9. AIR QUALITY EFFECTS ASSESSMENT

9.1 INTRODUCTION

This chapter presents the baseline air quality and meteorological conditions (summarized in detail in Appendix 9-A and 9-B, respectively), and undertakes a scoping and effects assessment to characterize potential effects on air quality as a result of the Harper Creek Project (the Project). Air quality is a valued component (VC) that is also used to inform the effects assessment for other VCs (e.g., human health, wildlife, terrestrial ecology, and surface water quality).

The Project will result primarily in the generation and airborne transport of fugitive dust particles. Fugitive dust typically refers to small particles of geological or other origin that are moved into the atmosphere from non-ducted, open sources. Fugitive dust sources can originate from both stationary and mobile sources such as open fields, open burning, agricultural activity, construction sites, logging road traffic, vehicle traffic on paved and unpaved roads, aggregate pits and storage piles, as well as open pit mines.

By contrast, non-fugitive sources are where emissions are discharged to the atmosphere in a confined flow stream, such as stacks, vents and vehicle exhausts. Stacks or vents at industrial or commercial facilities typically operate under some form of government authorization (e.g., a permit, approval or regulation). The Project's point sources include emissions from dust control and building ventilation systems at the primary crusher, lime silo, and the bucking room in the concentrator building which are in each case treated by baghouse and/or wet scrubber air emission control systems. The Project's emissions will be regulated by Permit under the *Environmental Management Act*.

At the Project, the primary potential sources of fugitive dust include: haul truck operations, open pit operations including drilling and blasting, activity around the ore processing plant (concentrator building), concentrate hauling, vehicle traffic along the mine site access road and on the site road network, road grading and wind erosion of waste rock stockpiles, soil stockpiles, low grade ore stockpiles and exposed tailings storage areas. Processing plant related fugitive dust emission sources include mineral material transfer systems associated with the primary crusher and the crushed ore stockpile. Studies undertaken at other mining operations have indicated that, in the absence of mitigation measures, dust entrainment by the wheels and the wake created by moving haul trucks generate almost 97% of suspended particulate emissions associated with mining activity, although most of this dust settles out rapidly and decrease to insignificant levels within the mine property boundaries (Reed and Organiscak 2005).

In terms of geologic origin, potential fugitive dust at the mine site will originate predominantly from a combination of relatively inert naturally occurring matter including background soils such as dirt, clay, silt and sand, copper/gold ore-grade materials or host rock materials.

The extent of fugitive dust emissions depends on several factors, the most important being particle size, wind speed, moisture content and dust density. Maximum fugitive emissions will take place during windy weather where small and light particles are present in dry, active surface material.

As a result, dust plumes tend to be most noticeable from potential sources when wind speeds are high and/or when vehicles are moving.

The potential drift distance of fugitive dust particles is governed by the initial injection height of the particle, the terminal settling velocity of the particle, and the degree of atmospheric turbulence. Dispersion models have been used to compute theoretical drift distance for fugitive dust emissions as a function of particle diameter and mean wind speed. Results indicate that, for example, at a wind speed of 16 km/h, particles larger than about 100 µm are likely to settle out within 6 to 9 m from the point of emission. Smaller particles have much slower terminal settling velocities and are much more likely to have their settling rate retarded by atmospheric turbulence. As a result, particles that are 30 µm to 100 µm in diameter are likely to undergo impeded settling (US EPA 1995).

Fugitive dust can be broken down into total suspended particulates (TSP), particulate matter (PM_{10}), respirable particulate matter ($PM_{2.5}$) and dustfall. TSP, PM_{10} and $PM_{2.5}$ belong to a group of pollutants known as criteria air contaminants (CACs). CACs are those pollutants for which ambient air quality standards have been established by government.

Dust emissions have the potential to affect local air quality, which is an important environmental factor in conserving the quality of local vegetation resources, wildlife, and human health. Indirect effects as a result of a change in air quality are assessed in Chapter 13, Surface Water Quality; Chapter 15, Terrestrial Ecology; Chapter 16, Wildlife and Wildlife Habitat; and Chapter 21, Human Health.

The air quality assessment draws on local and regional baseline data, and results from detailed dispersion modelling, to predict the potential impact of emissions from the Project. The existing baseline is summarized in this chapter and further details are included in Appendix 9-A, Air Quality Baseline Report. The analysis of air quality focuses on four components of airborne dust: the CACs, including particulates (TSP, PM_{10}, and $PM_{2.5}$) and dust deposition or dustfall. These pollutants are included in the approved Conceptual Model Plan, which provides an overview of the planned air quality assessment, and was provided to the BC Ministry of Environment (MOE) before modelling began to ensure that the general modelling approach was acceptable.

Particles less than 10 micrometers in diameter (PM_{10}) pose a health concern because they can be inhaled and accumulate in the respiratory system. Particles less than 2.5 micrometers in diameter ($PM_{2.5}$) are referred to as "fine" particles and are believed to pose the greatest health risks due to their small size which can lodge deeply into the lungs.

In B.C., the three main contributors to overall emissions of the fine fraction of airborne particulate matter are prescribed burning, forestry operations and residential woodstoves, representing about 64% of all such emissions. Transportation, representing 14%, also makes a significant contribution, especially in more densely populated areas.

Meteorological conditions are an important consideration when assessing air quality as they influence the behaviour of emissions following release. As such, meteorological data forms a key input into the dispersion model. In addition, meteorological data are also a major consideration for the design, construction, and maintenance of the proposed development. Meteorological data are therefore summarized in this chapter and in Chapter 27 (Effects of the Environment on the Project) and a full meteorological baseline report is provided in Appendix 9-B.

This chapter follows the effects assessment methodology described in Chapter 8 of the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS). Section 2 of this chapter sets out the air quality regulatory and policy framework, Section 3 outlines the approach used to scope the assessment, and Section 4 provides an overview of baseline conditions. Section 5 provides details of the effects assessment and mitigation measures that will be implemented, and Section 6 assesses the potential for cumulative effects on air quality. The conclusions of the study are presented in Section 7.

9.2 REGULATORY AND POLICY FRAMEWORK

This section provides an overview of the relevant regulatory framework and regulatory requirements for potential Project-related effects to air quality.

The Project is subject to both provincial and federal environmental assessment (EA) requirements under the BC *Environmental Assessment Act* (2002) and *Canadian Environmental Assessment Act* (1992). The requirements for the air quality effects assessment are defined in the Application Information Requirements (AIR) for the Project, approved by the British Columbia Environmental Assessment Office (BC EAO; 2011) on October 21, 2011 and in the Background Information Document issued by the Canadian Environmental Assessment Agency (CEA Agency; 2011) in April 2011.

The management of air quality across Canada requires collaboration between multiple levels of government, including federal, provincial, regional, and municipal. At the top tier, the federal government issued the *Canadian Environmental Protection Act* (1999) which came into force in March 2000; this Act is the main federal legislation for air quality. Pursuant to the CEPA (1999), the federal government established National Ambient Air Quality Objectives (NAAQOs), Canada Wide Standards (CWSs) and Canadian Ambient Air Quality Standards (CAAQS). CWSs and CAAQSs are intended to be achievable targets that will reduce health and environmental risks within a specific timeframe, whereas NAAQOs identify benchmark levels for protection of people and the environment (BC MOE 2008a). Within the NAAQO, three objective values have been recommended: maximum desirable, maximum acceptable, and maximum tolerable. New CAAQS for $PM_{2.5}$ were adopted in 2013 and will come into effect in 2015 and 2020, replacing the existing CWSs (CCME 2013).

At a provincial level, BC has also developed air quality objectives for a number of contaminants under the *Environmental Management Act* (2003) which came into force in July 2004. Within BC, three tiers of Ambient Air Quality Objectives have been established (Level A, Level B, and Level C). These are broadly comparable to the desirable, acceptable, and tolerable levels discussed above for the federal objectives.

Other air quality objectives relevant to the Project are detailed in the *Pollution Control Objectives for the Mining, Smelting, and Related Industries of British Columbia* (BC MOE 1979). These include dustfall objectives ranging from 1.7 to 2.9 milligram per decimetre^2 per day (mg/dm^2/day), averaged over 30 days. The 1.7 mg/dm^2/day objective is often considered to be applicable at residential areas whereas the 2.9 mg/dm^2/day objective is applicable for all other areas. The aim of the objectives are to protect the quality of BC's environment for the benefit of present and future citizens of the province, by minimizing the effect of known or potential harmful changes in receiving environments (BC MOE 1979).

Air quality standards and objectives are generally intended to protect all members of the general public, including sensitive individuals such as the elderly, infants, and persons with compromised health. Therefore, standards are applicable in areas that are accessible to the general public. Air quality modelling predictions are typically compared to standards and objectives at the fence line of the industrial property where emissions occur. Air quality standards or criteria for industrial settings are defined by occupational health and safety codes.

Relevant federal and provincial ambient air quality criteria are presented in Table 9.2-1. As a conservative approach, the most stringent values have been used for this assessment.

Table 9.2-1. Federal and Provincial Ambient Air Quality Criteria

Pollutant	Averaging Time	Canada: National Ambient Air Quality Objectives[a] Maximum Desirable	Canada: National Ambient Air Quality Objectives[a] Maximum Acceptable	Canada: Canadian Ambient Air Quality Standards[b]	British Columbia: Provincial Air Quality Objectives[c] Level A	British Columbia: Provincial Air Quality Objectives[c] Level B	British Columbia: Pollution Control Objectives[d]
TSP (μg/m³)	24-hour	-	120	-	150	200	-
	Annual	60	70	-	60	70	-
PM_{10} (μg/m³)	24-hour	-	-	-	50		-
$PM_{2.5}$ (μg/m³)	24-hour	-	-	28[e] (2015) and 27[e] (2020)	25[f]		-
	Annual	-	-	10[g] (2015) and 8.8[g] (2020)	8[h]		-
Dust deposition (mg/dm²/day)	30-day	-	-	-	-	-	1.7 – 2.9

Notes: (-) dash indicates not applicable

[a] *CCME (1999)*

[b] *CAAQS adopted in 2013 and will come into effect in 2015 and 2020 (CCME 2013).*

[c] *BC MOE (2013)*

[d] *Mining, Smelting, and Related Industries of British Columbia (BC MOE 1979).*

[e] *The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.*

[f] *Based on annual 98th percentile value.*

[g] *The 3-year average of the annual average concentrations.*

[h] *BC objective of 8 μg/m³ and planning goal of 6 μg/m³ was established in 2009.*

In addition to the federal and provincial regulations, the *Air Monitoring Site Selection and Exposure Criteria* (E. Taylor, pers. comm.) indicates suggested sensor heights for meteorological towers. Moreover, the British Columbia Ministry of Environment (BC MOE) has also produced the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008b). This document is intended to provide information for practitioners and those who use model outputs for decision-making. Details on the modelling approach for source type, model domain, receptor spacing, and interpretation of the model output, are provided in the document. The model guidelines detail a conceptual plan, which provides an overview of the planned air quality assessment, and should be provided to the BC MOE before work is started so that the general modelling approach can be agreed to. The Project's Air Dispersion Conceptual Model Plan (Appendix 9-C) was prepared based on the best practices from the guideline and was approved on April 9, 2014.

A guidance document, *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators*, has been produced by the BC MOE to outline and define the baseline study requirements and information considerations necessary to propose a mineral development project in BC (BC MOE 2012). The document focuses on the collection, analysis, interpretation, and submission of baseline information as part of a proposal to develop a mining project in BC.

At a regional and municipal level, community plans may also include objectives and policies relating to air quality. The *District of Clearwater Official Community Plan* (District of Clearwater 2012) includes an objective which states:

> *"2.2.1. Environmental Sustainability…*
>
> *e) Ensure the continuation of fresh, clean and safe airshed."*

The *District of Barriere Official Community Plan* (District of Barriere 2011) includes an objective which states:

> *"3.2.7 To move towards a level of air quality that does not impact the environment or population in a negative manner…*
>
> *b) To encourage the development and adoption of policies that contributes to the reduction and prevention of air pollution;"*

This air quality effects assessment has been conducted in accordance with the above guidance documents and compares dispersion modelling results to provincial and federal ambient air quality objectives as thresholds for significance.

9.3 SCOPING THE EFFECTS ASSESSMENT

9.3.1 Valued Components

The BC EAO defines VCs as components "that are considered important by the proponent, public, First Nations, scientists, and government agencies involved in the assessment process" (BC EAO 2013). To be included in the Application/EIS, there must be a perceived likelihood that VCs will be affected by the proposed Project. VCs proposed for assessment were identified in the AIR (BC EAO 2011) and in the CEA Agency (2011) Background Information document. Two subject areas have been identified as potential VCs; climate and air quality.

9.3.1.1 Consultation Feedback on Proposed Valued Components

A preliminary list of proposed VCs was drafted early in the project planning, based on the expected physical works and activities of the reviewable project; type of project being proposed; local area and regions where the proposed project would be located; and consultation with federal, provincial, and local government agencies. As part of the draft AIR review process, Metis Nation BC raised an issue regarding mitigation measures for dealing with fluctuations in potential contaminants and air quality. During consultations the Simpcw First Nation and the Little Shuswap Indian Band both raised issues regarding the effects of airborne dust from the Project. The effects of the project on air quality, in general, was raised by the Simpcw First Nation and the Little Shuswap Indian Band raised the issue of particulate matter effecting downwind air quality. The Neskonlith Indian Band raised the issue of impacts to air quality affecting wildlife on, and adjacent to the mine site. The impacts of air quality on wildlife is included in Chapter 16, Wildlife and Wildlife Habitat. A summary of how scoping feedback was incorporated into the selection of assessment subject areas and VCs is summarized below in Table 9.3-1.

