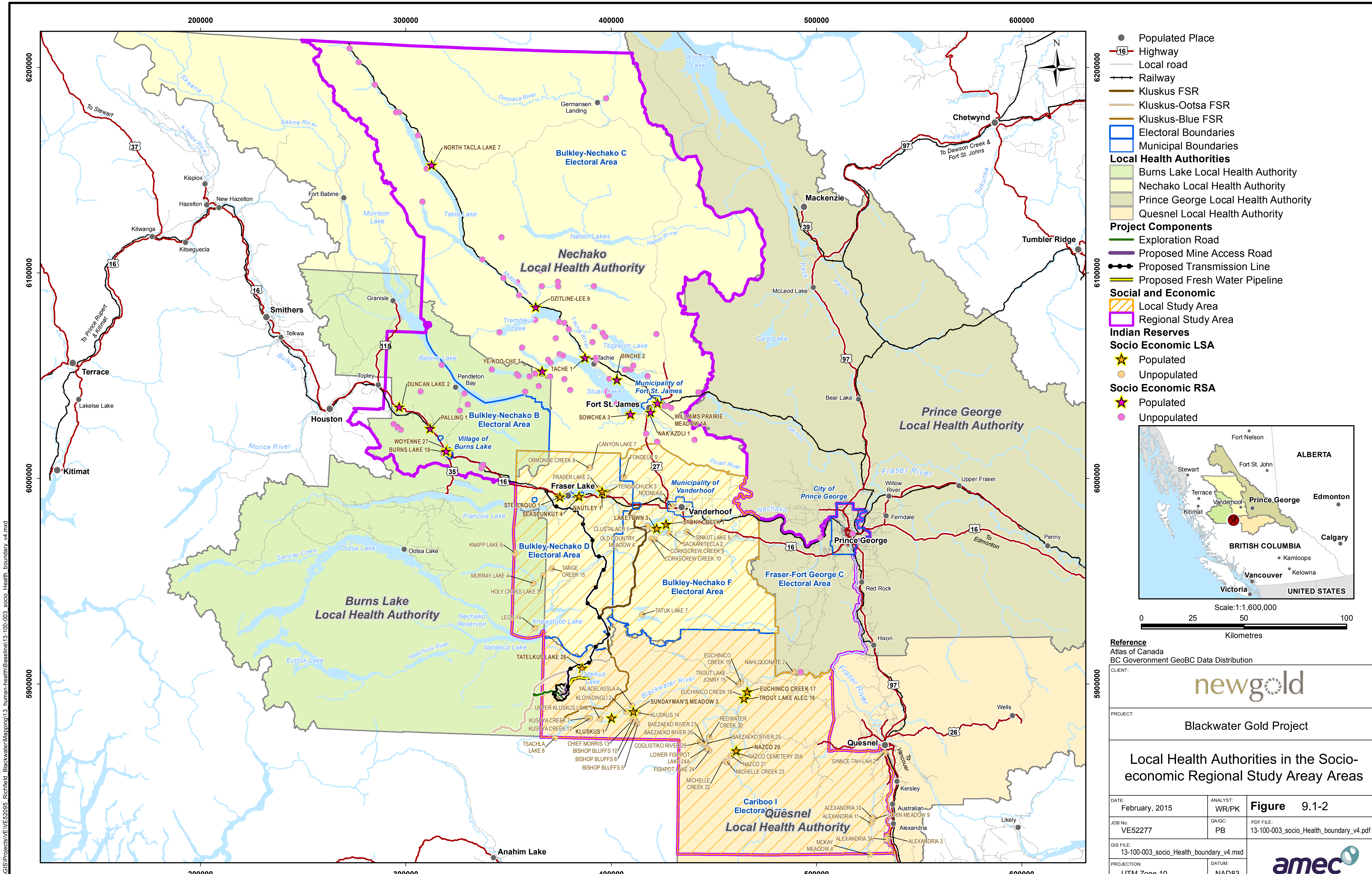
Nechako Local Health Authority
Burns Lake Local Health Authority
Prince George Local Health Authority
Quesnel Local Health Authority
Bulkley-Nechako C Electoral Area
Bulkley-Nechako B Electoral Area
Bulkley-Nechako D Electoral Area
Bulkley-Nechako F Electoral Area
Fraser-Fort George C Electoral Area
Cariboo I Electoral Area
Village of Burns Lake
Municipality of Fort St. James
Municipality of Vanderhoof
City of Prince George
Fort St. James
Fraser Lake
Vanderhoof
Prince George
Quesnel
Smithers
Houston
Terrace
Kitimat
Mackenzie
Chetwynd
Tumbler Ridge
Anahim Lake
Populated Place
Highway
Local road
Railway
Kluskus FSR
Kluskus-Ootsa FSR
Kluskus-Blue FSR
Electoral Boundaries
Municipal Boundaries
Local Health Authorities
Burns Lake Local Health Authority
Nechako Local Health Authority
Prince George Local Health Authority
Quesnel Local Health Authority
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Proposed Fresh Water Pipeline
Social and Economic
Local Study Area
Regional Study Area
Indian Reserves
Socio Economic LSA
Populated
Unpopulated
Socio Economic RSA
Populated
Unpopulated
Scale:1:1,600,000
0 25 50 100
Kilometres
Reference
Atlas of Canada
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Local Health Authorities in the Socio-economic Regional Study Areay Areas
DATE: February, 2015
ANALYST: WR/PK
Figure 9.1-2
JOB No: VE52277
QA/QC: PB
PDF FILE: 13-100-003_socio_Health_boundary_v4.pdf
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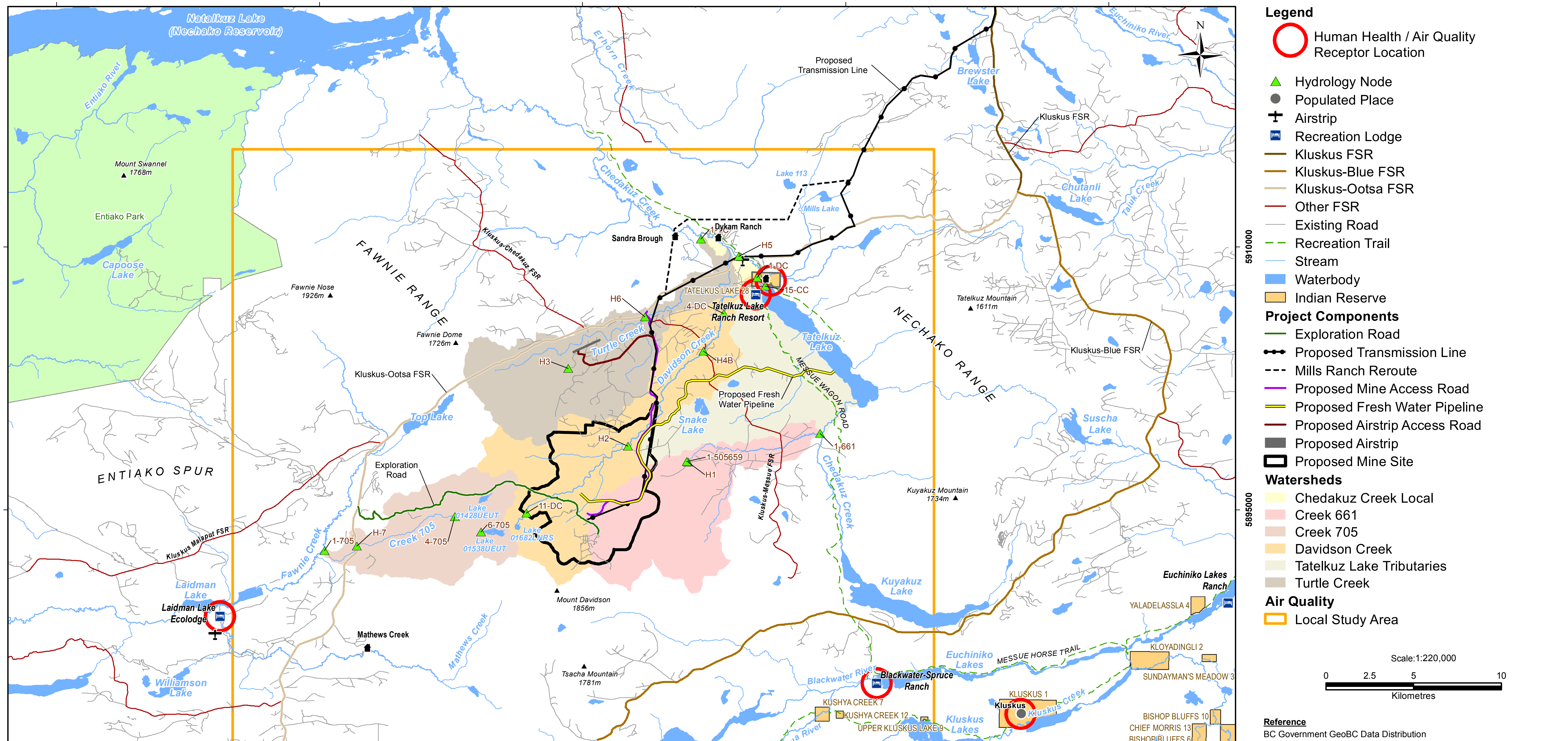
PROJECTION: UTM Zone 10
DATUM: NAD83
amec



CLIENT: newgold

PROJECT: Blackwater Gold Project

Human Health Receptor Locations

DATE: September, 2014	ANALYST: WR	Figure 9.1-3
JOB No: VE52420	QA/QC: BM	PDF FILE: 13-200-005_HumanHealth_InfoRequests.pdf
GIS FILE: 13-200-005_HumanHealth_InfoRequests.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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9.1.4 Health Overview

9.1.4.1 General Health Status

Health perception data are commonly used to indicate general levels of health in a community. Human Resources and Skills Development Canada (HRSDC) (2013a) explains:

> *The self-rated health indicator measures an individual's perception of his or her overall health. A predictor of real health status, it complements other health status indicators by taking into account factors such as the existence of disease and its severity.*

Health perception data can be used to identify general health sensitivities, because sensitivities likely exist where populations (e.g., a community) or subpopulations (e.g., seniors) experience lower health status.

Data collected during the Canadian Community Health Survey (Statistics Canada, 2013c) indicate that people 12 years of age and over in the Northern Interior HSDA are less likely to rate themselves in very good or excellent health (56.7%) when compared to the province overall (60.9%) or the nation (59.9%). Statistics Canada (2013a) reported no statistical significance in the difference in rates, suggesting that general health status is slightly lower in the HHSA than what it is in BC and Canada. This indicates there are marginal (not statistically significant) human health sensitivities in the HHSA when compared to the province and Canada.

Men and women in the HHSA appear to have similar health profiles. Statistics Canada (2013a, c) found little difference in the percentage of the sexes 12 years of age and over in the Northern Interior HSDA that rated themselves in very good or excellent health. Only 0.2% fewer females than males rated themselves in very good or excellent health in the HHSA in 2011. This indicates there are no general sex-related human health sensitivities in the HHSA, when compared to the province and Canada.

Data analysis at the LHA level showed variation among LHAs within HDSAs, including those in the Northern Interior regions (Kashaninia, 2011). Northern Health has identified health factors that contribute to the slightly lower health status and health inequities in the respective LHAs. For example, in the Quesnel LHA there are more children in care, in need of protection, or receiving income assistance for one year or more. There are fewer people aged 25 to 54 with post-secondary credentials. Infant mortality rates are higher, more youth are on income assistance, and there are more than double the number of teen pregnancies. Life expectancy, too, is shorter (Northern Health, 2012d).

In the Nechako LHA (within the LSA), there are more youth and children receiving income assistance, and there are higher serious juvenile crime rates when compared to BC’s general population. Fewer people have university degrees, infant mortality is higher, and the number of teen pregnancies is more than double. When compared to all of BC, life expectancy is shorter, and there are higher rates of hospitalization for respiratory diseases (Northern Health, 2012c).

In the Burns Lake LHA (within the RSA), more children are receiving income assistance, and serious crime rates are higher when compared with all of BC. There are more 18-year-olds who did not graduate from high school, more children in care, infant mortality is higher, and there is a higher rate of teen pregnancy. Life expectancy is shorter, and there is a higher potential years of life lost (PYLL) due to suicide or homicide when compared to the rest of BC (Northern Health, 2012a).

In the Prince George LHA (within the RSA), there are more youths and children receiving income assistance, and higher serious-crime and violent-crime rates compared to all of BC. Fewer people aged 25 to 54 have post-secondary credentials, more children are in care, and there is a slightly higher rate of teen pregnancy. Life expectancy is shorter when compared to the rest of BC (Northern Health, 2012b).

9.1.4.2 Mental Health Status

Mental health status is reported as a complementary indicator to general health status. HRSDC (2013b) explains:

> *Both physical health and mental health determine a person's overall health. Good mental health is now regarded as not only the absence of mental illness such as mental disorders, emotional problems, or distress, but also the presence of factors such as ability to enjoy life, balance, and flexibility.*

Data collected during the 2011 Canadian Community Health Survey (Statistics Canada, 2013a) indicate that people 12 years of age and over in the Northern Interior HSDA are more likely to rate themselves in very good or excellent mental health (70.0%) when compared to the province overall (69.7%) but less likely to rate themselves as such when compared to Canada in general (72.6%). Statistics Canada (2013b) reported no statistical significance in the difference in rates for the HHSA when compared to BC and Canada, suggesting that health is perceived in general, at similar levels in the HHSA as in BC and Canada.

Statistics Canada (2013a) finds that males 12 years of age and over in the Northern Interior HSDA are less likely to rate themselves in very good or excellent mental health (68.6%) than females (71.4%). This difference may not be statistically significant (Statistics Canada, 2013a) but suggests that males may be slightly more sensitive than females to determinants of mental health status in the HHSA.

9.1.4.3 Specific Health Conditions

Standardized Mortality Ratios (SMRs) are used for reporting mortality-related data (**Table 9.1-1**), and are easy to apply, as each SMR is referenced to the provincial average: the provincial SMR holds a standardized value of 1.00 for all indicators. Localized SMRs above 1.00 indicate potential sensitivities in the provincial context.

Table 9.1-1: Standardized Mortality[1] Ratios for Selected Causes of Death for LHAs in the HHSA and in BC (2011)

LHA or Region	All Causes (SMR)	All Cancer Sites (SMR)	Ischemic Heart Disease (SMR)	Respiratory Diseases (SMR)			
				Respiratory System	Pneumonia and Influenza	Chronic Lung Disease	Lung Cancer
LSA							
Quesnel	1.26	1.17	1.07	0.98	0.57	1.32	1.38
LSA							
Nechako	1.36	1.19	1.08	1.61	1.73	2.06	1.66
RSA[2]							
Prince George	1.25	1.27	1.12	1.27	1.09	1.41	1.64
Burns Lake	1.19	1.16	1.25	0.98	0.52	1.62	1.61
Other							
British Columbia[3]	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Minimum for any LHA in British Columbia[3],[4]	0.74	0.78	0.41	0.57	0.17	0.51	0.39
Maximum for any LHA in British Columbia	1.70	1.62	2.14	2.25	2.10	3.36	2.23

Source: BC Vital Statistics Agency, 2011

Note: [1] Based on five year average (2007 to 2011).
[2] Also includes Nechako LHA.
[3] The BC population is the reference population, so all SMRs for the province are 1.00.
[4] Excludes LHAs without SMR (unpublished).
LHA = Local Health Area; LSA = Local Study Area; RSA = Regional Study Area; SMR = Standardized Mortality Ratio.

In general, mortality rates for the HHSA (LSA and RSA) are higher than the province overall but well below the maximum for all LHAs in BC (**Table 9.1-1**). This indicates a slight sensitivity to mortality for the people residing in the HHSA in general. This has been validated by Northern Health (2012a, b, c, d), which concludes that health status indicators consistently show that residents of the Quesnel, Burns Lake, Nechako, and Prince George LHAs (the HHSA) are not as healthy as BC's general population. Lifestyle behaviours that contribute substantially to the excessive burden of disease in this area include smoking, alcohol abuse, lack of exercise, and poor eating habits (Northern Health, 2012a, b, c, d). Northern Health (2012a, b, c, d) has recommended research to understand the factors creating the health issues unique to these areas.

9.1.4.3.1. Cancer

There are many known risk factors for cancer. Tobacco use is the cause of approximately 30% of all fatal cancers in Canada. A fatty diet causes approximately 20% of fatal cancers Canada. The remaining 50% of fatal cancers are due to other risks that include workplace hazards, family history, alcohol use, reproductive factors, sexual activity, sun exposure, drugs, and ionizing radiation (Health Canada, 2012). Although not Canadian, a UK study estimated environmental contamination by carcinogenic chemicals via pathways such as food, air, and water is responsible for 1% to 5% cancers (Doll and Peto, 1998).

BC Vital Statistics (2011) data indicate that there is little difference between the number of mortalities caused by cancer in the LSA and those in the province overall (**Table 9.1-1**). Cancer SMR values tend to be slightly above the norm in the study area LHAs, except for those in the Prince George LHA. Based on these data, it was concluded that there are likely no sensitivities for cancer in the LSA, although slight sensitivities may exist in the RSA.

9.1.4.3.2. Ischemic Heart Disease

Smoking, sedentary lifestyle, and stress are the main causes of ischemic heart diseases (Public Health Agency of Canda (PHAC), 2009). However, ischemic heart disease has been associated with environmental exposures, including air quality and noise. Biological mechanisms linking air contaminants to heart disease involve direct effects of pollutants on the cardiovascular system, blood, and lung receptors, and indirect effects through pulmonary oxidative stress and inflammatory responses (Brook et al., 2004). Environmental noise has been identified as a psychosocial stressor (Babisch, 2014). People with existing congestive heart failure, frequent arrhythmias, or both are sensitive to ischemic health disease (Brook et al., 2004).

BC Vital Statistics Agency (2011) data indicate that the ischemic heart disease mortality rate in the LSA is similar to that of the province overall (**Table 9.1-1**). The SMR value in the Burns Lake LHA (within the RSA) is slightly higher than the standardized provincial value, indicating there are on average more people with heart conditions in this area of the RSA than in BC's general population. This suggests that people in this area of the RSA are likely more sensitive to air quality than people in BC's general population.

9.1.4.3.3. Respiratory Related Diseases

People with compromised respiratory systems, including people with asthma, and smokers, are sensitive to air quality.

BC Vital Statistics Agency (2011) data indicate that people in the Quesnel LHA have higher chronic lung disease and lung cancer rates than those in the province overall (**Table 9.1-1**), indicating that people in the LSA are likely sensitive to environmental exposures associated with chronic respiratory disease. In the Nechako LHA, SMRs for all respiratory diseases are higher than the province overall, indicating that those people are likely to be sensitive to air quality when compared to the province overall. Hospitalization rates for respiratory diseases in the Nechako LHA (Northern Health, 2012d) also suggest sensitivity to air quality in this area.

For the RSA, SMRs are generally higher for chronic lung disease and lung cancer than in the province overall (**Table 9.1-1**), indicating that people in the RSA are sensitive to environmental exposures associated with chronic respiratory disease. Those in the LSA have an increased sensitivity to respiratory-related disease compared to those in the RSA.

9.1.5 First Nation Health Overview

There are five First Nation Reserves—Kluskus 1, Sundayman's Meadow 3, Euchinico 17, Trout Lake 16, and Nazco 20—in the part of the LSA that is managed by the Quesnel Local Health Authority. The general health and mortality data describe the situation for the broader region within which the five reserves are located. However, they do not represent the health status for the First Nation subpopulation that resides within the HHSA.

Some health issues that are commonly managed and controlled in the general Canadian population are statistically observed as prevalent in the First Nation population (Health Canada, 2012). Most studies addressing the social determinants of health and health status of First Nation people living in rural BC indicate that they are worse than for non-First Nation residents in the same regions (Shandro et al., 2012). No specific data for these five reserves in the LSA could be identified.

9.1.5.1 General Sensitivities and Concerns

Environmental health concerns for First Nation peoples in Canada include adequate housing free of environmental contaminants, a safe and secure water supply and traditional foods, and various effects related to climate change (Health Canada, 2011). The First Nations Environmental Contaminants Program (FNECP) was established in 1999 to examine the effects of environmental contaminants on the health and well-being of First Nation communities across Canada (Health Canada, 2011).

A national First Nations Food, Nutrition and Environment Study is under way, led by Dr. Laurie Chan from the University of Northern British Columbia (UNBC). Chan et al. (2011) presents results of a 2008/2009 community survey of First Nations in BC. The closest study community to the Project is Tl'azt'en on the north shore of Stuart Lake. The results are of interest in raising awareness about the importance of traditional foods to wellness. Some study highlights include:

- Average amount of traditional food consumed in BC was 98 g/person/day;
- Traditional food use was measured as a percentage of those surveyed, and mainly consisted of fish (95%), berries (86%), land mammals (84%), beach foods harvested close to shore (60%), root crops and greens (26%), mushrooms (24%), birds/fowl (17%), and foods harvested from trees (9%). The location of the community will determine what proportions were harvested; however, the wide variety of foods gathered is notable;
- The study indicates the importance of traditional foods, the desire to increase the amount of traditional foods used, and some potential barriers to traditional food access related to government restrictions and industrial activities;
- Traditional foods complemented market foods rather than substituted for them. Dietary quality was improved on days when traditional foods were consumed as they were important contributors of protein, vitamins D and A, iron, zinc and several other nutrients;
- Samples were taken from 158 different types of traditional foods for contaminant analysis, and concentrations for arsenic (As), cadmium (Cd), lead (Pb), mercury (Hg) and methylmercury (MeHg) were measured and there was no evidence of point source

contamination. Minimal risk was identified for Cd, Hg, and Pb in the consumption of traditional foods;

- In addition to environmental health (contaminants), Health Canada (2012) identified the following health concerns for First Nation populations:
  - Diabetes;
  - Tuberculosis;
  - West Nile virus;
  - Healthy child development;
  - Healthy pregnancy and babies;
  - Injury prevention;
  - Mental health and wellness;
  - Oral health;
  - Suicide prevention;
  - Nutrition;
  - Substance use and treatment of addictions;
  - Alcohol, drugs, and solvents; and
  - Tobacco use.

9.1.5.2 General Health Status

Health and social conditions can vary substantially between First Nation people living on reserves and those residing elsewhere, and between those people in rural versus urban areas. Living in rural or remote areas can lead to reduced opportunities for education and employment (Pelletier et al., 2013), as well as reduced availability of a safe and healthy food supply (Statistics Canada, 2013a). Housing density, isolation, and income levels have a statistically significant association with tuberculosis (Clark et al., 2002), but all of these factors can have a negative effect on health. Additionally, people living in First Nation communities often have less access to health care services, due to geographic and language barriers (Health Canada, 2003b), and to the cost and limited availability of culturally appropriate services.

In recent years, First Nation health has improved; however, gaps remain in the overall health of First Nation persons when compared to the general Canadian population (Health Canada, 2012). First Nation people face serious health-related challenges—such as high rates of chronic and contagious diseases—and a shorter life expectancy. Health Canada (2012) identified three key examples, compared to the general Canadian population:

- Heart disease is 1.5 times higher;
- Type 2 diabetes is 3 to 5 times higher; and
- Tuberculosis infection rates are 8 to 10 times higher among First Nations people.

Heart disease and diabetes are associated with obesity, which is common in First Nation communities (Statistics Canada, 2013a, Health Canada 2012b, Willows and Delormier 2012, Young et al., 2000). Similar circumstances are found in American Indian communities (Story et. al., 1999), and in Australia (Australian Institute of Health and Welfare, 2011). Estimates for the period 2008 to 2010 determined that 74.4% of First Nation persons aged 18 years and older, and living on reserve, were overweight or obese, compared to 51.9% for the non-First Nation population. Unlike the pattern among the non-First Nation population in Canada, First Nation females have historically suffered a higher prevalence of diabetes than First Nation males. This is thought to be because First Nation females have higher rates of obesity than First Nation males. A rapid transition to energy-dense foods and away from traditional foods obtained through hunting, gathering, and fishing activities, combined with lower levels of physical activity, is associated with the dramatic increase in the rates of being overweight and obesity in First Nation populations in the last several decades (PHAC, 2011).

Diet, inactivity, being overweight or obesity, and smoking are key risk factors for Type 2 diabetes (PHAC, 2011). Diabetes is one of the fastest growing diseases among First Nation populations in Canada. Diabetes was not observed in First Nation populations until after 1950 (Health Canada, 2012). The rapid socio-cultural, biological, environmental, and lifestyle changes seen in First Nation populations in the last 50 years have contributed to increased rates of diabetes and its complications. In 2006 and 2007, 6.7% of BC First Nations people aged one year and older had diabetes, compared with 4.8% of the rest of BC residents (Health Canada, 2012).

Traditional First Nation diets are based on a combination of foods that includes fish, shellfish, marine and land mammals, and game birds, along with green and root vegetables, fruit, and berries. Such food sources reduce the potential for diabetes.

Tuberculosis occurs more frequently on First Nation reserves than in the general Canadian population. Since 2000, tuberculosis rates for First Nations living on reserves have stabilized. However, rates remain considerably higher than those observed in the Canadian-born non-First Nation population (Health Canada, 2010b). Rates for First Nations living on reserve in BC are above average for all First Nations in Canada. However, they are not substantially elevated as they are in Saskatchewan and Manitoba (Health Canada, 2011).

In 2004, First Nation people born in Canada accounted for 16.6% of reported tuberculosis cases, compared to 13.3% for Canadian-born non-First Nation people. This is important, considering First Nation peoples in Canada comprise only 3.8% of the total national population in 2006 (Health Canada, 2009).

9.1.5.3 Mental Health Status

In First Nation families or communities where traditional cultural teachings and practices have been maintained or restored, there is usually a positive sense of the many roles, social duties, and obligations to be fulfilled by youth (Health Canada, 2010b). Chandler and Lalonde (1998) found clear evidence of a positive relationship between First Nations mental well-being and cultural continuity integrated with or involving:

- Self-government;

- Land claims;
- Education;
- Health services;
- Cultural facilities, and
- Police and fire services.

However, rates of depression and acute stress are high in many First Nation communities. High suicide rates, and youth suicide in particular, is evidence of poor mental well-being in a community (Health Canada, 2013b). National suicide rates are five to seven times higher for First Nations youth than for non-First Nation youth (Health Canada, 2013b), and in BC, while there was a reduction in suicide rates among Status Indians between 1993 and 2004, these rates remained higher than for the general population (BC Ministry of Health, undated). This has been a longstanding problem with identified risk factors including (Health Canada, 2003b):

- Being male;
- Previous suicide attempts;
- Violence victimization;
- Violence perpetuation;
- Alcohol use;
- Marijuana use;
- School problems;
- Mood disorder (i.e., major depression);
- Social isolation; and
- Poverty and unemployment.