Table 9.3-1. Consultation Feedback on Valued Components

Subject Area	Feedback by			Issues Raised	Proponent Response
	AG	G	P/S		
Climate				No issues raised.	
Air quality	X	X		Effects of airborne dust. Effects on air quality.	Measureable parameters are selected to help define the effects of the Project activities on air quality.

**AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder.*

9.3.1.2 Selecting Valued Components

An understanding of the historical and current climate conditions is identified as an information requirement in the approved AIR. The purpose of characterizing the historical and present climate conditions for the Project is to develop an understanding of potential effects that weather and climate can have on the Project (presented in Chapter 27, Effects of the Environment on the Project), as well as the interactions with air quality and hydrological effects of the Project (presented in this chapter; Chapter 11, Groundwater; Chapter 12, Hydrology; and Chapter 13, Surface Water Quality). Climate, however, has been scoped out of the assessment as a separate VC. Climate may have the potential to vary as a result of greenhouse gases (GHGs) released in the atmosphere; however, unlike most project-related environmental effects, the contribution of an individual project to climate change cannot be measured due to the global scale, uncertainty, and complexity of assessing effects of collective anthropogenic GHG emissions on climate (CEA Agency 2003). Chapter 27, Effects of the Environment on the Project, will discuss how to manage and reduce potential risks posed by climatic factors (e.g., extreme precipitation events) to the Project.

Air quality has been selected as a VC because emissions of CACs and dust from the Project have the potential to affect air quality and indirectly, human health. Additionally, consultation with regulators, and Aboriginal groups identified concerns regarding air quality.

For the air quality VC, the specific parameters to be modelled and assessed were approved by the BC MOE as part of the Conceptual Model Plan (Appendix 9-C) and include:

- CACs:
  - TSP matter;
  - PM_{10};
  - $PM_{2.5}$; and
- dust deposition.

Further details of the air quality parameters included in the modelling study are listed in Table 9.3-2.

Table 9.3-2. Air Quality Parameters Included in the Air Quality Study

Parameters	Description
Criteria Air Contaminants	
TSP matter	TSP is the sum of all airborne particles that have a diameter of 100 microns (µm) or less. Sources of TSP include vehicle and engine exhaust and fugitive dust. Most particles with diameters between 2 and 30 µm are a result of fugitive dust. Fugitive dust is derived from the mechanical disturbance of granular material exposed to the air. Common sources of fugitive dust include unpaved roads, aggregate storage piles and construction operations. Particles can be composed of a wide range of materials, including minerals (sand, rock dust), engine soot, organic materials, or salt.
PM_{10}	PM_{10} particles are a subset of TSP and are defined as particles with a diameter less than 10 µm.
$PM_{2.5}$	$PM_{2.5}$ particles are a subset of TSP and are defined as particles with a diameter less than 2.5 µm. These particles are small enough to enter deep into the respiratory system. The majority of particulate matter emitted with diesel engine exhaust is $PM_{2.5}$.
Dust Deposition	
Dustfall	Small particles projected into the air by natural forces, such as wind or by man-made processes. Dust particles are usually in the size range from about 1 to 100 µm in diameter, and settle slowly under the influence of gravity and are deposited on the ground.

Other parameters, including nitrogen dioxide, sulphur dioxide, carbon monoxide, ground level ozone (O_3), reduced sulphur and volatile organic compounds (VOCs) have been scoped out of the assessment. Emissions of nitrogen dioxide, sulphur dioxide, and carbon monoxide will be produced by the Project; however, the emissions will be minimal and are not expected to have a significant effect on air quality. During the Operations phase, power for the Project will be supplied by BC Hydro rather than diesel generators. Additionally, since October 2010, sulphur content in diesel fuel has been reduced to a maximum of 15 mg/kilogram (kg), and as a result diesel combustion associated with Project activities is expected to produce minimal amounts of sulphur dioxide. Ground level ozone is not emitted in large quantities, but is formed in a series of complex atmospheric reactions that involve primary air pollutants such as nitrogen oxides and VOCs. The CALPUFF model does not include routines for calculating formation rates of ground level ozone. VOCs could potentially affect ambient air quality due to its role in the formation of secondary air contaminants; however, emission levels are expected to be minimal and standards or objectives for ambient VOC concentrations have yet to be established for either Canada or BC. Although reduced sulphur compounds can be a primary cause of odours, they are not normally considered a health hazard and will not be emitted by the Project in significant quantities. These pollutants are not considered further. This approach was described in the approved Conceptual Model Plan (Appendix 9-C).

The Project components and activities associated with each phase of the Project have been screened to identify potential interactions with air quality. A list of key Project components and activities has been developed from the *Technical Report & Feasibility Study for the Harper Creek Copper Project* (Merit 2014; Appendix 5-A). The preliminary evaluation of potential interactions between the Project components and activities with air quality was conducted and presented in Table 9.3-3 with "X" indicating a potential interaction between air quality and the Project component or activity.

Table 9.3-3. Project – Air Quality Interaction Matrix

Category	Project Components and Activities	Air Quality
Construction		
Concrete production	Concrete batch plant installation, operation, and decommissioning	x
Dangerous goods and hazardous materials	Hazardous materials storage, transport, and off-site disposal	x
	Spills and emergency management	
Environmental management and monitoring	Construction of fish habitat offsetting sites	x
Equipment	On-site equipment and vehicle use: heavy machinery and trucks	x
Explosives	Explosives storage and use	x
Fuel supply, storage and distribution	Fuel supply, storage, and distribution	x
Open pit	Open pit development - drilling, blasting, hauling, and dumping	x
Potable water supply	Process and potable water supply, distribution, and storage	
Power supply	Auxiliary electricity - diesel generators	x
	Power line and site distribution line construction: vegetation clearing, access, poles, conductors, tie-in	x
Processing	Plant construction: mill building, mill feed conveyor, truck shop, warehouse, substation, and pipelines	x
	Primary crusher and overland feed conveyor installation	x
Procurement and labour	Employment and labour	
	Procurement of goods and services	
Project Site development	Aggregate sources/ borrow sites: drilling, blasting, extraction, hauling, crushing	x
	Clearing vegetation, stripping and stockpiling topsoil and overburden, soil salvage handling and storage	x
	Earth moving: excavation, drilling, grading, trenching, backfilling	X
Rail load-out facility	Rail load-out facility upgrade and site preparation	x
Roads	New tailings management facility (TMF) access road construction: widening, clearing, earth moving, culvert installation using non-potentially acid-generating (PAG) material	x

(continued)

Table 9.3-3. Project – Air Quality Interaction Matrix (continued)

Category	Project Components and Activities	Air Quality
Construction *(cont'd)*		
Roads *(cont'd)*	Road upgrades, maintenance and use: haul and access roads	x
Stockpiles	Coarse ore stockpile construction	x
	Non-PAG waste rock stockpile construction	x
	PAG and non-PAG low-grade ore stockpiles foundation construction	x
	PAG waste rock stockpiles foundation construction	x
Tailings management	Coffer dam and south TMF embankment construction	x
	Tailings distribution system construction	x
Temporary construction camp	Construction camp construction, operation, and decommissioning	x
Traffic	Traffic delivering equipment, materials and personnel to site	x
Waste disposal	Waste management: garbage, incinerator and sewage waste facilities	x
Water management	Ditches, sumps, pipelines, pump systems, reclaim system, and snow clearing/stockpiling	x
	Water management pond, sediment pond, diversion channels and collection channels construction	x
Operations 1		
Concentrate transport	Concentrate transport by road from mine to rail load-out facility	x
Dangerous goods and hazardous materials	Explosives storage and use	x
	Hazardous materials storage, transport, and off-site disposal	x
	Spills and emergency management	
Environmental management and monitoring	Fish habitat offsetting site monitoring and maintenance	
Equipment fleet	Project Site mobile equipment (excluding mining fleet) and vehicle use	x
Fuel supply, storage and distribution	Fuel storage and distribution	x
Mining	Mine pit operations: blast, shovel, and haul	x
Ore processing	Ore crushing, milling, conveyance, and processing	x
Potable water supply	Process and potable water supply, distribution, and storage	
Power supply	Backup diesel generators	
	Electrical power distribution	
Processing	Plant operation: mill building, truck shop, warehouse, and pipelines	x
Procurement and labour	Employment and labour	
	Procurement of goods and services	

(continued)

Table 9.3-3. Project – Air Quality Interaction Matrix (continued)

Category	Project Components and Activities	Air Quality
Operations 1 ***(cont'd)***		
Rail load-out facility	Rail load-out activity (loading of concentrate; movement of rail cars on siding)	x
Reclamation and decommissioning	Progressive mine reclamation	x
Stockpiles	Construction of non-PAG tailings beaches	x
	Construction of PAG and non-PAG low-grade ore stockpile	x
	Non-PAG waste rock stockpiling	x
	Overburden stockpiling	x
Tailings management	Reclaim barge and pumping from TMF to plant site	
	South TMF embankment construction	x
	Sub-aqueous deposition of PAG waste rock into TMF	
	Tailings transport and storage in TMF	
	Treatment and recycling of supernatant TMF water	
Traffic	Traffic delivering equipment, materials and personnel to site	x
Waste disposal	Waste management: garbage and sewage waste facilities	x
Water management	Monitoring and maintenance of mine drainage and seepage	
	Surface water management and diversions systems including snow stockpiling/clearing	
Operations 2	*Includes the Operations 1 non-mining Project components and activities, with the addition of these activities:*	
Processing	Low-grade ore crushing, milling, and processing	x
Reclamation and decommissioning	Partial reclamation of non-PAG waste rock stockpile	x
	Partial reclamation of TMF tailings beaches and embankments	x
Tailings management	Construction of north TMF embankment and beach	x
	Deposit of low-grade ore tailings into open pit	x
Water management	Surface water management	
Closure		
Environmental management and monitoring	Environmental monitoring including surface and groundwater monitoring	
	Monitoring and maintenance of mine drainage, seepage, and discharge	
	Reclamation monitoring and maintenance	
Open pit	Filling of open pit with water and storage of water as a pit lake	
Procurement and labour	Employment and labour	
	Procurement of goods and services	
Reclamation and decommissioning	Decommissioning of rail concentrate load-out area	
	Partial decommissioning and reclamation of Project Site roads	x

(continued)

Table 9.3-3. Project – Air Quality Interaction Matrix (continued)

Category	Project Components and Activities	Air Quality
Closure		
Reclamation and decommissioning *(cont'd)*	Decommissioning and removal of plant site, processing plant and mill, substation, conveyor, primary crusher, and ancillary infrastructure (e.g., explosives facility, truck shop)	x
	Decommissioning of diversion channels and distribution pipelines	x
	Decommissioning of reclaim barge	
	Reclamation of non-PAG low-grade ore stockpile, overburden stockpile, and Non-PAG waste rock stockpile	x
	Reclamation of TMF embankments and beaches	x
	Removal of contaminated soil	x
	Use of topsoil for reclamation	x
Stockpiles	Storage of waste rock in the non-PAG waste rock stockpile	x
Tailings management	Construction and activation of TMF closure spillway	
	Maintenance and monitoring of TMF	
	Storage of water in the TMF and groundwater seepage	
	Sub-aqueous tailing and waste rock storage in TMF	
	TMF discharge to T Creek	
Waste disposal	Solid waste management	x
Post-Closure		
Environmental management and monitoring	Environmental monitoring including surface and groundwater monitoring	
	Monitoring and maintenance of mine drainage, seepage, and discharge	
	Reclamation monitoring and maintenance	
Open pit	Construction of emergency spillway on open pit	
	Storage of water as a pit lake	
Procurement and labour	Procurement of goods and services	
Stockpiles	Storage of waste rock in the non-PAG waste rock stockpile	
Tailings management	Storage of water in the TMF and groundwater seepage	
	Sub-aqueous tailing and waste rock storage	
	TMF discharge	

9.3.2 Defining Assessment Boundaries

Assessment boundaries define the maximum limit within which the effects assessment and supporting studies (e.g., predictive models) are conducted. Boundaries encompass where and when the Project is expected to affect air quality; any political, social, and economic constraints; and limitations in predicting or measuring changes. Boundaries relevant to air quality are described below.

9.3.2.1 Temporal Boundaries

Temporal boundaries, provided in Table 9.3-4, are the time periods considered in the assessment for various Project phases and activities. Temporal boundaries reflect those periods during which planned Project activities are reasonably expected to potentially affect air quality. Potential effects will be considered for each phase of the Project as described in Table 9.3-4.

Table 9.3-4. Temporal Boundaries used in the Assessment for Air Quality

Phase	Project Year	Length of Phase	Description of Activities
Construction	-2 and -1	2 years	Pre-construction and construction activities
Operations 1	1 – 23	23 years	Active mining in the open pit from Year 1 through to Year 23.

All of the Project phases could potentially interact with air quality; however, potential effects on air quality will be considered for peak periods during the Construction and Operations phases of the Project when activity levels are at their maximum, thus generating the highest emissions. By determining the effects of the years with the highest emissions, it can be assumed that if the effects during this year are found to be not significant, the potential effect for the entirety of the Project should also be not significant.

The Construction phase includes a variety of construction activities; however, in order to model a worst-case scenario, when construction activity levels are at their maximum, year minus one has been modelled. It is assumed that all Construction phase equipment, including vehicles, generators, and the incinerator, are operational and that drilling, blasting, and material handling at all stockpiles is taking place.

During the Operations phase, the production and mining activities are expected to be fairly consistent. Harper Creek Mining Corporation (HCMC) has indicated that from Year 3 to Year 15, the amount of waste rock and ore will be 60 million tonnes per year; however, it was predicted that the highest amount of fuel (35 million litres) will be used in Year 13. Moreover, the 220-tonne haul trucks were also predicted to be the most active in Year 13, which is during Operations Phase I. Year 13 was selected for modelling to represent the worst case during both Operations Phases I and II. Emissions during the Closure and Post-Closure phases will be significantly lower than those during Construction and Operations and have therefore not been modelled.

9.3.2.2 Spatial Boundaries

<u>Project Footprint</u>

The Project footprint consists of the mine site with a defined buffer of 500 m around the primary Project components, and also includes linear facilities (e.g., the power line options). Mine site components include the open pit; the open pit haul road, primary crusher, and ore conveyor; mill plant site with ore processing facilities and intake/outtake pipelines; TMF; overburden, topsoil, PAG waste rock, and non-PAG waste rock stockpiles; and non-PAG and PAG low-grade ore stockpiles.

Local Study Area

The local study area (LSA) includes the Project footprint and surrounding area within which there is a reasonable potential for immediate direct and indirect effects on air quality due to a Project interaction, also referred to as the zone of influence. The expected zone of influence was determined using baseline studies, consultation, and expert knowledge. The boundary, shown in Figure 9.3-1, is centred on the mine site, and extends 10 km in all directions. The extent of the modelling domain used for the air dispersion model was based on the LSA.

Regional Study Area

The regional study area (RSA) is defined as the spatial area within which there is potential for direct and indirect effects on air quality as a result of the Project and the area in which cumulative effects may occur. The boundary, shown in Figure 9.3-1, is centered on the proposed Project, and extends 50 km from the mine site.

There are no applicable administrative or technical boundaries relating to air quality.

9.4 BASELINE CONDITIONS

9.4.1 Regional and Historical Setting

The Project is located in the North Thompson, within the Thompson-Nicola Regional District of BC, approximately 150 km northeast of Kamloops along the Southern Yellowhead Highway (Highway 5). The area is considered rural. Two small communities, Vavenby and Birch Island, are located approximately 10 km to the northeast and northwest of the Project, respectively. Clearwater is located over 20 km to the northwest.

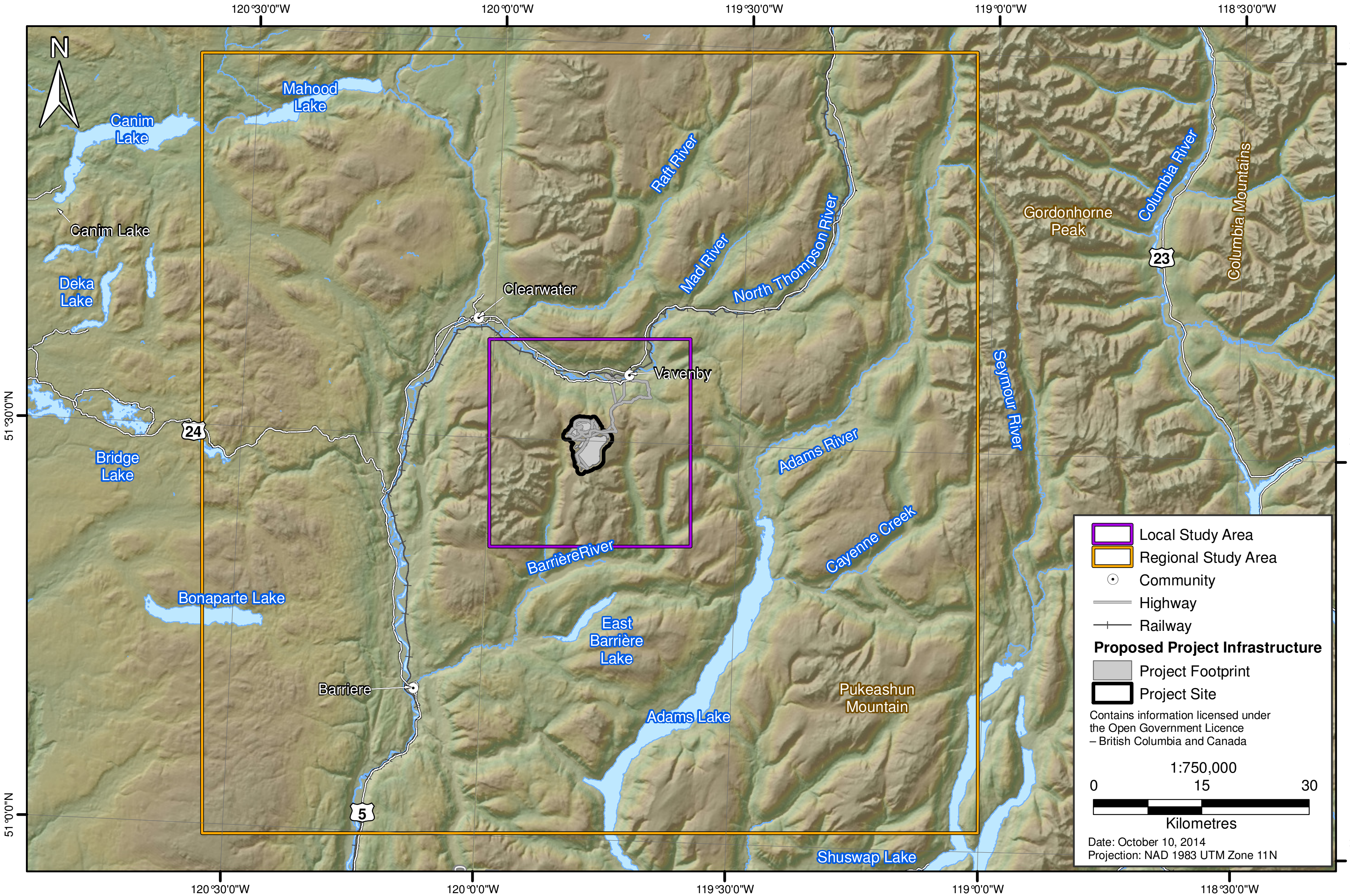
The climate of the North Thompson region is continental with strong seasonal variations. The chief characteristic is the long cold winter, liable to intense cold when continental polar air moves in from the north. Summers are short and generally cool. The topography of the region plays a large role in the region's climate and contributes to local variations in climate patterns. Climate elements such as temperature, precipitation, snow depth and wind show significant variations with elevation. The region is frequently influenced by moist air from the Pacific as well as drier continental air. Snow generally starts to accumulate in late October, peaking in April, and rapidly melting in late April.

Baseline air quality at the Project Site is unaffected by anthropogenic sources, reflecting the Project's remoteness. Although there are a number of anthropogenic sources within the regional area, including a timber mill within the town of Vavenby, overall air quality in the region is good due to the localized nature of emissions (i.e., hotspots).

9.4.2 Baseline Studies

Baseline air quality has been collected for the Project since 2011 when an air quality baseline program to monitor dustfall was initiated. Meteorological site conditions have been monitored since 2007. A detailed overview of the air quality and meteorology baseline programs is provided in Appendices 9-A (Air Quality Baseline Report) and 9-B (Meteorology Baseline Report).

Figure 9.3-1
Spatial Boundaries for Assessment of Air Quality Effects



The objectives of the baseline monitoring studies were to:

- provide understanding of existing baseline conditions in the vicinity of the Project;
- provide a benchmark for evaluating the potential future effects of the Project; and
- support predictive modelling for effects assessment.

9.4.2.1 Climate and Meteorology

The following section describes the existing baseline meteorological conditions of the area with respect to:

- wind;
- precipitation;
- air temperature;
- humidity;
- solar radiation; and
- evaporation.

Due to the terrain of the region, weather can vary significantly in different parts of the Project Site and over relatively short distances. The baseline meteorology study has drawn on data from six regional meteorology stations and two site-specific meteorology stations.

Data Sources

Meteorological data has been collected at the Project Site by two meteorological stations. The first was installed by Dillon Consulting Limited (DCL) in December 2007 within the location of the proposed open pit, at an elevation of 1,680 metres above sea level (masl). This station was decommissioned in April 2011 and a second station was installed by Knight Piésold Limited (KPL) in August 2011, close to the proposed plant site, at an elevation of 1,837 masl.

Many active and decommissioned stations operated by the Meteorological Service of Canada are, or have been, located in the region surrounding the Project. Stations used to characterize the climate of the Project region are presented in Table 9.4-1 and Figure 9.4-1. These stations have been chosen as they are still active or have been recently deactivated. They all have the most recent 1981 to 2010 climate normals (Environment Canada 2014b), and are close to the Project Site or relatively close to the Project elevation.

Data from both on-site stations were combined with historical data from the Meteorological Services of Canada branch of Environment Canada to develop long-term meteorological estimates for the Project Site.

Methods

In December 2007, a 3-metre (m) automated meteorological station was installed at the Project by DCL at the proposed open pit location, at an elevation of 1,680 masl. This station was decommissioned in April 2011, and replaced by a new 10-m automated meteorological station installed by KPL in September 2011 close to the proposed mine plant site, at an elevation of 1,837 masl. Table 9.4-2 summarizes the meteorological parameters monitored by each station.

Figure 9.4-1

Project and Regional Meteorological Stations

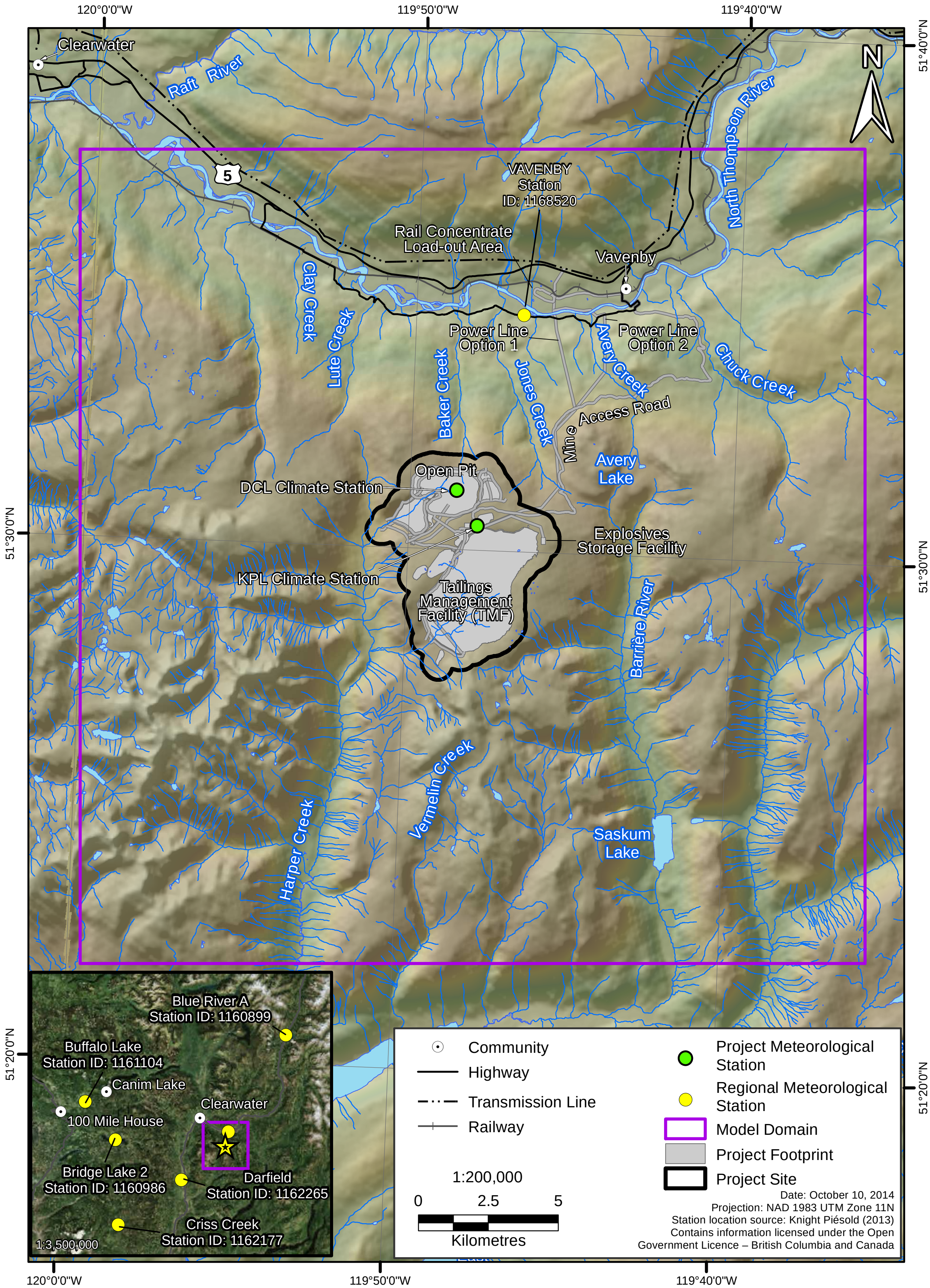


Table 9.4-1. Regional Meteorological Stations

Station Name	Start Year	End Year	UTM Coordinates		Elevation (masl)	Distance from Proposed Plant Site (km)
			Northing (m)	Easting (m)		
Blue River A	1969	Still Active	5,777,862	343,285[a]	690	78
Bridge Lake 2	1980	2010	5,708,164	653,138[b]	1,155	69
Buffalo Lake	1962	Still Active	5,730,246	632,465[b]	1,003	91
Criss Creek	1988	Still Active	5,655,586	659,291[b]	1,122	83
Darfield	1956	Still Active	5,686,660	696,408[b]	412	35
Vavenby	1913	Still Active	5,717,551	307,506[a]	445	8

Source: Environment Canada (2014b).
[a] NAD83 Zone 11U.
[b] NAD83 Zone 10U.