More young men are committing suicide than are young women. This is also true in the general population, although the rates differ. The reasons for this are unclear (Health Canada, 2003b).

Many First Nation youth are perceived, and/or perceive themselves, to be marginalized. Their sense of isolation may be profoundly greater than either that of their non-First Nation peers or that of older adults within their communities. Many First Nation youth are experiencing what has been termed “transgenerational grief,” and are affected by the trauma previous generations experienced in residential schools and other forms of cultural oppression (ibid). Other countries have observed transgenerational effects, and transgenerational trauma is an issue of concern to Aboriginal peoples in Australia (The Australian Child & Adolescent Trauma Loss & Grief Network, 2009).

9.1.5.4 Regional Knowledge

A baseline community health study in First Nation communities in the Nechako LHA, within the RSA, reported primary concerns voiced by the First Nation communities related to the health of children and youth (Shandro et al., 2012). Key issues included behavioural and developmental difficulties, derived from conditions such as attention deficit hyperactivity disorder, conduct disorder, oppositional defiant disorder, and mental health issues. Related concerns include how to provide treatment for a community with such complex health conditions, e.g., care is often not available on reserves, and transport to other communities in the LHA is required. Other key issues identified in the study were the availability of housing, on and off reserve, and the strong impact of mental and physical abuses resulting from residential school practices. Stress, depression, anxiety, violent behaviour, and substance abuse are resulting symptoms of those experiences (Shandro et al., 2012). These findings are consistent with the national discussion on First Nation health.

9.1.5.5 Health Services and Health Concerns of First Nation Groups Identified in Section 11 Order

Desktop research and information obtained from meetings or interviews have provided the following summary of health services and indicators of health concerns (by services provided) for the First Nations in the HHSA. Detailed information is provided in **Section 14** Aboriginal Groups Background Information:

- Lhoosk'uz Dene Nation (LDN)
  - Health department established to provide culturally appropriate health programs to members, and a medical van to provide transport between the reserve and Quesnel;
- Nadleh Whut'en First Nation (NWFN)
  - Health program managed by a community health representative responsible for delivering health care assistance and support services to community members;
- Saik'uz First Nation (SFN)
  - Saikuz First Nation Health Centre on the reserve, which provides access to a community health representative, health and wellness counselling, a health nurse, and family worker. Social Development Department that delivers programs on income assistance, child and family services, and family violence prevention;
- Stellat'en First Nation (StFN)
  - Community Health Department with a full-time community health representative, with initiatives underway that include communicable diseases, child health projects, infant and preschool health projects, school health projects, and adult/elder related health projects;
  - Future health-related projects will include community kitchens, mother and baby yoga, arthritis and exercise, diabetes group sessions, and a walking club;
- Ulkatcho First Nation (UFN)
  - Services include the Anahim Lake Nursing Station, a Health and Addiction Workers Unit, and a diabetic cooking program;
- Nazko First Nation (NFN)
  - Community Health and Social Services Department that provides services including health care programming and community health and wellness education. Staff include a community health care nurse, home and community care nurse, community

health representative, and a maternal child health educator. Services include diabetes education, home support, flu clinics, immunizations, and programs related to child car-seat safety, canning, a medical van and community gardening; and

- Skin Tyee First Nation (STN).

Community health representative is located on Uncha Lake IR 13a reserve, and a community nurse comes in weekly, though members have to go to Burns Lake to purchase prescriptions or receive dental care.

9.1.6 Environmental Exposures

Baseline conditions for environmental exposures are presented below. The exposures to environmental contaminants are addressed by describing baseline background concentrations of COPCs via direct contact with soil, inhalation of dust, or ingestion of soil, surface water, wild game, or fish.

9.1.6.1 Baseline Noise

As described in **Section 5.1.1.3**, long-term noise survey results indicate overall noise levels (L_{eq}) at the proposed mine site measured 31.1 dBA. Time weighted noise pressure levels (L_{eq}) at the airstrip and Tatelkuz Lake measured 26.4 dBA (average over two-day period) and 24.2 dBA, respectively. These results indicate that the sound levels and characteristics in the Project area are low, typical of a quiet, remote environment.

Maximum noise pressure levels (L_{max}) measured 67.5 dBA at the proposed pit location. Considering L_{eq} levels measured 31.1 dBA, it is inferred that potentially annoying noise (>55 dBA) currently occurs infrequently at the Project site.

9.1.6.1.1 Baseline Environmental Contaminants

As described in **Appendix 9.1A**, a conservative approach was taken in determining the primary exposure scenarios of concern. The exposure scenario assessed for non-carcinogenic chemicals involved a First Nation toddler accompanying an adult who spent all their time in the region engaged in traditional harvesting of country foods (i.e., hunting or fishing) or recreational activities (i.e., hiking) within the study areas of the Project. The toddler could potentially be exposed to background concentrations of COPCs via direct contact with soil, inhalation of dust, or ingestion of soil, surface water, vegetation, wild game, or fish. Similarly, the assessment of carcinogenic chemicals focused on a First Nation adult who spends all his time in the study areas and also engages in traditional activities. He/she could also potentially be exposed to background concentrations of COPCs via direct contact with soil, inhalation of dust, or ingestion of soil, surface water, wild game, or fish.

Chemical screening identified the following COPCs as requiring further assessment in the Preliminary Qualitative Risk Assessment (PQRA):

- Aluminum;
- Arsenic;
- Cadmium; and,
- Molybdenum.

The findings of the HHERA are as follows:

- Maximum baseline concentrations for arsenic and molybdenum exceeded human health criteria in soil, while maximum baseline concentrations for aluminum, arsenic, and cadmium exceeded human health criteria in surface water;
- The average values of the selected background levels were accepted as the Project baseline concentrations. Hazard quotients (HQs) were calculated by dividing the average concentration by each parameter's respective Toxicological Reference Value (TRV). HQ values were noted to be below 1 for all criteria air contaminants (CACs), suggesting that adverse health effects, as a result of inhalation exposures to CACs, would not likely to occur;
- The HQs calculated for aluminum, cadmium, and molybdenum are noted to be below Health Canada's target risk of 0.2 for the toddler receptor, suggesting that adverse health effects would not likely occur;
- Arsenic is noted to be above Health Canada's target risk of 0.2 for the toddler receptor. The exposure pathways responsible for the exceedance for the non-carcinogenic receptor are soil ingestion, surface water ingestion, and fish ingestion. It should be noted that uncertainties exist in the risk assessment process, both in the derivation of TRVs, as well as the exposure assessment assumptions (i.e., consumption rates). Actual exposures are likely to be substantially lower than those presented in this assessment; and the risk estimate for arsenic is noted to be above Health Canada's target risk level of 1.0×10^{-5} for the adult receptor. The main exposure pathways responsible for the exceedance for the carcinogenic receptor are noted to be surface water ingestion and fish ingestion. It should be noted that uncertainties exist in the risk assessment process, both in the derivation of TRVs as well as the exposure assessment assumptions (i.e., consumption rates). Actual exposures are likely to be substantially lower than those presented in this assessment.

The full baseline information for HHERA is presented in Environmental Health Baseline Report (**Appendix 9.1A**).

9.1.7 Conclusion

In general, the health status of people in the HHSA is slightly lower compared to people in BC and Canada, although the difference is statistically insignificant. Males and females in the HHSA appear to have similar levels of general health. As such, there are likely no general human health sensitivities in the HHSA, when compared to BC and Canada.

Mental health status is generally better within the HHSA, when compared to the provincial population. However, males appear slightly more sensitive to determinants of mental health status than women.

People in the LSA managed by the Quesnel LHA could potentially be more sensitive to air quality environmental exposures associated with chronic respiratory disease when compared to the province overall. Similarly, people in the RSA could potentially be more sensitive to air quality related exposures than people in the province overall.

A baseline community health study (Shandro et al., 2012) in Aboriginal communities in the Nechako LHA, within the RSA, reported First Nation concerns that mining projects brought socio-cultural, environmental, and lifestyle changes. The primary concerns voiced by the First Nation communities were those related to the health of children and youth, suggesting children and youth are sensitive to these determinants of health. These findings are consistent with the national discussion on First Nation health.

In terms of environmental exposures, potentially annoying noise (>55 dBA) currently occurs infrequently at the Project site. A HHERA identified maximum baseline concentrations for arsenic and molybdenum exceeded human health criteria in soil, while maximum baseline concentrations for aluminum, arsenic, and cadmium exceeded human health criteria in surface water. Arsenic is noted to be currently above Health Canada's target risk for carcinogenic and non-carcinogenic effects. The exposure pathways responsible for the current exceedances in the LSA and RSA are soil ingestion, surface water ingestion, and fish ingestion. It should be noted that uncertainties exist in the risk assessment process, both in the derivation of TRVs, as well as the exposure assessment assumptions (i.e., consumption rates – First Nation toddler and adult receptors are assumed to spend all their time in the area engaged in traditional harvesting or recreational activities). Actual exposures are likely to be substantially lower than those presented in this assessment.

9.2 Health Effects Assessment

9.2.1 Identification and Selection of Valued Components

The approach of selecting VCs is consistent with the Guideline for the Selection of Valued Components and Assessment of Potential Effects (BC Environmental Assessment Office (BC EAO), 9 September 2013) and requirements under the final Environmental Impact Statement (EIS) Guidelines (Agency, 2013) including the terminology and definitions for VCs and indicators. The purpose of this evaluation process is to select VCs that reflect the types of effects identified in the relevant legislation, revealed and identified though the issue scoping process, and to ensure effective, efficient, and focused analysis of potential effects from the Project (BC EAO, 2013).

Section 4.2 describes the methods used for determination of selected VCs. The process involves three steps:

- Identify Candidate VC,

- Evaluate Candidate VC, and
- Select Appropriate VCs.

The first step is the identification of the candidate VCs, which involves issue scoping. Issue scoping is done by identifying the interaction of the Project components or activities with the five pillars (Environmental, Economic, Social, Heritage, and Health), through consultation with stakeholder groups and by applying professional judgement taking into account environmental assessments conducted in the past on similar projects. Baseline characterization results provide the information to identify relevant candidate VCs representative of the five pillars.

The BC EAO established a Working Group (WG) consisting of provincial and federal regulatory agencies, Aboriginal groups, and identified stakeholder groups likely to be involved in, or affected by the Project. The WG's involvement in the pre-Application stage has focused primarily on reviewing the draft Application Information Requirements (dAIR) that includes information on the candidate VCs for the Project. The public also provided comments on the dAIR. The comments from the WG and public on the candidate VCs have been incorporated into the issues scoping process. In addition, the Project-specific issues are generally indicative of local and regional values held by the public, First Nations, and other stakeholders. Issues tracking tables that document issues and concerns raised during the preparation of the AIR and Application are presented in **Appendix 3.1.3A** and **Appendix 3.1.3B** of **Section 3**. A summary of consultations is provided in **Appendix 3.1.3C** and **Appendix 17A.**

Table 9.2-1 includes the rationale for choosing each candidate VC as a result of the issue scoping, including details on the interactions between the candidate VC and Project activities.

The second step is the evaluation of the candidate VCs to selected VCs. The candidate VCs were examined to confirm if they would interact with Project components and activities, and if those interactions would result in an environmental effect. Key interactions were identified as those that had a greater potential to result in adverse effects of higher significance. The evaluation also used the VC attributes and key questions from the Guideline for the Selection of Valued Components and Assessment of Potential Effects, as presented in **Table 9.2-2**.

In the evaluation process, if all attributes and questions were confirmed and answered with "Yes," the candidate VC becomes a selected VC. If "No" was answered to one or more of the attributes or evaluation questions, the candidate VC was not considered as a selected VC, unless it was a confirmed to be a component of concern. The outcome of the interactive process is a shorter list of VCs that appropriately reflects the concerns raised and the aspects of the broader environment that are of most value to society. This list allowed the assessment to focus on key issues for decision-makers and to address key concerns. **Section 4, Table 4.3-2** (Project Component and Activity Interaction Matrix) shows the potential key and moderate interactions between Project activities and components of the selected VCs.

The evaluation resulted in the following selected VCs for the human health subject area:

- Environmental exposures; and

- Worker safety and health.

The Heath Pillar VCs changed from BC EAO dAIR comments. The Healthy Living VC is no longer a requirement. However, health issues associated with camp and shift work are captured in the Social Pillar.

Indicators are identified as required to further focus the analysis of interactions between the Project and the selected VC. Indicators are aspects of the VC used to understand and evaluate the potential effect on the VC. They may comprise a species group, guild, or sub-population, or some other functional aspect, such as habitat, that is important to the integrity of the VC.

To be effective and useful, indicators must have the attributes from the Guideline for the Selection of Valued Components and Assessment of Potential Effects. The rationale for the indicators proposed for the selected Health Pillar VCs is shown in **Table 9.2-3**.