Table 9.4-2. Meteorological Parameters Measured by Project Stations

Station Name	Air Temperature	Relative Humidity	Wind Speed/Direction	Solar Radiation	Net Radiation	Barometric Pressure	Precipitation	Snow Depth
DCL climate station	✓	✓	✓	✓	-	✓	✓ (rainfall only)	-
KPL climate station	✓	✓	✓	✓	✓	✓	✓ (rainfall and snowfall)	✓

Existing Conditions

Data collected from the Project-specific meteorological stations and regional stations are summarized below. Further discussion, including the raw data and climate normal data, can be found in Appendix 9-B, Meteorology Baseline Report.

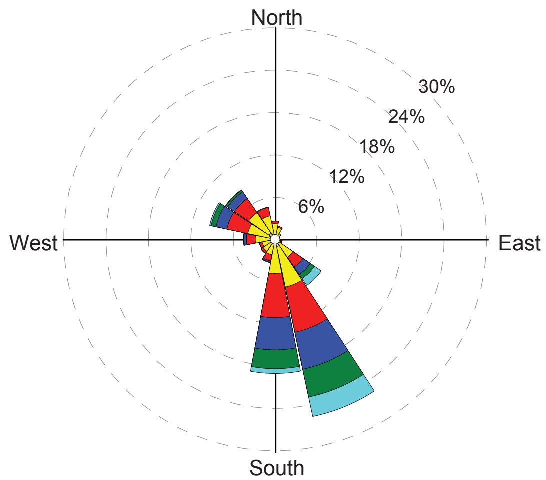
Wind Speed and Direction

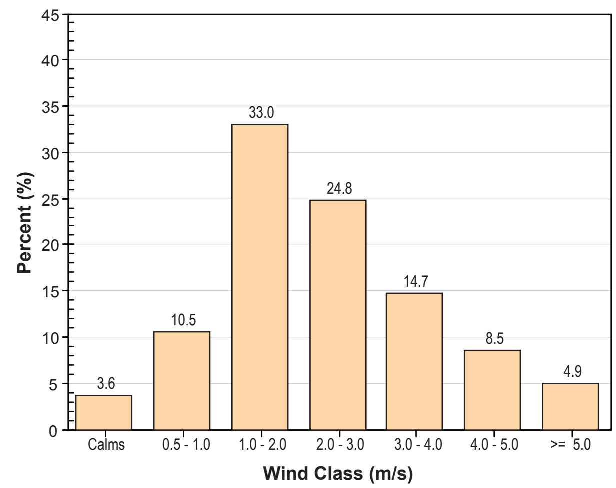
Wind speed is an important factor in assessing the effects of the Project on ambient air quality concentrations, as wind speed contributes to how quickly, and how far, compounds are carried and dispersed from their original source. Regional wind speed and relative humidity data are not available near the Project Site; therefore, the mean monthly values for these parameters are derived using measured data from both Project stations. Winds predominantly blow from the southeast and south-southeast during all seasons. Mean annual wind speeds were 1.6 m/second (s) at the DCL station (3 m anemometer height), and 2.3 m/s at the KPL station (10 m anemometer height). Wind speeds are generally faster and have greater deviation during the winter than during the summer. Annual and seasonal wind speed and frequency distributions for the KPL station, which were used in the modelling, are shown in Figure 9.4-2.

Figure 9.4-2

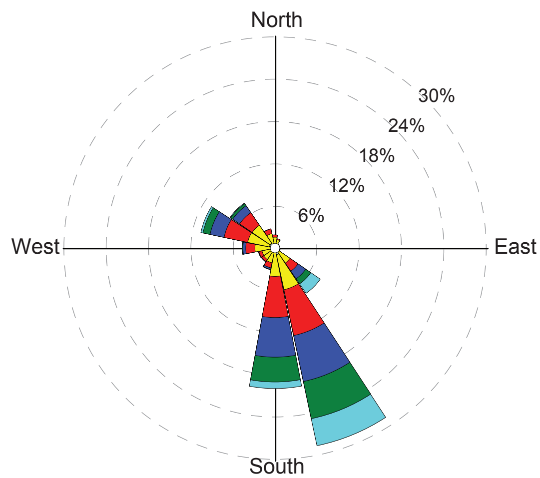
Wind Rose and Wind Speed Frequency Distribution, September 2, 2011 to May 8, 2014, KPL Station

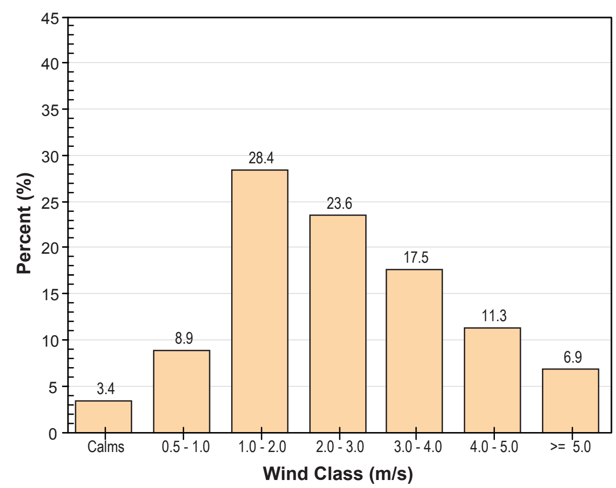
Annual



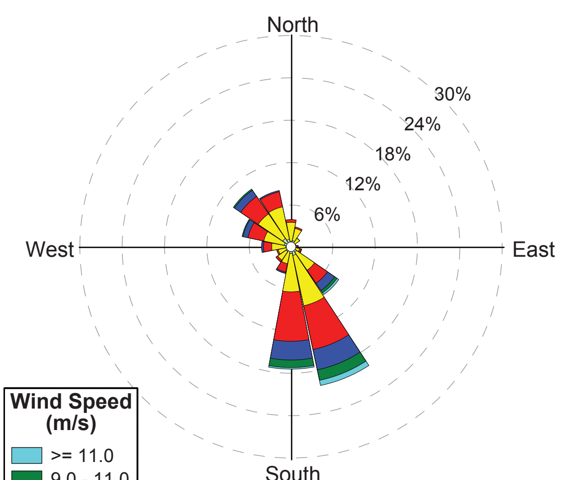


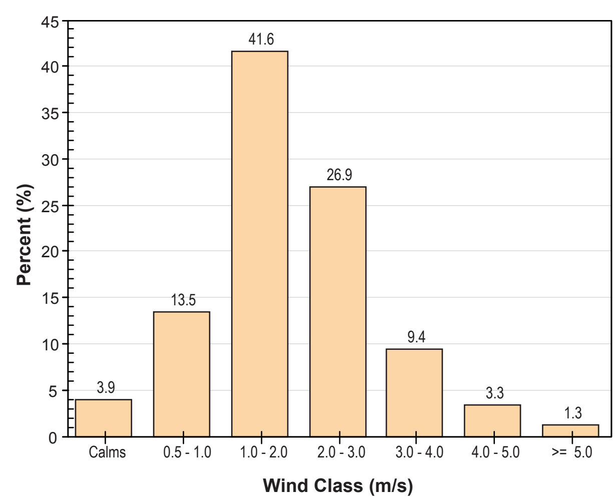
Winter

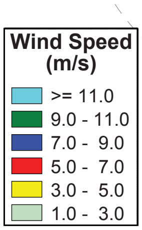




Summer







Notes: KPL Station anemometer located approximately 10 m above ground.
Calms = hourly mean wind speed <0.5 m/s.
Winds are blowing from the directions indicated.

Temperature

Temperature can affect air quality as it can influence the movement of air. For example, during a hot summer day, the air near the surface can be much warmer than the air above. Sometimes large volumes of warm air near the surface rises, which results in vigorous mixing of compounds. Mean monthly temperature values are estimated based on a long-term synthetic record developed for the Project Site. The available site data are correlated to the concurrent monthly temperature data at the Criss Creek Meteorological Service of Canada station using a simple linear regression analysis. The resulting synthetic temperature record has a mean annual temperature of 0.7ºC at the DCL station and 0.2ºC at the KPL station. Long-term monthly mean temperatures ranged from 10.9ºC in July to -9.8ºC in January. From the available Project station data, the lowest hourly temperature was -35.2ºC in January 2012 and the highest was 27.4ºC in July 2009.

Precipitation

The amount of precipitation affects the impact of the Project on air quality as it dampens material, reducing fugitive dust and removing contaminants from the air. The mean annual precipitation for the Project Site is estimated to be 852 millimetres (mm) at an elevation of 1,837 masl, with about 40% falling as snow and 60% falling as rain. The maximum daily precipitation recorded from either station was 34 mm in both June 2012 and 2013. Using adjusted historical precipitation data from regional stations, the Project Site 24-hour precipitation for 10-, 50-, and 200-year return periods were estimated to be 53 mm, 69 mm, and 82 mm, respectively.

Snow Depth

Snow depth affects the impacts of the Project on air quality as snow cover will minimize fugitive dust. From the available data, snow generally starts to accumulate in late October and peaks in April. In 2012, 2013, and 2014, snow depth peaked at approximately 1.7 m. On average, rapid melting begins in late April or early May, and the snowpack is fully melted by early June.

Humidity

Humidity has an influence on air quality as it influences the amount of moisture in the soil. When the temperature is high and the relative humidity is low, evaporation of water is rapid, and therefore soil dries quickly. When the temperature is low and the relative humidity is high, evaporation of water is slow. The mean annual relative humidity is approximately 75% at both Project stations. Summer months are less humid (mean monthly value of 50 to 80%) and winter months are more humid (mean monthly value of 70 to 90%).

Evaporation

Evaporation, similar to humidity, has an influence on air quality as it affects the amount of moisture in the soil. Evaporation data was not recorded at either Project station, or at any of the regional Meteorological Service of Canada stations. Therefore, lake evaporation for the site was estimated according to common empirical equations for potential evapotranspiration, as they are generally representative of lake evaporation. The empirical Thornthwaite equation was used with the measured site temperature record and the long-term synthetic temperature record to estimate a mean annual lake evaporation value (potential evapotranspiration) of 466 mm at the DCL station and 430 mm at the KPL station. Further details of this method can be found in the Meteorology Baseline Report (Appendix 9-B).

9.4.2.2 *Air Quality*

Baseline air quality data represent ambient air conditions prior to Project commencement, due to emissions from both natural and anthropogenic sources. In order to carry out a quantitative assessment of the potential effects of the Project on air quality, the existing ambient air quality concentrations must be established.

The following section describes the baseline air quality conditions with respect to the following:

- CACs;
  - TSP matter;
  - PM_{10};
  - $PM_{2.5}$; and
- dust deposition (dustfall).

<u>Data Sources</u>

The data sources that were reviewed to support the baseline program include the provincial air monitoring network (B.C. n.d). Continuous ambient monitoring equipment requires a continuous uninterrupted source of power, which can be challenging in remote areas. Therefore, background air quality data are limited for the area. Project-specific air quality monitoring has been restricted to passive dustfall monitors. Baseline data collection began in August 2011, at six locations. Appendix 9-A, Air Quality Baseline Report, provides details of site-specific monitoring.

In the absence of site-specific monitoring data for other pollutants, the BC Modelling Guideline recommends that other monitoring data from similar sources and meteorology studies be used. As such, the existing air quality across the study area has been determined from available monitoring data from representative stations and a literature review of other air quality studies in the area.

<u>Methods</u>

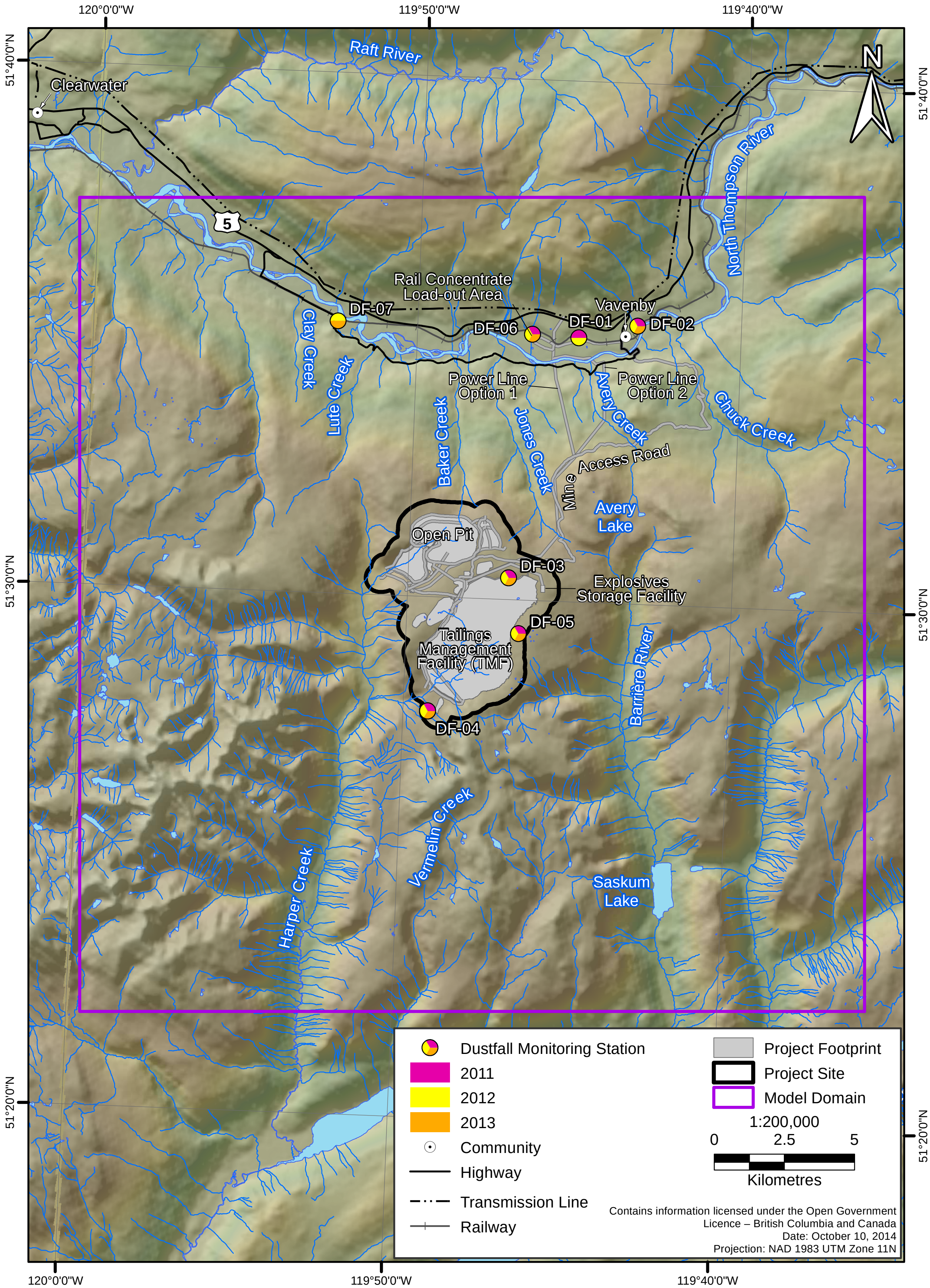
Dustfall Monitoring

The dustfall baseline monitoring program ran from 2011 to 2013, with monitoring occurring for two months in 2011, four months in 2012, and three months in 2013. Dustfall monitoring continues in 2014 and results will be presented in an air quality baseline report in 2015.

In 2011 dustfall measurements were collected at six locations: three sites located in the town of Vavenby and three sites located around the Project boundary. The three sites in Vavenby were selected to be representative of current baseline conditions in communities in the vicinity of the Project, and three sites around the Project boundary were selected to be representative of current conditions at the Project location. In 2012, an additional site was installed at Birch Island and the site DF-01 at Vavenby was deactivated. The locations of the dustfall monitoring stations are presented in Figure 9.4-3.

Figure 9.4-3

Dustfall Monitoring Stations



Dustfall analyses included particulates (total, soluble, and insoluble), anions (sulphate, nitrate, chloride, and ammonia), total metals, and various cations. The full dustfall methodology is contained in ASTM D 1739–98 (reapproved 2010) *Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter*; ASTM 2010). The guidance provided in the *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012) was also followed. Further details of the dustfall monitoring program are provided in Appendix 9-A, Air Quality Baseline Report.

Regional Monitoring

There is only one air quality monitoring station on the provincial air monitoring network, the Kamloops Federal Building station, within 100 km of the Project Site (B.C. n.d). This station is located 97 km southwest of the Project Site, within the centre of Kamloops; due to significant anthropogenic activity in the area, the station is not considered representative of conditions within the study area. A literature review was therefore carried out in order to identify background concentrations considered representative of background values at the Project Site.

Existing Conditions

Dustfall

Dustfall results for 2011 to 2013 are summarized in Figure 9.4-4. The monthly dustfall results ranged from less than 0.10 to 1.53 mg/dm²/day. The highest values were recorded near anthropogenic sources in the nearby communities, such as transport routes. These values are consistent with background monitoring at other proposed mine locations in BC which range from 0.09 to 1.22 (Rescan 2014). Maximum dustfall deposition rates of 0.62, 0.82, and 1.53 mg/dm²/day, were measured in 2011, 2012, and 2013, respectively. All the dustfall results measured were below the objective of 1.75 mg/dm²/day.

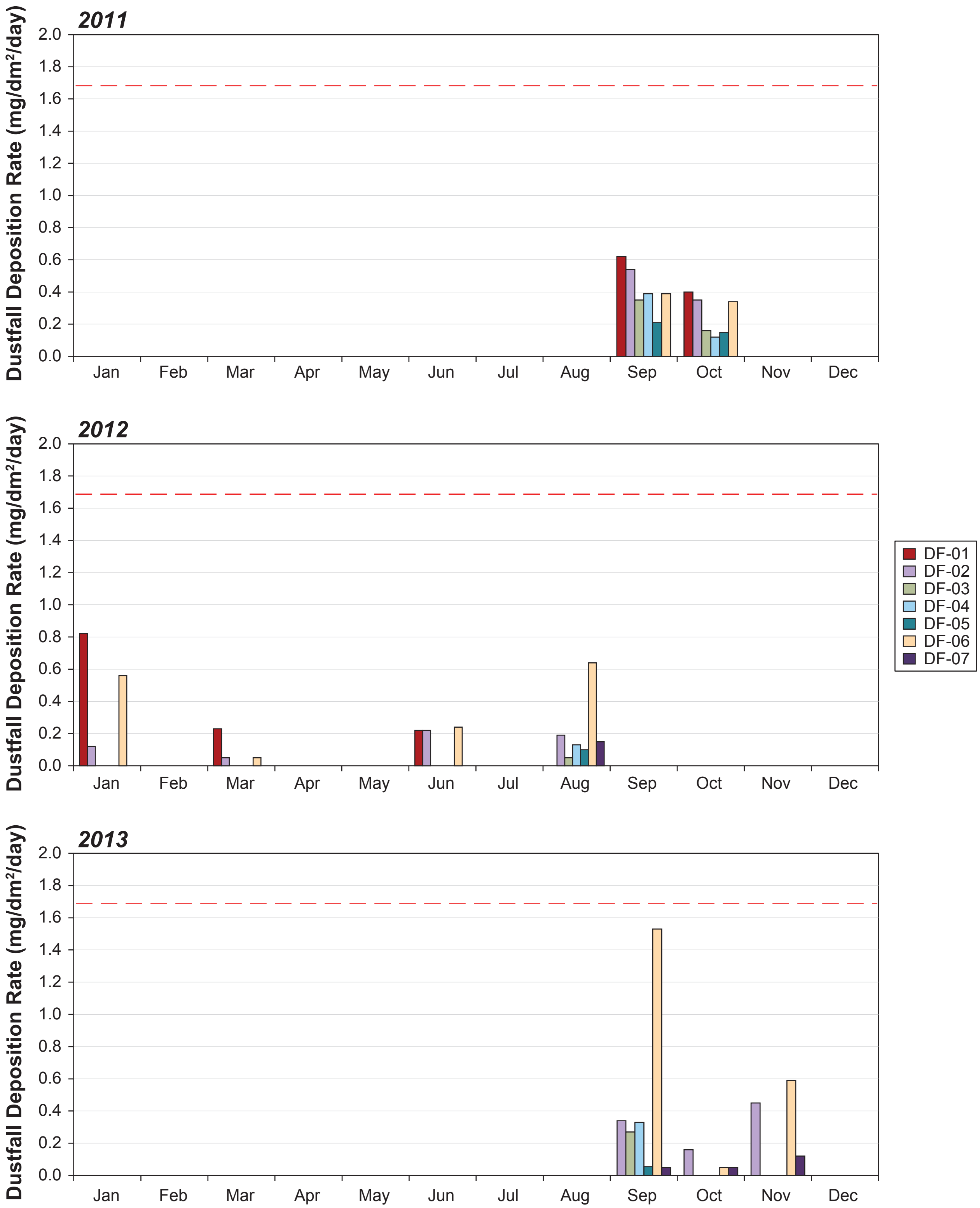
The monthly acid deposition results ranged from 79.1 (October 2011) to 242 eq/hq/yr (January 2012). The acid deposition results were all below the WHO guideline value of 250 eq/hq/yr (WHO 2000). The majority of the metal deposition values were either very low or below the detection limits. Further details regarding the acid deposition and metal deposition results are included in Appendix 9-A, Air Quality Baseline Report.

Based on the limited dataset, seasonal or annual change in dust deposition values cannot be assessed. However, background concentrations will vary throughout the year with the highest concentrations expected in the summer and the lowest concentrations occurring in the winter when the ground is snow covered or frozen, and precipitation rates are higher. There are likely to be other smaller peaks throughout the year due to seasonal emission sources such as wildfires.

The background dust deposition level, calculated as the 98th percentile of all measurements taken, was determined to be 0.6 mg/dm²/day.

Figure 9.4-4

Dustfall Results, 2011 to 2013



Note: Red dashed line represents BC Pollution Control Objective - Most Stringent (1.7 mg/dm²/day).

Criteria Air Contaminants (TSP, PM_{10}, and $PM_{2.5}$)

A report co-produced by the British Columbia Ministry of Water, Land and Air Protection, and the Pacific and Yukon Region of Environment Canada, titled *Particulate Matter in British Columbia: A Report on PM_{10} and $PM_{2.5}$ Mass Concentrations up to 2000* (2003), provides expected background concentrations for PM_{10} and $PM_{2.5}$, based on a study carried out in rural locations. The results showed PM_{10} concentrations in the range of 2.9 to 12.0 μg/m^3 with a mean value of 8.8 μg/m^3, and $PM_{2.5}$ concentrations between 1.7 to 3.8 μg/m^3 with an average of 3.2 μg/m^3. This is consistent with findings from other studies. A report by Vingarzan (2007) found that, in western Canada, background levels of 4 to 8 μg/m^3 have been reported for PM_{10} and levels of 1 to 4 μg/m^3 for $PM_{2.5}$. A background value of 8.8 μg/m^3 has been used for PM_{10} and a value of 3.2 μg/m^3 has been used for $PM_{2.5}$. This is consistent with other assessments in the area, e.g., Ruddock Mine (Ruddock Creek Mining Corporation 2014).

TSP is not a commonly monitored pollutant. The National Air Pollution Surveillance (NAPS) network has not modelled TSP since the 1990s (NAPS, pers. comm.). No background values for TSP are currently available in the area; therefore, the PM_{10} to TSP ratio calculated from data measured at the NAPS network was used (Brook, Dann, and Burnett 1997). On average, across all sites, PM_{10} accounted for 44% of the TSP. This ratio is similar to the ratio of 47% calculated using the aerodynamic particle size multiplier, provided in United States Environmental Protection Agency's (US EPA's) AP-42 section 13.2.4 (US EPA 2006b), which has been used to calculate background TSP values at other BC projects when no monitoring data is available (PRC 2010; Stantec 2012). Using the worst-case ratio of 44%, the background TSP value at the Project Site was assumed to be 20 μg/m^3.

Natural particulate matter events can result in higher daily average concentrations; however, no data are available for daily background levels. The values above have therefore been used to represent annual and daily background levels. The assumed annual values are higher than 24-hour values used in several other approved environmental assessments such as the KSM Project (Rescan 2013) and Galore Creek Copper-Gold-Silver Project (Rescan 2006). Therefore, although the results could potentially be slightly underestimated, they are considered reasonably representative. The uncertainties associated with this method will be included in the discussion of the results.

A search of the National Pollutant Release Inventory identified one emission source within the regional study area, a sawmill in Vavenby (Environment Canada 2014a). The reported emissions from the sawmill are presented in Table 9.4-3. The permit (3124) owned by the Canadian Forest Products Ltd. Sawmill in Vavenby allows a maximum TSP discharge rate of 115 mg/m^3 for 120 hours per week, 52 week/year from the cyclones and 8,760 hour/year from the kilns. The baghouse is limited to a maximum discharge rate of 20 mg/m^3 for 120 hour/week, 52 week/year. Energy generating systems are limited to 50 mg/m^3 of TSP for 8,760 hour/year.