Table 9.2-1: Candidate Valued Component Rationale

Valued Component Candidates	Interaction with Project Activities	First Nations[(1)]	The Public and Other Stakeholders[(2)]	EIS Guidelines
Environmental exposures	• Project activities (e.g., earth moving) during the construction, operations, and closure phases may generate potential air and water contaminants, including noise that may extend beyond the Project footprint • Provision of drinking water and foods on site	Ulkatcho First Nation; Lhoosk'uz Dene Nation	Rim Rock Ranch	
Worker safety and health	• Workers will be exposed to workplace hazards	No comments noted to date.	Landowner, Dykam Ranch and Woodlot Ltd, Tatelkuz Lake Ranch Resort	16 Monitoring Program and Environmental Management Plans
Healthy living	• Potential effects due to associated mine facilities	No comments noted to date.	No comments noted to date.	N/A

Note: (1) "First Nation" concerns are from comments in the tracking tables in reference to Version A through F of the dAIR.
(2) "The Public and Other Stakeholders" comments do not include comments specific to study design, methods proposed for sampling.
EIS = Environmental Impact Statement; N/A = Not Applicable
Refer to **Table 4.3-2** Project Component and Activity Interaction Matrix for Selected VCs

Table 9.2-2: Evaluation of Candidate Valued Components

		Attributes					Evaluation Key Questions				
Subject Area	**Candidate VC**	**Relevant[1]**	**Comprehensive[2]**	**Representative[3]**	**Responsive[4]**	**Concise[5]**	**Measurable[6]**	**Grouping[7]**	**Ultimate Receptor[8]**	**Component of Concern[9]**	**Selected VC (Included or Excluded)**
Human Health	Environmental exposures	Y – Applicable to the Human Health Pillar	Y– VC needed to have full understanding of the Human Health Pillar and Human Health subject area.	Y – VC is illustrative of the human environments to be possibly affected by the proposed project.	Y – VC is responsive to the potential project effects.	Y – Clear interaction with project activities and/or project component.	Y – VC has measureable parameters.	N – The potential effects of the candidate VC cannot be effectively represented by another VC.	Y – VC is an end point in the effects pathway.	Y – VC is raised as a concern though the issues scoping process.	Y - Environmental exposures is a selected VC. Included
	Worker safety and health	Y – Applicable to the Human Health Pillar	Y– VC needed to have full understanding of the Human Health Pillar and Human Health subject area.	Y – VC is illustrative of the human environments to be possibly affected by the proposed project.	Y – VC is responsive to the potential project effects.	Y – Clear interaction with project activities and/or project component.	Y – VC has measureable parameters.	N – The potential effects of the candidate VC cannot be effectively represented by another VC.	Y – VC is an end point in the effects pathway.	Y – VC is raised as a concern though the issues scoping process.	Y - Worker safety and health is a selected VC. Included
	Healthy living	Y – Applicable to the Human Health Pillar	N – VC is not needed to have full understanding of the Human Health Pillar and Human Health subject area.	Y – VC is illustrative of the human environments to be possibly affected by the proposed project.	Y – VC is responsive to the potential project effects.	N – There is not a clear interaction with project activities and/or project component.	Y – VC has measureable parameters.	Y – The potential effects of the candidate VC can be effectively represented by another VC.	N – VC is an intermediate receptor not the end point in the effects pathway.	N – VC was not raised as a concern though the issues scoping process.	N – Healthy Living is not a selected VC. Excluded

Notes:[1] **Relevant** to one of the five pillars (environmental, economic, social, heritage and health) and clearly linked to the values reflected in the issues raised in respect to the project
[2] **Comprehensive**, taken together, the VCs selected for an assessment should enable a full understanding of the important potential effects of the project
[3] **Representative** of the important features of the natural and human environment likely to be affected by the project
[4] **Responsive** to the potential effects of the project
[5] **Concise**, so the nature of the project-VC interaction and the resulting effect pathway can be clearly articulated and understood, and overlapping or redundant analysis is avoided
[6] **Measurable**, the potential effects of the project on the VC can be measured and monitored.
[7] **Grouping**, the potential effects of the candidate VC cannot be effectively represented by another VC.
[8] **Ultimate Receptor**, the ultimate receptors are humans.
[9] **Component of Concern**, includes issues and/or legislation raised by FNs, Federal or Provincial governments.
N = No; VC = Valued Component; Y = Yes
Refer to **Table 4.3-2** Project Component and Activity Interaction Matrix for Selected VCs

Table 9.2-3: Selected Valued Components and Rationale of Indicators and/or Factor

Pillar	Valued Components	Indicators and/or Factors for Assessment	Rationale of Indicator and/or Factor[1]
Health	Environmental exposures	• Noise and vibration • Air quality • Surface water and sediment quality • Groundwater quality • Fish • Soil quality • Contamination of country foods	The assessment of potential for health effects as a result of environmental exposures will include identifying components of the Project where potential environment exposure pathways exist, considering dependent discipline assessments (e.g., air quality, noise and vibration, surface water and sediment quality, soil quality, fish, and vegetation).
	Workers health and safety	• Occupational exposures • Safety in the workplace • Noise when workers are at rest (construction and operations)	The assessment of potential for worker safety and health effects as a result of exposures will include identifying components of the Project where potential environment exposure pathways exist, considering dependent discipline assessments (e.g., air quality, noise and vibration, surface water and sediment quality, soil quality, fish, and vegetation).

Note: [1] Included indicators follow these attributes: *Relevant*: indicators must relate directly or indirectly to the integrity of the selected VC; *Practical:* there must be a practical way to evaluate the indicator, using existing or achievable data, predictive models, or the means; *Measurable:* the measurement of the selected indicator must generate useful data that inform our understanding of the potential effect on the VC; *Responsive* to the potential effects of the project; *Predictable* in terms of their response to the project.
Refer to **Table 4.3-2** Project Component and Activity Interaction Matrix for Selected VCs

9.2.2 Environmental Exposures

The evaluation of environmental exposures was based on comprehensive assessments detailed in this Application, namely the Noise and Vibration Effects Assessment (**Section 5.2.2**) and the HHERA (**Appendix 9.2.2A**).

The assessment of effects on human health is supported by the human health risk assessment component of the HHERA. The HHERA evaluates potential direct and indirect exposure pathways via water, air, soil, and country foods (i.e., vegetation, wild game, and fish). Camp noise effects were assessed as part of the worker health and safety VC.

9.2.2.1 Introduction

Noise and environmental contaminants effects were assessed as part of the environmental exposures VC. The assessment of environmental contaminants effects incorporated evaluations of water, air, soil, and country foods (i.e., vegetation, wild game, and fish). Worst case conservative scenarios were evaluated for both noise and environmental exposures. Construction, operations, and closure phases were integrated within the scenarios.

9.2.2.1.1 Noise

Noise annoyance is considered an adverse health effect by the World Health Organization (WHO) (1999). Health Canada (2005) uses an annoyance-based criterion of 55 dBA to assess noise effects on quality of life.

9.2.2.1.2 Regulatory Considerations and Environmental Contaminants

The regulatory framework on which the HHERA is supported consists of air quality and water quality guidelines and objectives used in the assessment of residual effects on air quality (**Section 5.2.4**) and surface water quality (**Section 5.3.3**). The approach adopted in evaluating the potential risks to human health was consistent with the approach recommended by Health Canada (2010a, 2010b), which has established a four-step paradigm for conducting health-based risk assessments. This paradigm has also been adopted by Canadian federal and provincial health and environmental agencies. This paradigm is described in **Appendix 9.2.2A**.

As described in **Appendix 9.2.2A**, HHERA is a process whereby all available scientific information is brought together to produce a description of the nature and magnitude of the risk associated with exposure of human receptors to one of more environmental chemicals (BC Ministry of Environment (MOE), 1993). The HHERA led to an assessment of the source of COPCs, their release mechanisms, their fate and transport mechanisms after release into the environment, and the means by which humans might be exposed using conservative assumptions and thresholds. The approach adopted in evaluating the potential risks to human health of the Project was consistent with the approach recommended by Health Canada (2010).

Emphasis was given to those chemicals directly associated with operation of the facilities that have potential to migrate locally and regionally. Emitted chemicals that represent the greatest concern were selected for the assessment. Chemicals of greatest concern were defined as, for one part, chemicals viewed as a concern by the regulatory authorities and also chemicals perceived as a concern by the public and identified during consultation.

The CACs, i.e., nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), and particulate matter ($PM_{2.5}$, and PM_{10}), were considered a concern for assessment because they are federally regulated.

In addition, COPCs that were screened for assessment under the Environmental Health Baseline Report (**Section 9.1A**) were also included in the HHERA. A complete list of COPCs included in the HHERA can be found in **Appendix 9.2.2A**. The study area for the HHERA was identified as a 40 km x 40 km area centred on the proposed open pit and a 3-km wide corridor centred on the footprint of the proposed road access routes and transmission line. This study area is equal to the study area used for air quality effects assessment (**Section 5.2.4**).

To evaluate the COPCs loading to a surface water body from its associated watershed, waterbody parameters (i.e., surface area, watershed surface area, velocity of watershed, etc.) from the Davidson Creek watershed were evaluated with respect to human exposure. The water body parameters for Davidson Creek were selected and used in the HHERA based on the creek's highest potential for impact from the mine and on the close proximity of the creek to the mine site. Surface water quality data (i.e., COPC concentrations) from various hydrology nodes from various waterbodies within the study area were evaluated and used in the human health exposure model. The watershed parameters for Davidson Creek were provided by in **Section 5.3.3** (Surface Water Quality Effects Assessment) for use in the human health model calculations. Most of the parameters used in the HHERA model are site-specific. Where site-specific parameters were not available, default or estimated values provided by United States Environmental Protection Agency (US EPA) (2005) were used. It should be noted that the use of default parameters adds an uncertainty to the assessment as the values may not accurately represent site-specific conditions. As a result, this uncertainty may under- or overestimate the predicted risks from the HHERA model. Site-specific and default water body parameters used in the model are presented in **Appendix 9.2.2A**, Annex 9.2.2E, HHERA Model Calculations, Section 1.4.

The exposure scenario assessed for non-carcinogenic chemicals involved an Aboriginal toddler accompanying an adult who spent all his time in the region engaged in traditional harvesting of country foods (i.e., hunting or fishing) or recreational activities (i.e., hiking) within the HHERA study areas of the Project. The toddler could potentially be exposed to concentrations of COPCs via direct contact with soil, inhalation of dust, or ingestion of soil, surface water, vegetation, wild game, or fish. The assessment of carcinogenic chemicals focused on an Aboriginal adult who spends all of their time in the study areas and also engages in traditional activities. He/she could also potentially be exposed to concentrations of COPCs via direct contact with soil, inhalation of dust, or ingestion of soil, surface water, wild game, or fish.

Four receptor locations were identified within the HHERA study area. The basis and location of these receptor locations are described in **Appendix 9.2.2A.** The four receptor locations were:

- Blackwater-Spruce Ranch;
- Laidman Lake Ecolodge;
- Pan Phillips Resort and IR Kluskus 1; and
- Tatelkuz Lake Resort and IR Tatelkus Lake 28.

It should be noted that Blackwater Spruce Ranch, Tatelkuz Lake Resort and Tatelkus Lake IR 28 are within the LSA while Laidman Lake Ecolodge and Pan Phillips receptor locations are situated outside of the LSA, near the boundary. Despite being outside of the LSA, the latter two locations were selected because they are representative of other locations to the west and south of the mine site, respectively. Each receptor location was selected based on their orientation in relation to the mine site in order to cover potential exposure from air emission in all directions (i.e. North, East, South and West). Other sites (i.e., Kluskus 1 IR) noted to be at a greater distance from the mine site when compared to the identified receptor locations are expected to be exposed to lower concentrations of COPCs in ambient air. Therefore, overall risks are also expected to be lower, given the increased distance from the mine site.

Human receptor characteristics are summarized in **Table 9.2-4**.

Table 9.2-4: Summary of Human Health Receptor Characteristics for the Project

Receptor Characteristic	Receptor Parameters		Source
	Toddler	**Adult**	
Age	7 months to 4 years	>20 years	HC, 2010a
Exposure duration (years)	4.5	60	Based on 80-year lifespan
Body weight (kg)	16.5	70.7	Richardson, 1997
Soil ingestion rate (g/d)	0.08	0.02	CCME, 2006
Surface water ingestion rate (L/d)	0.6	1.5	Richardson, 1997
Inhalation rate (m^3/d)	8.3	16.6	Allan et al., 2008
Food ingestion (g/d)			
• Root vegetables	105	188	Richardson, 1997
• other vegetables	67	137	Richardson, 1997
• Fish[1]	85	270	Richardson, 1997
• Wild Game[1]	95	220	Richardson, 1997
Skin surface area (cm^2)			
• Hands	430	890	Richardson, 1997
• Arms (upper and lower)	890	2,500	Richardson, 1997
• Legs (upper and lower)	1,690	5,720	Richardson, 1997
Soil loading to exposed skin (mg/cm^2)			
• Soil adhesion to skin (based on hands)	0.1	0.1	Kissel et al., 1996, 1998
• Soil adhesion to skin (other than hands)	0.01	0.01	Kissel et al., 1996, 1998

Notes: [1]Ingestion rates for Canadian First Nations populations;
CCME = Canadian Council of Ministers of the Environment; cm^2 - square centimetres;
g/d = grams per day; HC = Health Canada; kg = kilogram; L/d = litres per day;
m^3/d = cubic metres per day; mg/cm^2 = milligrams per cubic centimetre

Human receptor characteristics and food ingestion values, for the human receptors, were obtained from Health Canada (2010) and listed in **Appendix 9.2.2A**. When available, site-specific values for food ingestion rates were employed for subsistence users and populations residing near the geographic center of BC. Additional details for the characterization of potential human receptors are provided in the Environmental Health Baseline Report (**Appendix 9.1A**). These assumptions provide the basis of the exposure assessment.

After identifying the human receptors within the study areas, the method by which human receptors could be exposed to the COPCs (the source-to-receptor exposure pathway) was identified. The potential exposure and uptake pathways for human receptors that are located within the study area and that are evaluated in this assessment are summarized in **Appendix 9.2.2A**. The exposure pathways considered in the HHERA for human receptors include inhalation of emissions, ingestion and dermal contact with surface water, dermal contact with soil, inhalation of re-suspended soil particles, inadvertent ingestion of soil and ingestion of country foods (i.e., vegetation, fish and wild game). Details and the justification of the selection of exposure and uptake pathways for the human receptors are provided in **Appendix 9.1A**.

The potential exposure and uptake pathways for human are summarized in **Table 9.2-5**.

Table 9.2-5: Human Health Exposure Pathways

Environmental Media	Exposure Pathway
Emissions	Inhalation
Surface water	Ingestion
Surface water	Dermal contact (i.e., swimming or fishing)
Soil	Inadvertent ingestion
Soil	Inhalation of re-suspended soil particles
Soil	Dermal contact
Vegetation	Ingestion
Fish	Ingestion
Wild Game	Ingestion

The toxicity assessment includes hazard identification, which describes the potential adverse effects associated with a chemical and whether they are likely to occur in humans, and dose-response evaluation, which quantifies the relationship between chemical dose and the incidence of adverse health effects in the exposed populations. Exposure limits or TRVs were usually developed by regulatory agencies (i.e., Health Canada, US EPA) based on a technical review of all of the available scientific information and application of professional judgment. These limits are considered protective of the most sensitive toxicological endpoints in individuals and include an adjustment of uncertainty factors. In general, such exposure limits were developed to protect the most sensitive individuals in a population, including sensitive life stages (e.g., pregnant women, the elderly) and individuals with compromised health (e.g., asthmatics). Typically, exposures below these exposure limits would not be associated with adverse health effects and thus, would not represent a concern. As exposures increased to levels above prescribed exposure limits, the probability of increased health risk increased. **Appendix 9.2.2A** provides the details of the potential adverse effects on humans with exposure to COPCs.

The risk characterization, the final step in the risk assessment process, integrates the results of the exposure and toxicity assessments for each COPC in order to estimate the potential for carcinogenic and non-carcinogenic human health effects from exposure to that COPC.

The site-specific non-carcinogenic risk levels were calculated and presented in terms of HQs, as these can be directly compared to Health Canada's target HQ of 0.2 (Health Canada, 2010). For non-carcinogens, Health Canada's target HQ is based on an estimate of chemical intake that is unlikely to cause adverse health effects even if exposure occurs for an entire lifetime. For carcinogens, Health Canada's allowable Incremental Lifetime Cancer Risk (ILCR) target is set at 10^{-5}, or 1 in 100,000 (HC, 2010). If the ILCR was less than 1 in 100,000 for carcinogens, or the HQ less than 0.2 for non-carcinogens, then the health risk was considered acceptable. Any HQs exceeding a target were evaluated in context in order to determine the likelihood for adverse effects.

For CACs, HQs were calculated by dividing measured CAC concentrations by each parameter's respective TRV. The TRV is defined as an estimate of chemical intake that is unlikely to cause adverse health effects even if exposure occurs for an entire lifetime. Typically, TRVs are set at conservative levels. The HHERA (**Appendix 9.2.2A**) discusses in more details the level conservatism used in the assessment.

For the full HHERA, refer to **Appendix 9.2.2A**.

9.2.2.2 Valued Component Baseline

Baseline environmental exposures for noise and environmental contaminants are presented below. Exposures to environmental contaminants were assessed in terms of HQs.

9.2.2.2.1 Past, Present and Future Projects and Activities

No past, present or future projects/activities that may impact environmental exposures have been identified. A comprehensive list of past, present and future project and activities located within the RSA for all selected VCs is presented in **Appendix 4C** and is summarized in **Section 4, Table 4.3-11**.

9.2.2.2.2 Traditional Ecological and Community Knowledge

Community knowledge provided by local non-Aboriginal trappers and cattle ranchers indicate that a quiet environment is important to their livelihoods. They anticipate an increase in noise as a result of the Project. Information obtained through interviews and traditional knowledge studies with Aboriginal Groups suggests that a quiet, peaceful environment is important, and that noise and vibrations may negatively affect Aboriginal and non-Aboriginal use and enjoyment of the land and environment, and disrupt wildlife and livestock. A local outfitter noted that noise/human activity related to power line construction and wildlife may be a problem for in the fall when hunting (**Appendix 3.1.3C**).

Community knowledge relating to contaminants was not collected. HHERA exposure scenarios were based on aggregated community knowledge published by Health Canada (2010). Where available, BC-specific values for food ingestion rates from Chan et al. (2011) were employed for subsistence users and populations residing near the geographic centre of BC. Chan et al. (2011) conducted a First Nations food, nutrition, and environment study with the active participation of some BC First Nations. The study describes the traditional diet of First Nations people found on the land and waters around their communities. Additional details for the characterization of potential human receptors are provided in the Environmental Health Baseline Report (**Appendix 9.1A**).

9.2.2.2.3 Noise Baseline

As described in **Appendix 5.1.1.3A** (Noise and Vibration Baseline Report), the long-term noise survey indicates the pre-Project overall noise pressure levels (measured in equivalent sound pressure level (L_{eq})) at the Blackwater Project area at 31.1 dBA. Time-weighted noise pressure levels (L_{eq}) at the airstrip and Tatelkuz Lake were measured at 26.4 dBA (average over a two-day period) and 24.2 dBA, respectively. These results indicate that the sound levels and characteristics in the Project area are low, typical of a quiet, remote environment.

Pre-project maximum noise pressure levels (L_{max}) were measured at 67.5 dBA at the Project location. Considering that L_{eq} levels were measured at 31.1 dBA, it is inferred that potentially annoying noise (>55 dBA) currently occurs infrequently at the Project site probably related to current exploration activities within the proposed mine site.

9.2.2.2.4 Environmental Health Baseline

The Environmental Health Baseline Report (**Appendix 9.1A**) describes the estimates of risks to humans potentially exposed to background concentrations of contaminants within the study area of the Project. There are no significant sources of COPCs in the RSA that may impact human health. The following is a summary of the HHERA findings:

- Maximum baseline soil concentrations for arsenic and molybdenum were screened against and exceeded human health-based soil criteria;
- Maximum baseline surface water concentrations for aluminum, arsenic, and cadmium were screened against and exceeded human health-based surface water criteria;
- The baseline total HQs calculated for aluminum, cadmium, and molybdenum were considered to be acceptable (below Health Canada's target risk of 0.2 for the toddler receptor) using conservative assumptions of exposure, suggesting that adverse health effects will not likely occur;
- The baseline non-carcinogenic health risk, for arsenic was calculated to be above Health Canada's target risk of 0.2 for the toddler receptor. The exposure pathways primarily responsible for the exceedance for the non-carcinogenic receptor are soil ingestion, surface water ingestion, and fish ingestion. Uncertainties existed in the HHERA, including the calculation of TRVs and conservative exposure assessment assumptions, including consumption rates). Moreover arsenic is assumed to be fully bioavailable; unrealistic for the soil ingestion pathway in particular since the majority of the arsenic is expected to be present in low bioavailable sulphide minerals. Actual exposures are therefore likely to be substantially lower than those presented in the HHERA (**Appendix 9.2.2A**);
- In terms of baseline cancer risk, the ILCR estimate for arsenic is noted to be above Health Canada's target risk level of 1.0×10^{-5} for the adult receptor. The main exposure pathways primarily responsible for the exceedance for the carcinogenic receptor are surface water ingestion and fish ingestion. Uncertainties existed in the HHERA, including the calculation of TRVs and conservative exposure assessment assumptions (full-time presence within study area), including consumption rates. Actual exposures are likely to be substantially lower than those presented in the HHERA (**Appendix 9.2.2A**); and
- For baseline CACs (NO_2, SO_2, CO, $PM_{2.5}$, and PM_{10}), HQs were calculated by dividing measured CAC concentrations by each parameter's respective TRV. Baseline HQ values are below 1.0 for all CACs, suggesting that adverse health effects will not likely occur.

9.2.2.3 Potential Effects of the Project and Proposed Mitigation

Effects are evaluated through a quantitative human health risk assessment considering dependent discipline assessments (noise, air quality, surface water quality). Receptors for the assessment including Aboriginal reserves are identified and described in **Section 9.2.2.1.2** and presented in **Figure 9.1-3**.

Key interactions have been identified for project activities occurring at the mine site only. These key interactions are caused by activities such as drilling, blasting, hauling, and dumping of ore and waste rock that could generate air emissions or liquid effluents to which humans could be exposed. Moderate interactions occurring during the construction and operations phases are also captured in the assessment as emissions occurring along the linear components. As explained in **Section 9.1.3.7**, the activities occurring during the operations phase represent the worst case scenario for environmental exposures and have been subject of HHERA modelling.

Project-related noise and environmental contaminants effects are discussed below. If the residual effect of the Project on the environmental exposures is determined to be other than negligible and a potential temporal or spatial interaction with another project or activity is identified, then a CEA will be conducted taking into account past, present, certain and reasonably foreseeable future project or activities. The CEA is discussed in **Section 9.2.2.5**.

9.2.2.3.1 Noise Effects

The noise modelling results (**Appendix 5.2.2A**) show that the project components that represent major noise sources at the proposed operation will be in the pit area, where ore-extracting equipment (e.g., shovels, loaders, trucks, drills, etc.) will operate. **Figure 5.2.2-1** in **Section 5.2.2** (Noise and Vibration Effects Assessment) shows that the 55 dBA contour is almost exclusively within the Project footprint. This indicates that there is very limited potential for community annoyance from mine site activities. Potential for community annoyance exists only for persons in the area directly adjacent to the open pit and near to the truck stop. There are no residents within this area. Affected persons could include temporary land-users conducting traditional or recreational activities adjacent to the open pit and visitors to the mine site.

Based on Health Canada (2005) criteria, blasting has the potential to cause annoyance at less than 3-km distance from the Project footprint. However, as described in **Section 5.2.2**, at a distance, blasting is usually heard as a low rumble or “popping” sound that lasts one or two seconds. If the wind is blowing away from the listener, there may be no audible sound. There are no residents within this area. Affected persons could include temporary land-users conducting traditional or recreational activities in the vicinity of the Project footprint.

Boeing 737s are the largest sized aircraft to potentially be used at the Project; however, smaller Dash 8 sized aircraft would most likely be used. As described in **Section 5.2.2**, residents in the region will not be exposed to noise levels above permissible criteria. Based on Health Canada (2005) criteria, the airstrip has the potential to cause community annoyance to four permanent and seasonal residences during take-off of a Boeing 737 to the northeast. These residences are at least 7.5 km from the air strip. These residences include one permanent residence of a Lhoosk'uz Dene family at IR 28. All the residences are all at least 7.5 km from the air strip. Predicted noise levels at these residences are between 65 dBA and 72 dBA during take-off, which is expected to occur 2 or 3 times per week with a 2- to 3-minute duration. Community annoyance is not expected to occur during aircraft landing. Flights using smaller, less noisy, aircraft are expected to occur two times per week during the construction phase. There are no regular flights proposed during the operations phase.

9.2.2.3.2 Environmental Health Effects

The HHERA within **Appendix 9.2.2A** presents the details of the potential Project-specific and cumulative effects and risks to humans exposed to contaminants associated with the operations phase of the Project, since this phase is more likely to represent higher potential for COPC air emissions when compared to the construction and closure phases. There are no significant sources of air emissions around the Project area. The only major project within 50 km was the Chu Molybdenum mine and that application has been 'withdrawn'. The findings of the HHERA (refer to **Appendix 9.2.2A**) are summarized below.

The HHERA, considered that the operations phase of the Project would represent maximum air emissions for the mine site project component when compared to the construction, closure and post-closure phases. The operations phase activities at the mine site involve drilling, blasting, hauling of ore, ore processing and disposal of tailings, and creation of waste rock dumps. Heavy equipment used for the mining and transport of the ore would be at the highest during operations which will release the greatest emissions from vehicular traffic. Generation of particulates would be greatest as the ore is mined and crushed. Therefore, when compared to the construction, closure and post closure phases, it is expected that the operations phase represents the maximum air emissions for the mine site.

The construction phase of the Project involves site preparation such as stripping of the overburden, and drainage controls and construction of the main ore processing facilities, dams for storage of water and tailings, and ancillary facilities such as the workforce accommodation camp and access roads. This phase will also involve land disturbance, for development of equipment laydown areas and construction of truck shops and offices. The activities involved with the construction phase are short-term when compared to the life of the mine. The closure activities involve decommissioning and demolition of facilities, recontouring and re-vegetation and the flooding of the open pit. Additionally, maintenance of in stream flows in Davidson Creek will continue through the closure and post closure phases. The HHERA model considered surface water quality estimates for all project phases.

The findings of the HHERA (refer to **Appendix 9.2.2A**) are summarized below.

9.2.2.3.2.1 Criteria Air Contaminants

Predicted 1-hour, 8-hour, and 24-hour ground-level NO_2, SO_2, $PM_{2.5}$, PM_{10} and CO concentrations do not result in any acute short-term exposure HQ values above 1.0 for any of the receptor locations. The highest HQ values for NO_2, SO_2, $PM_{2.5}$, PM_{10} and CO are 0.051, 0.00067, 0.065, 0.19 and 0.023, respectively, at Tatelkuz Lake Resort and Tatelkus Lake IR 28. Adverse health effects for human receptors are unlikely to occur following acute short-term exposures to NO_2, SO_2 $PM_{2.5}$, PM_{10} and CO.