Table 9.4-3. National Pollutant Release Inventory Emission Sources 2013

		Emissions (Tonnes)		
Company Name	Sector	TSP	PM_{10}	$PM_{2.5}$
Canadian Forest Products Ltd.	Sawmills and Wood Preservation	120	30	4.5

Summary

The background concentrations used in the model are shown in Table 9.4-4. The background values were discussed with the BC MOE during the model set-up phase, in August 2014 (R. Adams, pers. comm.). The TSP, PM_{10}, and $PM_{2.5}$ background values are considered representative of rural background conditions, such as those at the Project Site. The background dustfall values are based on data taken from all the dustfall stations, and are therefore representative of average conditions in the area. The results will therefore be slightly overestimated in rural areas, such as the Project Site. A discussion of the cumulative impacts of particulate emissions and dust deposition from existing sources, such as in residential areas, will be discussed in the cumulative impacts section (Section 9.6).

Table 9.4-4. Assumed Background Air Contaminant Concentrations

Air Contaminant (μg/m³)	Assumed Background Concentration	Location	Source
PM_{10}	8.8	Rural background	British Columbia Ministry of Water, Land and Air Protection, and the Pacific and Yukon Region of Environment Canada, *Particulate Matter in British Columbia: A Report on PM_{10} and $PM_{2.5}$ Mass Concentrations up to 2000* (2003).
$PM_{2.5}$	3.2	Rural background	British Columbia Ministry of Water, Land and Air Protection, and the Pacific and Yukon Region of Environment Canada, *Particulate Matter in British Columbia: A Report on PM_{10} and $PM_{2.5}$ Mass Concentrations up to 2000* (2003).
TSP	20	Rural background	Ratio from Brook, Dann, and Burnett (1997).
Total dustfall (mg/dm²/day)	0.6	Average of all sites	On-site monitoring (98th percentile).

9.5 Effects Assessment and Mitigation

This section outlines the overall assessment methodologies and criteria used to identify and analyze potential effects, select mitigation measures for implementation, characterize residual effects on air quality, and determine the significance of an increase in pollutant levels as a result of the Project.

9.5.1 Screening Potential Project Effects

Potential effects of the Project on air quality were first explored by conducting a comprehensive review of all Project emission sources with the potential to emit emissions above background levels. A risk rating exercise was then conducted to identify which Project components and activities have the greatest potential to emit the most emissions.

A review of existing Project data and information relevant to the air quality effects assessment was completed, including a review of Chapter 5, Project Description; *Technical Report & Feasibility Study for the Harper Creek Copper Project* (Merit 2014; Appendix 5-A); Appendix 5-E, Traffic Impact Assessment, and Project Site plans (Chapter 1). Emission sources have been identified based on this review and in discussions with HCMC.

Potential interactions between the Project with air quality have been identified and risk-weighted using professional judgement and experience at other similar projects in BC. Project activities for each Project phase and the potential to pose a low, moderate or major risk to air quality is assessed in Table 9.5-1.

Table 9.5-1. Risk Ratings of Project Effects on Air Quality

Category	Project Components and Activities	Air Quality
Construction		
Concrete production	Concrete batch plant installation, operation, and decommissioning	🟢
Dangerous goods and hazardous materials	Hazardous materials storage, transport, and off-site disposal	🟡
Environmental management and monitoring	Construction of fish habitat offsetting sites	🟢
Equipment	On-site equipment and vehicle use: heavy machinery and trucks	🟡
Explosives	Explosives storage and use	🟡
Fuel supply, storage, and distribution	Fuel supply, storage, and distribution	🟡
Open pit	Open pit development: drilling, blasting, hauling and dumping	🟡
Power supply	Power line and site distribution line construction: vegetation clearing, access, poles, conductors, tie-in	🟢
	Auxiliary electricity: diesel generators	🟡
Processing	Plant construction: mill building, mill feed conveyor, truck shop, warehouse, substation, and pipelines	🟡
	Primary crusher and overland feed conveyor installation	🟢
Project Site development	Earth moving: excavation, drilling, grading, trenching, backfilling	🟡
	Clearing vegetation, stripping and stockpiling topsoil and overburden, soil salvage handling and storage	🟡
	Aggregate sources/ borrow sites: drilling, blasting, extraction, hauling, crushing	🟡
Rail load-out facility	Rail load-out facility upgrade and site preparation	🟢
Roads	New TMF access road construction: widening, clearing, earth moving, culvert installation using non-PAG material	🟢
	Road upgrades, maintenance, and use: haul and access roads	🟡
Stockpiles	PAG and non-PAG low-grade ore stockpiles foundation construction	🟡
	PAG waste rock stockpiles foundation construction	🟡
	Non-PAG waste rock stockpile construction	🟡
	Coarse ore stockpile construction	🟡
Tailings management	Coffer dam and south TMF embankment construction	🟡
	Tailings distribution system construction	🟢
Temporary construction camp	Construction camp construction, operation, and decommissioning	🟡

(continued)

Table 9.5-1. Risk Ratings of Project Effects on Air Quality (continued)

Category	Project Components and Activities	Air Quality
Construction ***(cont'd)***		
Traffic	Traffic delivering equipment, materials, and personnel to site	🟡
Waste disposal	Waste management: garbage, incinerator, and sewage waste facilities	🟡
Water management	Water management pond, sediment pond, diversion channels, and collection channels construction	🟢
	Ditches, sumps, pipelines, pump systems, reclaim system, and snow clearing/stockpiling	🟢
Operations 1		
Concentrate transport	Concentrate transport by road from mine to rail load-out facility	🟡
Dangerous goods and hazardous materials	Explosives storage and use	🟡
	Hazardous materials storage, transport, and off-site disposal	🟡
Equipment fleet	Project Site mobile equipment (excluding mining fleet) and vehicle use	🟡
Fuel supply, storage, and distribution	Fuel storage and distribution	🟢
Mining	Mine pit operations: blast, shovel, and haul	🟡
Ore processing	Ore crushing, milling, conveyance, and processing	🟡
Processing	Plant operation: mill building, truck shop, warehouse, and pipelines	🟡
Rail load-out facility	Rail load-out activity (loading of concentrate, movement of rail cars on siding)	🟢
Reclamation and decommissioning	Progressive mine reclamation	🟢
Stockpiles	Construction of non-PAG tailings beaches	🟡
	Construction of PAG and non-PAG low-grade ore stockpile	🟡
	Overburden stockpiling	🟡
	Non-PAG waste rock stockpiling	🟡
Tailings management	South TMF embankment construction	🟢
Traffic	Traffic delivering equipment, materials, and personnel to site	🟡
Waste disposal	Waste management: garbage and sewage waste facilities	🟢
Operations 2	*Includes the Operations 1 non-mining Project components and activities, with the addition of these activities:*	
Processing	Low-grade ore crushing, milling, and processing	🟡
Reclamation and decommissioning	Partial reclamation of non-PAG waste rock stockpile	🟢
	Partial reclamation of TMF tailings beaches and embankments	🟢
Tailings management	Construction of north TMF embankment and beach	🟢
	Deposit of low-grade ore tailings into open pit	🟢

(continued)

Table 9.5-1. Risk Ratings of Project Effects on Air Quality (completed)

Category	Project Components and Activities	Air Quality
Closure		
Reclamation and decommissioning	Reclamation of non-PAG low-grade ore stockpile, overburden stockpile and non-PAG waste rock stockpile	●
	Reclamation of TMF embankments and beaches	●
	Use of topsoil for reclamation	●
	Decommissioning and removal of plant site, processing plant and mill, substation, conveyor, primary crusher, and ancillary infrastructure (e.g., explosives facility, truck shop)	●
	Decommissioning of diversion channels and distribution pipelines	●
	Decommissioning and reclamation of Project Site roads	●
	Decommissioning of rail concentrate load-out area	●
	Removal of contaminated soil	●
Waste disposal	Solid waste management	●

Notes:
** Includes Operations 1 and Operations 2 as described in the temporal boundaries.*
● (green) = *Low risk interaction: a negligible to minor adverse effect could occur; no further consideration warranted.*
● (yellow) = *Moderate risk interaction: a potential moderate adverse effect could occur; warrants further consideration.*
● (red) = *High risk interaction: a key interaction resulting in potential for significant major adverse effect or significant concern; warrants further consideration.*

9.5.1.1 Construction

As shown in Table 9.5-1, the majority of Project activities during the Construction phase interact with air quality; however, only low or moderate risk interactions are expected to occur. Emissions associated with Construction were calculated and entered into the air quality model to predict air contaminant concentrations. The following emission sources are included in the air quality model:

- stack emissions, such as the generators;
- equipment exhaust emissions from vehicles such as dozers, graders, and haul trucks;
- fugitive dust from vehicles travelling on on-site unpaved roads;
- fugitive dust from drilling and blasting;
- fugitive dust from material handling such as drop of material onto stockpiles; and
- fugitive dust emissions from equipment activities such as bulldozing and grading.

As discussed in Section 9.3.2, the air quality modelling study includes the year with the highest emissions during the Construction phase (-1 Y).

9.5.1.2 Operations

As shown in Table 9.5-1, the majority of Project activities during the Operations phases interact with air quality; however, only low or moderate risk interactions are expected to occur. Emissions associated with Operations were calculated and entered into the air quality model to predict air contaminant concentrations. The following emission sources are included in the air quality model:

- stack emissions, such as the primary crusher, lime silo vent and bucking room vent;
- equipment exhaust emissions from vehicles such as dozers, graders, and haul trucks;
- fugitive dust from vehicles travelling on on-site unpaved roads;
- fugitive dust from drilling and blasting;
- fugitive dust from material handling such as drop of material onto stockpiles; and
- fugitive dust emissions from equipment activities such as bulldozing and grading.

As discussed in Section 9.3.2, the air quality modelling study includes the year with the highest emissions during the Operations phases (Y 13).

9.5.1.3 Closure and Post-Closure

As shown in Table 9.5-1, Project activities during the Closure phase interact with air quality; however, only low-risk interactions are expected to occur. There are no interactions during Post-Closure. As discussed in Section 9.3.2, the air quality model includes the years with the highest emissions. There will be limited emission sources during Closure and Post-Closure, and therefore the air quality impacts are expected to be negligible or minor in comparison to those during the year with the highest emissions for either the Construction or Operations phases. It is assumed that if the effects during the worst-case Construction or Operations years are found to be not significant, the potential effects for Closure and Post-Closure of the Project will also be not significant.

9.5.2 Analysis of Potential Air Quality Effects

The purpose of this section is to analyze potential air quality effects by identifying and quantifying the emissions from the various sources associated with the Project and to present the results of the atmospheric dispersion modelling. The methodology used to undertake atmospheric dispersion modelling is also described.

9.5.2.1 Emissions Inventory

An inventory of emission sources from the Project was prepared and used as an input to the air dispersion model. The objective of the emissions inventory was to estimate maximum emissions of selected air contaminants from Project activities.

The emissions inventory has been generated from manufacturers' specifications when available, the US EPA's AP-42 emission factors (US EPA 1995), the NONROAD2008 model emission standards (US EPA 2008), and from data provided by the Project engineering team.

<u>Emission Sources</u>

The potential sources of air emissions associated with the Project include:

- stack emissions from generators;
- stack emissions from the incinerator;
- stack emissions from the primary crusher and concentrator building;
- exhaust emissions from vehicles such as dozers, haul trucks, forklifts, graders, and fuel trucks;
- fugitive dust from vehicles travelling on on-site unpaved roads ;
- fugitive dust from stockpiles;
- fugitive dust from material handling; and
- fugitive dust emissions from mining activities such as bulldozing and grading.

Each of the emission sources are discussed below. Appendix 9-D, CALPUFF Model Input Parameters, provides additional details of the emissions sources included in the model and the emission factors used.

Generators

There will be three generators used during the Construction phase, all located in the vicinity of the main construction area near the mill. Emission rates for the generators were taken from manufacturers specifications (CAT 2011). Particulate emission factors are assumed to be the same for TSP, PM_{10}, and $PM_{2.5}$. All generators are assumed to be running 24 hours a day, seven days a week throughout the year, as a conservative approach.

Incinerator

One incinerator will be used during the Construction phase. The incinerator is also included in the modelling study during Operations; however, due to a change in design, the incinerator will only be used during Construction. This has resulted in a slight overestimate in emissions around the vicinity of the incinerator during the Operations phase.

No details were available on the specific model of incinerator to be used; therefore, it is assumed an incinerator similar to an Eco Waste Solutions CA-600 Incinerator will be used. The incinerator emissions are scaled using the number of employees at the camp, as camp waste is typically proportional to the number of employees. The incinerator is assumed to be running 24 hours a day, seven days a week throughout the year, as a conservative approach.

Stack Emissions from Primary Crusher and Concentrator Building

Emissions rates and mitigation efficient rates for the primary crusher and the two stacks at the concentrator building, the lime silo vent, and the bucking room vent, were provided by HCMC. All three stacks will have a dust suppression/collection system such as baghouses, wall vent, extractor hood and fan, and internal air recirculation, with over 99.9% efficiency as indicated by HCMC. The primary crusher is assumed to be running 24 hours a day, seven days a week throughout the year, as a conservative approach. The lime silo vent will only be operational for two hours a week; however, due to limitations with the model, a conservative approach of two hours a day was assumed (12:00 to 14:00). The bucking room vent will be operational for 10 hours a day; in the model it was assumed the operational hours would be during the day (8:00 to 20:00).