Predicted annual ground-level NO_2, SO_2 and $PM_{2.5}$ concentrations do not result in any chronic HQ values above 1.0 for any of the receptor locations. The highest HQ values for annual chronic exposure to NO_2, SO_2 and $PM_{2.5}$ are 0.14, 0.041, and 0.53, respectively, at Tatelkuz Lake Resort and Tatelkus Lake IR 28. There is no consistent pattern in regards to the total HQ values between the baseline conditions and the effects assessment. However, since the total HQ values in the baseline condition and effects assessment remain less than 1.0, adverse health effects for human receptors are unlikely to occur following chronic exposures to NO_2, SO_2 and $PM_{2.5}$.

9.2.2.3.2.2 COPCs

The risk estimate for chronic exposures to arsenic is above HC's target risk level of 1.0×10^{-5} for the adult receptor (for both adult alone and composite lifetime receptor) at each human receptor location. ILCRs ranged from 2.0×10^{-4} at Laidman Lake Ecolodge and Pan Phillips Resort to 2.1×10^{-4} at Tatelkuz Lake Resort and Blackwater Spruce Ranch. Both the baseline and effects assessment had ILCR values greater than 1.0×10^{-5} for human receptors. The primary exposure pathway that contributes the most to the carcinogenic risks for arsenic exposure is through ingestion of surface water and fish. Effects assessment ILCRs were noted to be lower when compared to the Baseline ILCRs. This is expected since the predicted surface water concentrations for the EA were low and within BC Freshwater Guidelines or site-specific water quality objectives. However, although there are exceedances, uncertainties exist in the risk assessment process, both in the derivation of TRVs as well as the exposure assessment assumptions (see uncertainties in **Appendix 9.2.2A**), that may tend to overestimate the risk. Actual exposures are likely to be substantially lower than those presented in this assessment. Also, conservative assumptions were considered throughout the assessment with regards to exposure duration. For example, the adult receptor was assumed to spend their entire lifetime within the LSA. This assumption is conservative as the human receptors aren't likely to spend all their time in the LSA. Since arsenic can exist in a trivalent or pentavalent state, a worst-case assumption was made that 100% of the arsenic was present in its most toxic trivalent form and not in the less toxic pentavalent form. These assumptions may overestimate the level of risks to the adult receptor. Deposition of COPCs to soils, via dustfall, were calculated and are shown in **Appendix 9.2.2A**.

Current risks associated with all non-carcinogenic COPCs for both chronic and acute exposure are noted to be below HC's risk target level of 0.2 for non-carcinogenic effects. With the exception of arsenic, the risk associated with the remaining carcinogenic COPCs, for both the adult alone and composite adult (i.e., amortized over lifetime) receptor is below HC's risk target level of 1.0×10^{-5} for carcinogenic effects.

In summary, arsenic was observed to have an ILCR values greater than 1.0×10^{-5} for both the baseline and Project scenarios. The increase in potential exposure as a result of the Project is highly unlikely to result in measurable effects. In addition, uncertainties exist at each stage of the HHERA process. They represent limitations in knowledge about the actual value of a parameter (e.g., human receptor contact rates were assumed, but actual rates may vary considerably from assumed values). The lack of knowledge may be associated with either incomplete datasets (e.g., dermal penetration of chemicals was estimated rather than actually measured), or through the normal variability that may exist in the data used in the HHERA. Moreover, the assessment conservatively assumed that human receptors were present full time at the modelled receptor locations and that arsenic was completely bioavailable. Receptor characteristics (i.e., exposure duration and frequency), exposure pathways, are presented in **Appendix 9.2.2A**. Uncertainties arise from several areas in the assessment, and are further described in **Appendix 9.2.2A**.

Chronic health effects associated with exposure to arsenic include skin lesions and liver injury which manifests as jaundice and progress to cirrhosis and liver cancer (**Appendix 9.2.2A,** Annex 9.2.2C).

Environmental impact assessments typically use descriptors to qualify the potential impacts of the Project. These descriptors include direction, magnitude, geographic extent, duration/frequency, and reversibility. However, unlike other disciplines, these descriptors are not used in the evaluation of the environmental health risk. In the determination of the environmental health risk estimates, these descriptors are inherently incorporated in the fate/transport and exposure modelling.

9.2.2.3.3 Past, Present and Future Projects and Activities

No past, present or future projects/activities that may impact environmental exposures have been identified; therefore, potential adverse effects are not described.

9.2.2.3.4 Mitigation

Mitigation measures are based on improving air quality and surface water quality. Air quality mitigation measures are presented in **Section 5.2.4**, and include provisions to minimize emission of combustion gases. There will be no surface water discharges from the Project during the operations phase and seepage from mine facilities will be managed. Water quality in streams downstream of the project is predicted to meet BC Freshwater Guidelines or site-specific water quality objectives throughout all phases of the Project. Therefore, this is not expected to result in harmful accumulation and release of metals from downstream surface water or sediments. Conceptual management of mine water is discussed in detail in **Section 2.2** and in the Mine Water Management Plan (MWAMP), **Section 12.4.1.18.4.18** and **Section 5.3.3** discusses potential effects on water quality in detail.

A Country Food Monitoring Plan (**Appendix 9.2.2B**) will be developed and submitted for review with relevant agencies and designated Aboriginal groups. Country Foods Monitoring Plan will be implemented prior to mine operations and provide results of monitoring within one year of completion of the monitoring to those groups. A monitoring program will enable environmental contaminant concentrations in air, water and country foods to be observed, reported, and evaluated. Air and water monitoring programs are described in **Section 12.2.1** (Environmental Management Plans (EMPs)). The Proponent will engage nearby First Nations in the environmental monitoring, including the country foods monitoring program. The proposed Country Food Monitoring Plan is presented as **Appendix 9.2.2B**.

Table 9.2-6 provides ratings for effectiveness of mitigation measures to avoid or reduce potential effects on environmental exposures during mine site development.

Table 9.2-6: Mitigation Measures and Effectiveness of Mitigation to Avoid or Reduce Potential Effects on Environmental Exposures during Mine Site Development

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Effectiveness of Mitigation Rating
Environmental exposures	Construction, Operations, Closure, Post-Closure	Air quality mitigation measures are presented in **Section 5.2.4**, and include provisions to minimize emission of combustion gases	High
		Section 2.2 states that there will be no surface water discharges from the Project during the operations phase and seepage from mine facilities will be managed (Mine Water Management Plan **Section 12.4.1.18.4.18).**	Moderate - High

In summary, low success rating means mitigation has not been proven successful, moderate success rating means mitigation has been proven successful elsewhere, and high success rating means mitigation has been proven effective. The mitigation proposed for environmental exposures relies entirely on mitigation for the main pathways identified in the assessment, which are air and water. The effectiveness of mitigation measures for air quality is rated high because the proposed mitigation measures are technologies that are widely used in mining and other industries and proven over a long period of time at reducing emissions. For surface water quality mitigation measures high success ratings have been applied above to mitigation measures that have proved effective at other mine sites. Where there is some question of the degree of success of mitigation, i.e., for alternate treatment options provided as contingencies, a rating of moderate is applied.

9.2.2.4 Residual Effects and their Significance

Effects of the Project on human health are considered in the context of affecting change in population health (i.e., annoyance, injury, or disease). Overall, health effects for environmental exposures for Aboriginal and non-Aboriginal peoples are qualitatively rated as negative but not significant, based on quantitative evaluations (**Table 9.2-7**). Note that the HHERA model used worst-case conservative exposure scenarios, including one Aboriginal receptor inside the air quality study area. As the Aboriginal receptor has increased potential exposure compared to a non-Aboriginal receptor, the results and conclusions of the HHERA can also be applied to the non-Aboriginal population,

The attributes used for the determination of the significance of the residual effect include context, magnitude, geographic extent, duration, frequency, and reversibility, as described in **Section 4.3.5** (Assessment Methodology). In the determination of the environmental health risk estimates, these attributes are inherently incorporated in the fate/transport and exposure modelling.

In addition to the attributes listed above, direction is considered as part of the risk assessment process as it is intended to evaluate the potential negative health effects. In the human health risk assessment component, the risks for non-carcinogenic and carcinogenic effects are determined. These effects are all considered negative.

HQ defines the magnitude of the risk as a proportion of a tolerable dose/concentration, while ILCR indicates the magnitude of the incidental increase in the cancer rate.

Context is considered to be neutral, because of the absence of any other projects and activities that generate environmental contaminants with the potential to affect human health. Therefore, it is considered that the VC has the capacity to accommodate change and is responsive to management actions.

Geographic extent is addressed by the definition of the various receptor locations in the study area and determination of locations that have higher risk estimates than others. The dispersion modelling of the air emissions from the Project defines the extent of the potential impacts following exposure (**Appendix 5.2.2A**). Measureable environmental exposures were found to occur within the local study area for the human health.

Duration and frequency are included in the calculations of exposure as these are exposure terms in the mathematical models (**Appendix 9.2.2A**, Annex 9.2.2D). The duration and frequency of exposure in the human health risk assessment component use the one-hour maximum, 24-hour maximum, or annual average modelled concentrations and their corresponding tolerable concentrations. Also, the human health risk assessment considered both acute (i.e., less than 24 hours) and chronic (i.e., lifetime) exposures in the evaluation.

Effects on environmental health from short-term exposures are generally considered to be reversible. For these short-term exposures, the receptor may experience an adverse health effect (e.g., eye irritation) for the duration of the exposure. However, when the exposure has ended, the environment effect would resolve itself (e.g., eyes no longer irritated). The potential health risks from acute exposures can be decreased further by reducing or limiting the ambient air COPC concentrations.

The health risks associated with long-term or chronic exposures, including cancer health risks, are considered to be generally irreversible.

A CEA for environmental health is not considered because the residual effects are expected to be Not Significant (negligible) during the construction, operation, closure and post-closure phases of the Project and that there are no other significant sources of emissions of COPCs around the Project area that may impact human health.

Ratings for the determination of significance for environmental exposures are presented in **Table 9.2-7**.

Table 9.2-7: Significance of Residual Project Effects for Environmental Exposures

Categories for Significance Determination	Noise	Environmental Contaminants
Context	neutral	neutral
Magnitude	Low	Negligible
Geographic extent	Local	Local
Duration	Short-term	Long-term
Reversibility	Yes	Yes
Frequency	Intermittent	Continuous
Likelihood determination	High	Low
Statement of the level of confidence for likelihood	High	Moderate
Significance determination	Not significant (Negligible)	Not significant (Negligible)
Statement of the level of confidence for significance	High	High

Note: The determination of significance considers all Project phases but it is based on the HHERA conducted for the operations phase, which reflects the worse conditions for noise and environmental contaminants.

9.2.2.5 Cumulative Effects

Residual effects of the Project related to environmental exposures are predicted to be Not Significant (negligible); therefore, a CEA is not required.

9.2.2.6 Limitations

Uncertainties exist at each stage of the HHERA. They represent limitations in knowledge about the actual value of a parameter (e.g., receptor contact rates were assumed but actual rates may vary considerably from the assumed value). The lack of knowledge may be associated with either incomplete datasets (e.g., dermal penetration of chemicals was estimated rather than actually measured) or through the normal variability that may exist in the data used in the risk assessment. Uncertainties arise from several areas; therefore, a discussion of uncertainty is necessary to identify areas where information gaps exist and where there is potential to affect the risk assessment. Several overly conservative assumptions are associated with the HHERA, which are described in **Appendix 9.2.2A**, Section 4.6. These include:

- The HHERA exposure assessment assumes that human receptors would inhabit the area within the Project's LSA for their entire lifetime, and be exposed daily through the inhalation of chemicals in the air or re-suspended particulates, consumption of wild game, ingestion of vegetation and soil, ingestion of surface water, and dermal contact with the soil. This is a conservative assumption and will overestimate the risks for the human receptor;

- Contaminants are completely bioavailable. Metal contaminants in wastes at mines are typically present in sulphide minerals that exhibit low bioavailability. This assumption is considered conservative and will overestimate the risks;
- It is not known which portions of the country foods human receptors will eat (i.e., fillet fish vs. whole fish, muscle tissue vs. fat, organs and carcass parts). As a result, uniform distribution of chemicals was assumed in the soil, plant tissues, fish, and meat, especially the edible portions such as the muscles, which may under or overestimate the overall risks;
- Conservatism in air quality predictions (see Air Quality Model Assumptions in **Section 5.2.4 and Appendix 5.2.4A**);
- The assessment assumed that individuals will be eating wild game as part of their normal diet. However, there is no analysis of game meat quality but rather the assessment relied on mathematical modelling to predict the tissue concentrations. As a result, there is an uncertainty related to the contribution of game meat ingestion to the overall COPC intake;
- Datasets of toxicological information for many chemicals are incomplete. As a result, toxicity values based on these datasets often have varying degrees of uncertainty associated with them, leading to overestimation of risks;
- Use of short-term toxicity studies (e.g., maximum two years for rodent studies) to predict effects from long-term exposures in humans;
- Prediction of the adverse health effects of low dose exposures in humans based on high or maximum tolerated doses in laboratory animals;
- The use of default parameters adds uncertainty to the assessment as the values may not accurately represent site-specific conditions. As a result, this uncertainty may overestimate the predicted risks from the HHERA model;
- Exposure limits developed by leading regulatory agencies typically incorporate large safety/uncertainty factors to compensate for uncertainties. The exposure assessment makes conservative assumptions regarding the exposure regimes that the human receptors undergo; and
- Characterization of the risk for carcinogens may have uncertainty and conservatism added to it, particularly in the derivation of the cancer slope or unit risk factors. These factors, which are used to estimate the ILCR, are often an upper bound estimate of the probability of response. Risk factors based on animal data are considered equally with those based on human exposures. As a result, these two factors may contribute to an overestimation of risk.