Equipment Exhaust Emissions

Diesel-powered mining equipment such as loaders, dozers, and on-road transport trucks, are sources of TSP, PM_{10}, and $PM_{2.5}$. Emission rates depend on factors such as the engine size (i.e., horsepower rating), emissions control equipment, and age of equipment.

The US EPA has developed the NONROAD2008 model to provide emissions factors for creating accurate and reproducible non-road emissions inventories (US EPA 2008). NONROAD2008 provides emission estimates based on fuel use in a diverse collection of vehicles and equipment. Air emissions from the diesel equipment were based on the horsepower rating and utilization factor for each piece of equipment, and emission factors from the NONROAD2008 model. Equipment lists, including operating hours, were supplied by HCMC.

The roads included in the model consist of the access road via the Forestry Service Roads (FSR), including Vavenby Mountain FSR, Saskum Plateau FSR, and Vavenby-Saskum FSR, Vavenby Bridge Road through Vavenby to the highway, and McCorrie Road to the rail load-out facility. The increase in traffic on the regional roads will be minimal as the concentrate will be transported across BC via rail.

Unpaved Roads

In addition to tailpipe emissions due to fuel combustion, equipment will also create fugitive dust emissions when driven on unpaved roads. When vehicles travel on an unpaved surface, the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

For vehicles travelling on an unpaved road, the fugitive dust emissions are a function of the road surface silt content and the mean vehicle weight. Emission factors for unpaved road dust are calculated using the methodology presented in AP-42, section 13.2.2 (US EPA 2006a).

All active roads will be watered by the proponent on an as-needed basis, i.e., when the roads are dry and dusty. A control efficiency of 75% is applied to all the unpaved road emission rates (US EPA 2006a). It is assumed the roads will be frozen during winter, and therefore there will be limited emissions. Frozen days are identified using the air temperature data from the Harper Creek meteorological station.

Paved Roads

Particulate emissions also occur whenever vehicles travel over a paved surface due to emissions from re-suspended road surface material. For vehicles travelling on paved roads, the fugitive dust emissions are a function of the number of vehicles, the mean vehicle weight, and road surface silt loading. Road surface loadings are generally heaviest during the late winter and early spring months when the residual loading from snow/ice controls is greatest. Once replenishment of fresh material is eliminated, the road surface loading can be expected to reach an equilibrium value; therefore, silt loading is substantially lower during the summer and autumn.

Emission factors for paved road dust are calculated using the methodology presented in AP-42, section 13.2.1 (US EPA 2011). Predicted and existing traffic data on the paved roads are provided by the traffic consultants, McElhanney in Traffic Impact Assessment (Appendix 5-E). Existing traffic data for the roads are used in conjunction with predicted traffic data in order to determine silt loading on the road.

Stockpile Wind Erosion

During periods of high winds, there is potential for wind-blown dust to be generated from stockpiles. Meteorological conditions, frequency and extent of pile disturbances, silt content, and moisture levels are the most important factors in determining the magnitude of wind-blown dust emissions from stockpiles.

The fastest mile method was used to estimate emissions from open stockpiles using the magnitude of wind gusts (US EPA 2006c). For overburden, assuming a threshold friction velocity of 1.02 m/s and roughness height of 0.3 cm as suggested by the US EPA, wind erosion occurs only when wind speeds exceed 19 to 21 m/s at 10 m above ground. Assuming the non-PAG low grade or waste rock are similar to scoria, a threshold friction velocity of 1.33 m/s and roughness height of 0.3 cm are suggested by the US EPA. The wind erosion occurs only when wind speeds exceed 25 to 27 m/s at 10 m above ground. The maximum wind speed collected at the Harper Creek meteorological station was 8.3 m/s, which occurred during the winter months when the piles will be frozen, and is therefore not a significant source of dust. The highest recorded wind speed during the summer months was 6.9 m/s. In order to trigger wind erosion, the wind speed has to be greater than 19 m/s, almost three times greater than the highest recorded summer wind speed. Therefore, emissions from stockpiles are not included in the modelling. Additionally, the topsoil stockpiles will be progressively re-vegetated during Construction and Operations to preserve the topsoil for application during late Operations and Closure. The topsoil will therefore have limited exposure to wind. Emissions from material handling associated with the stockpiles, and activity on the stockpiles, have been included (details of the material handling and equipment activity methodologies are provided below).

Material Handling

Material handling activities at the Project Site include truck loading at the open pit, truck unloading at each of the stockpiles, unloading from haul trucks to the primary crusher, loading from the primary crusher onto the conveyor, the conveyor drop off, loading at the concentrator building, and loading of trains.

Loading at the primary crusher, the concentrator building, and at the rail load-out facility will be carried out indoors; therefore, emissions will be confined and not released to the environment. The length of the conveyor will be closed or semi-closed to prevent dust generation, and will not result in dust emissions except during drop off. The three areas where potential emissions have been identified are the truck loading at the open pit, the unloading to stockpiles, and the drop from the conveyor. Emission factors were calculated using the methodology outlined in the US EPA's AP-42, section 13.2.4 (2006b). Further details regarding the model inputs can be found in Appendix 9-D, CALPUFF Model Input Parameters.

Equipment Activities

In order to calculate emissions from grading and bulldozing, emission factors provided in the US EPA's AP-42, section 11.9 (US EPA 1998) were applied. It is conservatively assumed that the on-site access road would be graded once per day. It is assumed the bulldozers would be operational for approximately 8 hours a day within the open pit, on all stockpiles, and on the tailings dam. Further details regarding the model inputs can be found in Appendix 9-D.

Blasting and Drilling

Emission factors for blasting and drilling are calculated using the methodology presented in AP-42, section 11.9 (US EPA 1998). Details of the blasting and drilling were supplied by HCMC. Blasting will typically be carried out once per day, six days a week during Operations and three times a week during Construction. A total of 9,236 holes will be drilled during Construction, and a total of 20,506 holes per year will be drilled during Operations. Further details regarding the model inputs can be found in Appendix 9-D.

Emission Estimation Limitations

The emission factors from the US EPA's AP-42 used in the calculation of emission rates have varying confidence levels. Every effort has been made to use site-specific correction factors where possible so that the highest data quality rating could be achieved; however, there is still a degree of uncertainty associated with the predicted emission rates. Mining operations are considered to be operating at maximum handling rates and in many cases include equipment operating continuously. This high level of activity is unlikely, and therefore represents a conservative (i.e., overestimated) scenario.

The incinerator is included in the model during Operations; however, due to a change in design the incinerator will only be used during Construction. This will have resulted in a slight overestimate in emissions during the Operations phase, around the vicinity of the incinerator.

Fugitive dust sources are modelled separately from other sources of TSP, PM_{10}, and $PM_{2.5}$. The rationale for this is that there are larger uncertainties associated with fugitive dust emission factors from AP-42. Fugitive dust sources include road dust from both paved and unpaved roads, blasting, drilling, material handling, grading, and bulldozing, Fugitive dust sources are also expected to have the highest contribution of TSP, PM_{10}, and $PM_{2.5}$; therefore, by modelling the fugitive and non-fugitive sources separately, the contribution of the different sources can be analyzed.

Emission Summary

Tables 9.5-2 and 9.5-3 present the total annual emissions for each of the various sources during Construction and Operations I. During both phases, unpaved road dust typically has the most significant contribution to TSP, PM_{10}, and $PM_{2.5}$ emissions.

Tables 9.5-4 and 9.5-5 present the TSP, PM_{10}, and $PM_{2.5}$ emissions associated with non-fugitive and fugitive sources. For all emission categories, fugitive sources are the largest contributor. The main source of fugitive dust during both Construction and Operations I is unpaved road dust.

Table 9.5-2. Emissions Inventory - Construction

Sources	Emissions (tonnes/year)		
	TSP	PM_{10}	$PM_{2.5}$
Stacks	19.3	14.2	12.5
Equipment	15.6	15.6	15.1
Unpaved road dust	**486.5**	**128.8**	**12.9**
Paved road dust	13.5	2.6	0.6
Grading	2.5	0.7	0.1
Bulldozing	45.8	8.6	4.8
Drilling	5.4	2.8	0.8
Blasting	14.7	7.6	0.4
Stockpiles	-	-	-
Material handling	10.1	10.1	10.1
Total	**613.3**	**191.0**	**57.4**

Table 9.5-3. Emissions Inventory - Operations

Sources	Emissions (tonnes/year)		
	TSP	PM_{10}	$PM_{2.5}$
Stacks[a]	6.4	6.4	6.4
Equipment	10.1	10.1	9.8
Unpaved road dust	**818.2**	**216.6**	**24.3**
Paved road dust	52.1	10.0	2.4
Grading	2.5	0.7	0.1
Bulldozing	40.3	7.6	4.2
Drilling	12.1	6.2	1.8
Blasting	35.1	18.2	1.1
Stockpiles	-	-	-
Material handling	18.3	18.3	18.3
Total	**995.3**	**294.4**	**68.7**

[a] *An additional 0.3 tonnes of TSP, PM_{10} and $PM_{2.5}$ were included in the model due to the inclusion of the incinerator during operation, however, due to a design change the incinerator will not be operational during operation.*

Table 9.5-4. Emissions Summary - Construction

Sources	Emissions (tonnes/year)		
	TSP	PM_{10}	$PM_{2.5}$
Non-fugitive	34.9	29.8	27.6
Fugitive	578.5	161.2	29.7
Total	**613.3**	**191.0**	**57.4**

Table 9.5-5. Emissions Summary - Operations

Sources	Emissions (tonnes/year)		
	TSP	PM_{10}	$PM_{2.5}$
Non-fugitive	16.8	16.8	16.5
Fugitive	978.5	277.6	52.2
Total	**995.3**	**294.4**	**68.7**

Table 9.5-6 shows the emissions from other operating metal ore mines in BC, taken from the National Pollutant Release Inventory dataset (NPRI; Environment Canada 2013a). The data is from 2012, which is the most recent year with available data showing the emissions broken down into the various sources. For the majority of mines it is evident that fugitive sources are the largest contributor to TSP, PM_{10}, and $PM_{2.5}$ emissions. The only other gold and silver mine in the NPRI dataset is the New Afton mine at Kamloops. The stack emissions from the Harper Creek Project are predicted to be similar to those at New Afton; however, the fugitive emissions are substantially higher at New Afton.

9.5.2.2 Modelling Methodology

Model Selection

The CALPUFF air dispersion modelling system (US EPA approved version 5.8.4) was chosen for the modelling study. The CALPUFF model is a non-steady-state Lagrangian Gaussian air quality modelling system for regulatory use.

The US EPA and BC MOE have promoted the use of CALPUFF for long-range dispersion model studies and for near-field studies on a case-by-case basis (US EPA 2003; BC MOE 2008b). CALPUFF offers considerable flexibility with respect to meteorological, geo-physical and emissions inputs.

There is inherent uncertainty associated with the use of any model as real world processes, such as atmospheric conditions, are simplified. In general, air dispersion models accurately, but conservatively, predict atmospheric concentrations and deposition levels so that model results are often interpreted with the understanding that the predicted effects are likely overestimated. There is, however more confidence associated with the predictions of atmospheric concentrations than the predictions of dust deposition. As discussed in the introduction larger particles are expected to settle close to the source, and therefore there will be little atmospheric dispersion. Smaller particles such as TSP, PM_{10} and $PM_{2.5}$, have much slower gravitational settling velocities and are therefore more likely to have their settling rate influenced by atmospheric turbulence.

Model Domains and Receptors

The model domain encompasses the Project Site and a buffer of 10 km (Figure 9.3-1). The size of the modelling domain was established such that the majority of air contaminants approach background concentrations within the modelling domain. For parameters with predicted maximum concentrations that were well above background concentrations, it is ensured that areas of potential exceedances of ambient air quality objectives are well within the modelling domain.

Additional specific receptors were also chosen in order to support the human health effects assessment and to determine air quality effects on traditional use sites. Receptor locations were sourced using data from Appendix 17-A (Socio-economic Baseline Data) and Appendix 22-A (Simpcw First Nation Traditional Use and Ecological Knowledge Study). Receptors include locations at Vavenby and Birch Island, and also at camp and cabin locations. Results at these locations are discussed in Chapter 21, Human Health and used to support an effects assessment on current use of lands and resources for traditional purposes by Aboriginal persons in Chapter 18 (Commercial and Non-commercial Land Use).

Additionally, a Cartesian grid of discrete receptors is applied with the following spatial resolution, as suggested in the BC Model Guideline (2008b):

- 20 m spacing along the boundary of the Project Site;
- 50 m spacing within 500 m of the Project Site. An additional area encompassing Vavenby was also included for human health receptors;
- 250 m spacing within 2 km of the Project Site;
- 500 m spacing within 5 km of the Project Site; and
- 1,000 m spacing beyond 5 km of the Project Site.

Figure 9.5-1 presents the air dispersion modelling domain and the receptor grid selected for the model runs.

Model Input Parameters

Meteorological Input Data

Air dispersion models require the input of meteorological data to generate a model meteorological field from which air dispersion characteristics are calculated. Site-specific or locally observed surface and upper air meteorological data are preferred as model inputs. Typically, hourly records of various meteorological parameters are required. For projects located in remote regions, local or regional meteorological data is often limited or unavailable, particularly upper-air data (BC MOE 2008b).