Some of the assumptions for the assessment could be considered less conservative. An example of such an assumption is the use of statistical parameters (e.g., mean) of the exposure (e.g., body weight, ingestion rate) that may result in an underestimation of risks (depending on the distribution of the data). The use of such statistical measures for calculating exposures may lead to an under-estimating of the potential exposures and therefore, subsequent health risk. However, these statistical parameters were selected based on recommendations by the appropriate regulatory authority (e.g., Health Canada, US EPA) for use in the HHERA. Also, the use of overly conservative assumptions in other model parameters is expected to adequately offset the lower conservative assumptions and result in still overestimation of the risks.

9.2.2.7 Conclusion

Intermittent exposure to noise during northeastward take-off of aircraft may cause limited community annoyance to one Lhoosk'uz Dene family residing at IR #28 and three non-Aboriginal families at their residences up to twice per week during the construction phase. This potential effect was rated Not Significant (negligible).

Based on Health Canada criteria, modelled baseline and Project-related health risks are acceptable for potential exposure to all environmental contaminants except arsenic. Both the baseline and Project scenarios had HQ values greater than 1.0 and ILCR values greater than 1.0 x 10^{-5} for arsenic based on conservative exposure assumptions. A small increase was detected in the Project scenario, but the Project does not substantially increase the health risks for land users within the HHERA study areas. This potential effect was rated Not Significant (negligible).

9.2.3 Worker Safety and Health

Surface mining is one of the safest heavy industries in BC (BC Ministry of Energy and Mines (BC MEM), undated). This is demonstrated by the industry's average workplace insurance premium base rate in BC (WorkSafeBC, 2012), which is generally lower than other heavy industries in the province.

Safety procedures and site standards help to ensure that tasks and work practices are performed in a safe manner with minimized risk. The Proponent has established formal risk management processes to identify hazards, assess risk, determine appropriate control measures for those hazards, and monitor the effectiveness of those controls. The Proponent maintains a "safety-first" culture, in which employees and contractors are motivated to do the right thing to keep themselves and their colleagues healthy and injury free. Training programs, safe work procedures, site housekeeping, and operational standards are enforced to improve workplace safety and minimize risk to people and equipment (New Gold, 2012a).

9.2.3.1 Introduction

The health and safety risk for workers is assessed quantitatively by comparing average worker compensation insurance base rates for industries within the region with those related to construction and mining (described in more detail below). This quantitative assessment is supported by a qualitatively by describing the major hazards for these industries. For camp noise, the assessment uses accepted guidelines (see below).

9.2.3.1.1 Legislation

In BC, worker health and safety in mines is regulated by BC MEM. The Health, Safety and Reclamation Code for Mines in British Columbia 2008 (Mines Code) (BC Ministry of Energy, Mines and Petroleum Resources (BC MEMPR), 2008) includes provisions that protect mine workers and the general public.

With few exceptions, WorkSafeBC (2013a) regulates occupational health and safety for non-mine workers under the BC Occupational Health and Safety (BC OHS) regulations. These workers include contracted construction labourers.

Worker health and safety for highway transportation falls under federal (Human Resources and Skills Development Canada (HRSDC)) jurisdiction (Canada Centre for Occupational Health and Safety (CCOHS), 2008). As such, occupational health and safety for the transportation of contractors is regulated under the *Canada Occupational Health and Safety Regulations* (Government of Canada, 1986).

9.2.3.1.2 Guidelines

In terms of camp indoor noise levels, Health Canada (2005) advises adherence to the WHO guidelines, when considering sleep disturbances and community noise. WHO has established a guideline of 30 dBA inside a dwelling to avoid sleep disturbance (WHO, 1999).

9.2.3.1.3 Workforce

Potential Project workers are either currently employed in the construction sector, mining subsector, other industry subsectors, or new entrants to the labour force. Forestry and the public sector are currently the prominent industry subsectors in the SERSA (refer to **Section 6**, Assessment of Potential Economic Effects). Therefore, it is assumed that potential Project workers resident in the SERSA are either currently employed in the construction, mining, forestry and public sectors or new entrants to the labour force.

9.2.3.1.4 Workers Compensation Insurance Premiums

WorkSafeBC is responsible for workplace compensation insurance throughout BC. Such insurance protects employers against lawsuits from injured workers, including mine workers. Workplace compensation insurance ensures that workers are protected from economic hardship caused by work-related injuries or disease. WorkSafeBC (2012a) calculates and charges insurance premiums to companies in BC based on past claims for injuries and occupational diseases according to the respective sector, subsector, industry, and company.

9.2.3.2 Valued Component Baseline

The human health baseline is presented in **Section 9.1**, and includes an overview of general health and wellbeing for the general population and First Nations population. The human health baseline identified vulnerabilities in First Nations health, indicating that First Nations employees may be at increased risk to health effects of workplace exposures. The human health baseline identified no vulnerabilities between men and women in terms of physical health. The human health baseline did conclude that males in the region are more vulnerable in terms of mental health. The baseline characterization and assessment of potential effects was based on publicly available information, particularly information posted by WorkSafe BC and traditional or community knowledge was not considered.

9.2.3.2.1 Past, Present and Future Projects and Activities

A comprehensive list of past, present and future project and activities located within the RSA for all selected VCs is presented in **Appendix 4C** and is summarized in **Section 4, Table 4.3-11**. The projects and activities with the potential to affect the Worker Safety and Health in the SERSA include existing mining and forestry operations and could involve the workforce that would be hired for development of the Nulki Hills Wind, Fraser Lake Sawmill Biomass, Coastal GasLink Pipeline and Pacific Gas Looping projects.

9.2.3.2.2 Current Worker Health and Safety On-Site

The Project site currently supports exploration and environmental work tasks. Current health and safety provisions on site include an emergency helicopter landing area; a site-specific emergency response plan; a health, safety, and environmental induction program; an ongoing medical conditions and medications tracking system; and an on-site fitness and wellness program (New Gold, 2012b).

9.2.3.2.3 Current Worker Health and Safety Hazards in the SERSA

As described above, potential Project workers who reside in the SERSA are either currently employed in the construction, mining, forestry and public sectors or new entrants to the labour force. Common hazards for these industry sectors are described below.

9.2.3.2.3.1 Construction Hazards

Common hazards in the construction industry include chemical, physical and safety hazards. Potential chemical hazards include exposure to welding fumes, dusts, and vapours (Weeks, 2011). Potential physical hazards in the construction industry include exposure to noise, heat and cold, radiation, and vibration (Weeks, 2011). Main safety risks include falls from working at height; crush injuries in excavation work; slips and trips; being struck by falling objects; and moving heavy loads (European Agency for Safety and Health at Work, undated),

9.2.3.2.3.2 Mining Hazards

The International Labour Organization (Dotson and Hethmon, 2011) reported that the leading causes of injuries in surface mines are materials handling, slips and falls, machinery, hand tool use, power haulage, and electrical source contact. Donoghue (2004) summarized the hazards in mines:

- Physical hazards: rock fall, fire, explosions, mobile equipment, noise;
- Chemical hazards: crystalline silica, diesel particulate;
- Ergonomic hazards: extended work shifts; and

- Psychosocial hazards: drug and alcohol abuse.

9.2.3.2.3.3 Forestry Hazards

Common hazards in the forestry industry include those related to falling trees, heavy equipment, noise exposure, UV exposure, fatigue, working alone, working at night, falls, slips and trips, and extreme weather conditions (WorkSafe Victoria, undated).

9.2.3.2.3.4 Public Sector Hazards

Public sector employment includes government administration, public works, hospitals, and schools. Common hazards in the public sector subsector include those related to exposure to chemicals, ergonomics, blood-borne pathogens, tuberculosis, machinery hazards, violence, motor vehicles, and flammable materials (LeGrande, 2011).

9.2.3.2.4 Current Worker Health and Safety Risk in the SERSA

9.2.3.2.4.1 Average Worker Compensation Insurance Base Rates

The health and safety risk for workers in industries can be compared quantitatively using average worker compensation insurance base rates. The insurance base rates are effectively an indicator of occupational injury and disease. The average worker compensation insurance base rates for industries where workers resident in the SERSA are either currently employed, are presented below.

The average worker compensation insurance base rate for the general construction and heavy construction subsectors are $4.46 per $100 of employers' assessable payroll and $7.18 per $100 of employers' assessable payroll, respectively. The base rate for the open pit mining is $1.21 per $100 of employers' assessable payroll. The average worker compensation insurance base rate for the forestry and public sector subsectors are $8.43 per $100 of employers' assessable payroll and $1.35 per $100 of employers' assessable payroll, respectively. Comparing these industries, there is an increased likelihood of injury and disease as a result of exposure to workplace hazards in the forestry subsector than that found in the construction subsectors. There is an increased likelihood of injury and disease as a result of exposure to workplace hazards in the construction sectors than that found in the public sector and open pit mining sector.

9.2.3.2.4.2 Injury Rate

Injury rates are less indicative of worker health and safety risk than worker compensation insurance base rates, because they do not take into account injury severity. The injury rates for industries where workers resident in the SERSA are either currently employed were similar in 2012. WorkSafeBC (2013c) reported 5 claims per 100 person years of employment during 2012 for both the forestry and general construction subsectors. WorkSafeBC (2013c) reported 4 claims per 100 person years of employment during 2012 for both the heavy construction and public administration subsectors.

9.2.3.3 Potential Effects of the Proposed Project and Proposed Mitigation

The Project will have key and moderate interactions with the workforce that will be employed during the construction, operation and closure phases. **Section 4, Table 4.3-2** (Project Component and Activity Interaction Matrix) shows the potential key and moderate interactions between Project activities and components of the selected VCs. During the construction phase the workforce will peak with most of the work concentrated within the mine site. The construction of the linear components will also involve workforce in lesser numbers. During the operations phase most of the workforce will be concentrated at the mine site with only transportation and maintenance activities being undertaken along the linear components. During the closure phase the workforce numbers will be reduced significantly. A very low number of workers will be needed during the post-closure phase for periodic maintenance and monitoring activities resulting in no interaction.

Workplace hazards and the likelihood of illness and disease vary between Project phases. Project closure involves activities similar to those in Project construction. Project construction and closure phases are assessed jointly. Project construction and operation involve different work activities and tasks, and are assessed separately.

Vulnerable populations include young workers (WorkSafeBC, 2013a), people previously without employment, people currently employed in occupations with lower health and safety risks than the construction or mining subsectors, and workers exposed to multiple hazards, such as maintenance workers (BC MEM, 2008). Based on data collected for the baseline study, Aboriginal employees from the region may be at increased risk to health effects of workplace exposures. When compared to female workers, male workers will likely be more vulnerable in terms of mental health (**Section 9.2.3.2**).

If the residual effect of the proposed Project on worker safety and health is determined to be other than negligible and a potential temporal or spatial interaction with a project or activity is identified, then a CEA will be conducted taking into account past, present, certain and reasonably foreseeable future project or activities. The CEA is discussed in **Section 9.2.3.5**.

9.2.3.3.1 Project Construction and Closure Effects

Common hazards in the construction industry are described above, including chemical, physical and safety hazards.

In general, Project construction and closure work will be performed by businesses in the general construction and heavy construction industry subsectors. For Project workers currently employed within the existing construction industry, workers will likely be familiar with the range of on-site hazards occurring at the Project site.

The average worker compensation insurance base rate for the general construction and heavy construction subsectors are $4.46 per $100 of employers' assessable payroll and $7.18 per $100 of employers' assessable payroll, respectively. These are lower than the base rates for the forestry subsector, and higher than the base rates for the public sector.

The injury rate for the general construction and heavy construction subsectors are 5 claims per 100 person years of employment and 4 claims per 100 person years of employment (WorkSafeBC 2013c). These are similar to the injury rate for the forestry subsector and public sector, respectively.

This suggests that, overall, the introduction of Project construction activities would not introduce increased worker health and safety risk within the SERSA. Project workers currently resident in the SERSA will, in general, be exposed to an equal risk of workplace injury and disease as that found in their current workplace. Workers exposed to multiple hazards, such as maintenance workers, are vulnerable (BC MEM, 2008). New, young and inexperienced employees will be most at risk (WorkSafeBC, 2013a).

Worker health and safety effects during construction and closure will be neutral and negligible.

9.2.3.3.2 Project Operation Effects

Project operation effects are described above in terms of general mining hazards. Additional hazards are described below.

9.2.3.3.2.1 Mining

Donoghue (2004) reported that the most important concerns remaining in mining today are noise-induced hearing loss, ergonomics, respiratory disease, and health and safety risk management systems. The scope of directives, hazard alerts, and information letters issued by BC MEM pertaining to issues and safety incidents within the BC mining industry are consistent with those reported by International Labour Organization (Dotson and Hethmon, 2011) and Donague (2004), described above. Over the past five years, hazard alerts and information letters from BC MEM (2013) have included information about:

- Parking brake actuation on haulage trucks;
- Audiometric data (measuring noise effects);
- Detonator transportation;
- Lightning strikes;
- Overhead power line contact;
- Industrial protective headgear;
- Minimum age of mine workers;
- Accident reporting;
- Boosting vehicles; and
- Excavators in the mining industry.

Donoghue (2004) recognized that formalized risk management systems are an important tool for maintaining good working conditions and preventing occupational injury and disease.

9.2.3.3.2.2 Mineral Processing

Mining Industry Human Resources Council (undated) summarized the hazards in the mineral processing environment, including:

- Physical hazards: slippery floors, working at heights, mobile equipment, noise;
- Chemical hazards: dust, vapours/fumes, chemical irritants
- Ergonomic hazards: segmental and whole body vibration, shift work; and,
- Psychosocial hazards: deadline pressures, shift work and extended shift demands.

9.2.3.3.2.3 Mine Operations in General

As described above, Project workers currently resident in the SERSA will likely have experience in the construction, mining, forestry and public sectors or are new entrants to the labour force. For Project workers currently employed within the existing open pit mining sector, workers will likely be familiar with the range of onsite hazards occurring at the Project site.

As demonstrated above, the health and safety risk for workers in industries can be compared quantitatively using average worker compensation insurance base rates. The base rate for the open pit metal and mineral mining industry is $1.21 per $100 of employers' assessable payroll (WorkSafeBc 2013b). This is lower than the base rates for the prominent industry subsectors in the SERSA, at $8.43 per $100 and $1.35 per $100 of employers' assessable payroll for the forestry and public sector subsectors, respectively.

The injury rate for the mineral resources (mining) subsectors is 1 claim per 100 person years of employment (WorkSafeBC 2013c). This is lower than the injury rates for the prominent industry subsectors in the SERSA, at 5 claims per 100 person years of employment and 4 claims per 100 person years of employment, respectively.

This suggests that, in general, while future employees in the SERSA will be exposed to workplace hazards; they will be less likely to incur a workplace injury or disease at the Project than at their current workplace. Workers exposed to multiple hazards, such as maintenance workers, are vulnerable (BC MEM, 2008). New, young, and inexperienced employees will be most at risk (WorkSafeBC, 2013a).

Net Project effects during operations would be positive and relatively small.

9.2.3.3.3 Camp Noise Effects

As described in **Section 5.2.2** (Noise and Vibration Effects Assessment), noise levels outside of the construction camp and operations camp buildings will be approximately 40 dBA. The camps will be constructed as prefabricated modules, made with metal-clad walls with thick thermal insulation. Because of this, the walls will serve as effective noise barriers. Their octave band noise reduction and transmission loss have been estimated with an engineering acoustics program (Engineering Noise Control 2004) as having an overall transmission loss of 20 dBA. Therefore, an outdoor sound level of 40 dBA will be reduced to an indoor sound level of 20 dBA in the construction and operations camp buildings; lower than the 30 dBA guideline. Further information is presented in **Section 5.2.2**.

9.2.3.3.4 Past, Present and Future Projects and Activities

Existing mining and forestry operations and could involve the workforce that would be hired for development of the Nulki Hills Wind, Fraser Lake Sawmill Biomass, Coastal GasLink Pipeline and Pacific Gas Looping projects. Worker health and safety risk, existing mining and forestry operations have been evaluated as part of the effects assessment above.

It is feasible that construction workers from the Project are hired for the construction phase of the proposed Nulki Hills Wind, Fraser Lake Sawmill Biomass, Coastal GasLink Pipeline and Pacific Gas Looping projects; however, the introduction of these additional construction activities would not introduce increased worker health and safety risk within the SERSA.

In terms of the operations phase, if Project workers are hired for from the proposed Nulki Hills Wind, Fraser Lake Sawmill Biomass, Coastal GasLink Pipeline and Pacific Gas Looping projects. The base rate for the open pit metal and mineral mining industry is $1.21 per $100 of employers' assessable payroll (WorkSafeBc 2013b). This is lower than the base rates for the industry subsectors related to the potential future projects in the SERSA, at $3.08 per $100 and $4.04 per $100 of employers' assessable payroll for pipeline construction and sawmill subsectors. This is higher than the base rates for utilities subsector at $1.04 per $100 of employers' assessable payroll (WorkSafeBc 2013b). Therefore, worker health and safety risk would likely decrease for these workers, except for wind farm workers who would likely be subject to increased health and safety risk if they were hired at the Project.

9.2.3.3.5 Mitigation

The Proponent will strive to maintain an excellent safety culture, operate with an occupational health and safety management system, use preferred safety practices and procedures, and implement an occupational hygiene program, as per recommendations by BC MEM. To ensure continual improvement, health and safety targets will be established and published annually, as part of the New Gold Sustainability Report series. Targets published in 2013, include reducing the Lost-Time Injury Frequency Rate by 10% year on year and reducing the Total Reportable Injury Frequency Rate by 10% year on year (New Gold, 2013).

The Proponent will continue to develop the current integrated health, safety, and environment management system, the medical conditions and medications tracking system, and the on-site fitness and wellness program. These programs will be continually developed and adjusted to meet changing Project requirements. Specific attention will be provided during transitions to each new Project phase.

Establishing a positive safety culture and implementing comprehensive management systems have proven to be highly efficient mechanisms in injury prevention. In fact, since the implementation of the Proponent's health and safety systems and training, safety records have improved (New Gold, 2012b, 2013).

The Occupational Health and Safety Management Plan (OHSMP) is provided in **Section 12.2.1.18.4.15**. The Project will promote a safety culture, meeting or exceeding all regulatory requirements by establishing and implementing the OHSMP. Safety records will be maintained and resulted reported to BC MEM and designated Aboriginal groups.

Table 9.2-8 outlines the proposed mitigation measures and effectiveness of mitigation applicable for each Project phase with respect to worker safety and health.

Table 9.2-8: Mitigation Measures and Effectiveness of Mitigation to Avoid or Reduce Potential Effects on Worker Safety and Health during Mine Site Development

Likely Project Effect	Project Phase	Mitigation/Enhancement Measure	Effectiveness of Mitigation Rating
Worker safety and health	Construction, Operations, Closure, Post-Closure	The Proponent will strive to maintain an excellent safety culture as per recommendations by BC MEM	High
		The Proponent will strive to operate with an occupational health and safety management system as per recommendations by BC MEM	High
		The Proponent will strive to use preferred safety practices and procedures as per recommendations by BC MEM	Moderate
		The Proponent will strive to implement an occupational hygiene program as per recommendations by BC MEM	Moderate
		To ensure continual improvement, health and safety targets will be established and published annually, as part of the New Gold Sustainability Report series	High
		The Proponent will continue to develop the current integrated health, safety, and environment management system, the medical conditions and medications tracking system, and the on-site fitness and wellness program. These programs will be continually developed and adjusted to meet changing Project requirements	Moderate

Note: BC MEM = British Columbia Ministry of Energy and Mines

In summary, low success rating means mitigation has not been proven successful, moderate success rating means mitigation has been proven successful elsewhere, and high success rating means mitigation has been proven effective. Where effectiveness of mitigation measures was rated high, the proposed mitigation measures are policies that have been widely used in the mining industry other industries, and these practices have proven over a long period of time to reduce workplace hazards and incidents. Where effectiveness of mitigation measures was rated moderate, the proposed mitigation measures are policies that have been adopted by mining companies and other industries using preferred safety practices and procedures, and these practices have been successful in reducing workplace hazards and incidents.

9.2.3.4 Residual Effects and their Significance

Health and safety effects of the Project on worker health are considered in the context of potential changes in health risk with the potential to result in a change in likelihood of injury or disease. Overall, worker health and safety effects are quantitatively rated as neutral to positive but not significant (**Table 9.2-9**). Worker health and safety effects are rated as neutral for the construction and closure phase. Effects are rated as positive for the operations phase. These ratings are based on employees working in a neutral or lower risk industry, who will benefit from above average occupational health programs contributing to risk reduction of workplace safety hazards and occupational exposures. Ratings are based on criteria defined in **Section 3**, Assessment Process.

Table 9.2-9: Significance of Residual Project Effects for Worker Health and Safety

Categories for Significance Determination	Project Phase / Rating	
	Construction and Closure	**Operations**
Context	Neutral	Neutral
Magnitude	Low	Low
Geographic extent	Site-specific	Site-specific
Duration	Short-term	Long-term
Reversibility	Yes	Yes
Frequency	Continuous	Continuous
Likelihood determination	High	High
Statement of the level of confidence for likelihood	High	High
Significance determination	Not significant (Negligible)	Not significant (Negligible)
Statement of the level of confidence for significance	Moderate	Moderate

9.2.3.5 Cumulative Effects

Residual effects for worker health and safety concerns are predicted to be Not Significant (negligible); therefore, a CEA is not required.

9.2.3.6 Limitations

A comprehensive hazard assessment was not conducted as part of this review. Quantitative assessment is based on indirect data; workplace compensation insurance rates are based on total cost of compensation claims. That said, sample numbers are large, and rates are based on a complex statistical analysis that takes into account all industries, sectors, and subsectors, which indicates robustness and confidence. The use of current workplace compensation insurance rates does not predict future workplace compensation insurance rates; for instance, in some industries, occupational disease rates are increasing as certain diseases are being better recognized as occupationally-related (e.g., silicosis).

9.2.3.7 Conclusion

In general, future employees in the SERSA will be exposed to workplace hazards, including safety risks and workplace exposures. Vulnerable populations include young workers, people previously without employment, people currently employed in occupations with lower health and safety risks, Aboriginal workers, and workers exposed to multiple hazards, such as maintenance workers.

Residual effects of the Project on worker health and safety are neutral to positive and Not Significant (negligible).

9.3 Summary of Assessment of Health Effects

The assessment of human health effects used Environmental Exposures and Worker Health and Safety as VCs and predicted no adverse residual effects as a result from the Project. **Table 9.3-1** summarizes the assessment detailing the potential effects, key mitigation, and significance determination.

The intermittent exposure to noise during take-off of the aircraft in a northeast direction from the mine air strip has the potential of causing limited annoyance to one Aboriginal family and three non-Aboriginal families at their residences up to twice per week during the construction phase. The Environmental Exposures VCs potential effect was rated not significant and negligible.

Based on Health Canada criteria, modelled baseline and Project related health risks are acceptable for potential exposure to all environmental contaminants except arsenic. Both the baseline and Project scenarios had HQ values greater than 0.2 and ILCR values greater than 1.0×10^{-5} for arsenic based on conservative exposure assumptions. A small incremental increase was detected in the Project scenario, but the Project does not substantially increase the health risks for land users within the HHERA study areas. This potential effect on Environmental Exposures was rated Not Significant (negligible).

In general, future employees in the SERSA will be exposed to workplace hazards, including safety risks and workplace exposures; however, it is likely that employees will be at decreased health and safety risk than in their current workplace. Vulnerable populations include young workers, people previously without employment, people currently employed in occupations with lower health and safety risks, and workers exposed to multiple hazards, such as maintenance workers. Potential worker health and safety effects are neutral to positive, negligible, and Not Significant.

Table 9.3-1: Summary of Assessment of Potential Human Health Effects

Valued Components (Identify Phase of Project)	Potential Effects	Key Mitigation Measures	Evaluation of Significance of Residual Effects (Summary Statement)
Environmental Exposures*	• Project-related noise and environmental contaminants	Mitigation measures are based on improving air quality and surface water quality. A monitoring program will enable environmental contaminant concentrations in air, water, and country foods to be observed, reported, and evaluated. Air and water monitoring programs are described in **Section 12.2.1** and the proposed Country Food Monitoring Plan is presented as **Appendix 9.2.2B**.	Effects of the Project on human health are considered in the context of affecting change in population health (i.e., annoyance, injury, or disease). Overall, health effects for environmental exposures are qualitatively rated as negative but Not Significant (negligible), based on quantitative evaluations.
Worker Health and Safety (C, O, CL)	• Common hazards in the construction industry: chemical and physical hazards. • Potential chemical hazards include exposure to welding fumes, dusts, and vapours (Weeks, 2011). • Potential physical hazards in the construction industry include exposure to noise, heat and cold, radiation, and vibration (Weeks, 2011). • Project operation effects are discussed in terms of mining, mineral processing and mine operations in general.	The Proponent will strive to maintain an excellent safety culture, operate with an occupational health and safety management system, use preferred safety practices and procedures, and implement an occupational hygiene program, as per recommendations by BC MEM. To ensure continual improvement, health and safety targets will be established and published annually, as part of the New Gold Sustainability Report series. Targets published in 2013, include reducing the Lost-Time Injury Frequency Rate by 10% year on year and reducing the Total Reportable Injury Frequency Rate by 10% year on year (New Gold, 2013). The proponent will continue to develop the current integrated health, safety, and environment management system, the medical conditions and medications tracking system, and the onsite fitness and wellness program. These programs will be continually developed and adjusted to meet changing Project requirements. Specific attention will be provided during transitions to each new Project phase.	Health and safety effects of the Project on worker health are considered in the context of potential changes in health risk with the potential to result in a change in likelihood of injury or disease. Overall, worker health and safety effects are quantitatively rated as neutral to positive but Not Significant (negligible). Worker health and safety effects are rated as neutral for the construction and closure phase. Effects are rated as positive for the operations phase. These ratings are based on employees working in a neutral or lower risk industry, who will benefit from above average occupational health programs contributing to risk reduction of workplace safety hazards and occupational exposures.

Note: C = construction; O = operations; CL = closure; *the determination of significance considers all Project phases but it is based on the HHERA conducted for the operations phase, which reflects the worse conditions for noise and environmental contaminants.