CALPUFF was run using on-site meteorology data collected from the KPL station from January through December, 2013. The meteorology station is a 10-m tower, located close to the proposed plant site. The data capture at the station for 2013 is over 90%. There is also a meteorological station at Clearwater, operated by the BC Wildfire Management Branch, located approximately 25 km northwest of the Project Site. The completeness of data for this station was also over 90% in 2013; therefore, the hourly data from the Clearwater station was used to increase the number of observational data for the CALMET domain. A larger meteorological domain (50 by 50 km) was prepared to incorporate the Clearwater station in the meteorological model (CALMET).

Currently, there is no upper-air data available in the area. The closest upper-air station is in Kelowna, which is approximately 180 km south of the Project Site. Data was therefore obtained from mesoscale meteorological model output (MM5) data.

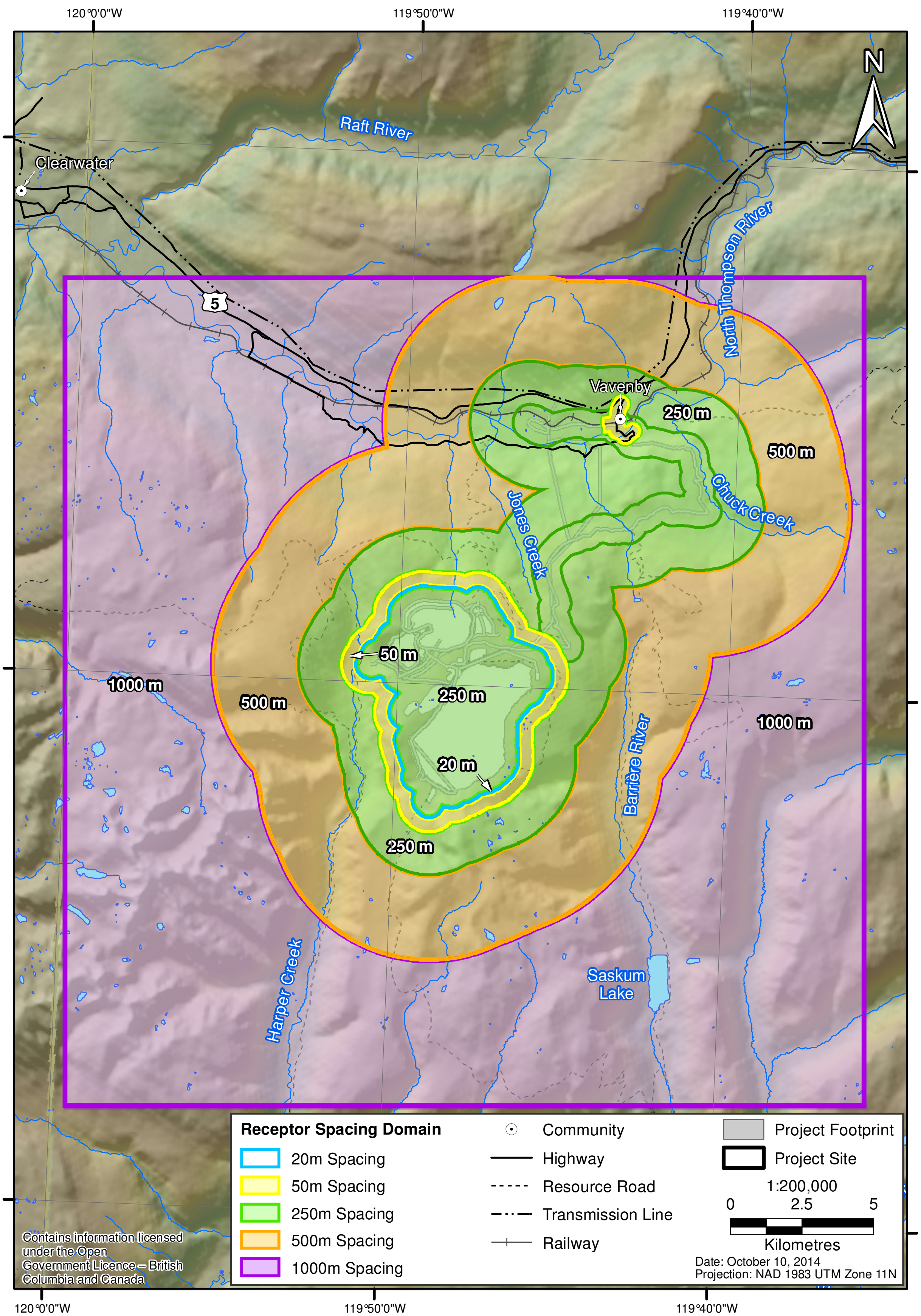
Table 9.5-6. Pollution Release Inventory – Metal Ore Mining, British Columbia

Facility Name	Gibraltar Mine (SFO)			Nyrstar Myra Falls Ltd		Endako Mine			Highland Valley Copper			Mount Polley Mine			Kemess South Mine			New Afton		
City	McLeese Lake			Campbell River		Endako			Logan Lake			Likely			Smithers			Kamloops		
Sector	Copper-Zinc Ore Mining			Copper-Zinc Ore Mining		All Other Metal Ore Mining			Copper-Zinc Ore Mining			All Other Metal Ore Mining			All Other Metal Ore Mining			Gold and Silver Ore Mining		
Pollutant (tonnes)	TSP	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Stack Emissions	72.5			0.8	0.7	63.9	19.6	9.4	37.8	6.6	4.5	115.7	46.3	23.2	0.4	0.4	0.4	35.8	25.3	18.8
Storage / Handling	73.6	27	0.04			7.5	3.6	1.3							42.7	12.7	0.7			
Fugitive Emissions	7.1					432.2	215.9	85.5	8,499	4,401.5	2147.8	0.1	0.9	0.4				5,544.3	1,792.7	1,698.6
Other	1,449.6	573.2	51.8			0.03		0.03												
Total	**1,602.8**	**600.2**[a]	**51.8**[a]	**0.8**[a]	**0.7**[a]	**503.6**	**239.1**	**96.2**	**8,536.8**	**4,408.1**	**2152.3**	**115.8**	**47.2**	**23.6**	**43.1**[a]	**13.1**[a]	**1.1**[a]	**5,580.1**	**1,818.1**	**1,717.4**

[a] *No fugitive emissions included. Total results, including fugitive emission, are therefore expected to be sustainably higher.*

Figure 9.5-1

Model Domain and Receptor Locations



The CALMET output was checked for quality assurance purposes following recommendations outlined in the BC Model Guideline (BC MOE 2008b). Hourly records of modelled wind speed and wind direction were compared to station observations to ensure that the model results were in line with observations. Wind roses were provided in the approved Model Plan (Appendix 9-C).

Buildings

The presence of large buildings near point emission sources may influence ground-level concentrations of air pollutants because of the building downwash effect. Building downwash occurs when the aerodynamic turbulence induced by nearby buildings cause a pollutant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground level concentrations. All the buildings on site were included in dispersion modelling with the Building Profile Input Program. The building heights used in the building downwash effect are shown in Appendix 9-D, CALPUFF Model Input Parameters.

Emission Sources

Three types of emission sources were included in the model: point sources (such as the generators and incinerator), volume sources (such as the conveyor drop off), and area sources (such as bulldozing). The point sources model input parameters are listed in Appendix 9-D. Stack height, exhaust temperature, and velocity were estimated based on professional opinion and confirmed with HCMC. The equipment and mine activity sources were modelled as volume sources and area sources and are listed in Appendix 9-D. Area emission rates in grams/s/m^2 were calculated by dividing instantaneous emission rates, by the area of the source. Due to limitations in the area source module in CALPUFF, areas are restricted to five-sided polygons.

CALPUFF Switches

The CALPUFF switches configure the method and assumptions used in the model. The CALPUFF model switches used in the Project are detailed in Appendix 9-D, CALPUFF Model Input Parameters. All of the switches were configured in accordance with the BC Model Guideline (BC MOE 2008b).

Model Run Parameters

The output from the CALPUFF model is 1-hour average concentrations at each of the modelled receptor points, for each hour of meteorology included in the CALMET data file. This assessment was based on a full year of meteorological data. Hourly data was then post-processed to determine the maximum predicted 24-hour, monthly, or annual average concentrations at each of the receptors. The highest concentration was determined for all pollutants except $PM_{2.5}$. For $PM_{2.5}$, the seventh-highest value was also calculated in order to calculate the 98th percentile.

Fugitive dust sources are modelled separately from other sources of TSP, PM_{10}, and $PM_{2.5}$. The rationale for this is that there are larger uncertainties associated with fugitive dust emission factors from AP-42. AP-42 emission factors are used for fugitive dust emissions from unpaved roads, material handling, grading, and bulldozing. Fugitive dust sources are also expected to have the highest contribution of TSP. By modelling the fugitive and non-fugitive sources separately the contribution of the different sources can be analyzed.

Several assumptions are used in the modelling study to ensure that predicted concentrations of air contaminants reflect a reasonably conservative scenario. Many of the emissions sources for the Project would not be active 24 hours a day; however, it is assumed that estimated maximum emissions occur continuously throughout the year. This assumption ensures that maximum hourly emissions coincide with the meteorological conditions that are least ideal for dispersion. While this approach may result in reasonable estimates of maximum hourly ambient air contaminant concentrations, the predicted 24-hour and annual average concentrations are overestimated.

9.5.2.3 Air Quality Modelling Results

Predictive modelling results, using methodologies described in Section 9.5.2.2, are presented in this section for each scenario. Overall, there are some localized, short-term levels predicted to be above objectives due to fugitive dust sources; however, other mine sites in BC also predicted levels to be above the 24-hour average TSP and PM_{10}, and 30-day dustfall objectives, due to fugitive sources (Stantec 2012, AMEC 2011, Rescan 2013, Rescan 2014).

Construction

The maximum model results for construction are presented in Table 9.5-7 below. The contour figures are provided in the relevant sections below, and in Appendix 9-E, CALPUFF Contour Plots.

Table 9.5-7. Predicted Maximum Concentrations during Construction

Pollutant	Averaging Period	Concentrations (µg/m³) and Dust Deposition Rate (mg/dm²/day)				
		Objective	Background	Maximum Predicted Concentration (Project)	Maximum Predicted Concentration (Project + Background)	Frequency of Levels Predicted to be above Objectives per Year (%)
TSP	24-hour	120	20	97.4	117.4	-
	Annual	60	20	6.0	26.0	-
PM_{10}	24-hour	50	8.8	**97.4**	**106.2**	**12**
$PM_{2.5}$	24-hour [a]	25	3.2	12.6	15.8	-
	Annual	8	3.2	2.8	6.0	-
Dustfall	30-day	1.7	0.6	**2.0**	**2.5**	**50**

Notes:
Levels predicted to be above the most stringent objectives highlighted in bold.
[a] *Based on annual 98th percentile value.*

TSP

Predicted maximum annual TSP concentrations are all well below the objective outside of the Project Site. The maximum predicted annual concentration of 26.0 µg/m³, which includes a background of 20 µg/m³, is 43% of the objective.

Maximum 24-hour average TSP concentrations are also all below the objective outside of the Project Site. The maximum predicted 24-hour concentration of 117.4 µg/m³ is 98% of the most stringent objective, however well below the maximum acceptable provincial objective The highest area of TSP concentrations (over 100 μg/m³), outside of the Project Site, is located within an area approximately 400 m from the northwest of the Project Site, due to the prevailing wind direction.

As the 24-hour concentrations are approaching the most stringent objective, the nature of the source has been assessed. The model was run for each source separately and therefore the contribution from different sources could be assessed. This also allows the results from fugitive and non-fugitive sources to be calculated separately, as fugitive dust emission factors have a lower confidence level. Table 9.5-8 shows the concentrations outside of the Project Site were primarily from fugitive sources.

Table 9.5-8. Total Suspended Particulates Sources

Phase	Averaging Period	Objective	Background	Maximum Predicted Concentrations (Project + Background)		
				Non-fugitive	Fugitive	Total[a]
Construction	24-hour	120	20	30.5	111.4	117.4

Notes:
[a] Predicted maximum concentrations will occur at different locations; therefore, the sum of the maximum non-fugitive and fugitive concentrations does not equal the total.

PM_{10}

Maximum 24-hour average PM_{10} concentrations were predicted to be above the objective outside of the Project Site, however, due to the prevailing wind direction, only at a small area approximately 500 m northwest of the Project Site, shown in Figure 9.5-2.

To examine the nature of the predicted levels, a frequency analysis was completed. It was predicted that these elevated PM_{10} concentrations outside of the Project Site will occur, during the worst-case scenario, 12% of the time. The model was run for each source separately and therefore the contribution from different sources could be assessed. This also allowed the results from fugitive and non-fugitive sources to be calculated separately, as fugitive dust emission factors have a lower confidence level. Table 9.5-9 shows the elevated concentrations outside of the Project site were primarily from fugitive sources. The model has been run assuming road watering; however, there are many other mitigation measures which can be employed for fugitive dust which would reduce 24-hour PM_{10} concentrations. Other means of emission control are described in Section 9.5.3, Measures to Mitigation Emission Sources, and the Air Quality Management Plan (Section 24.2).

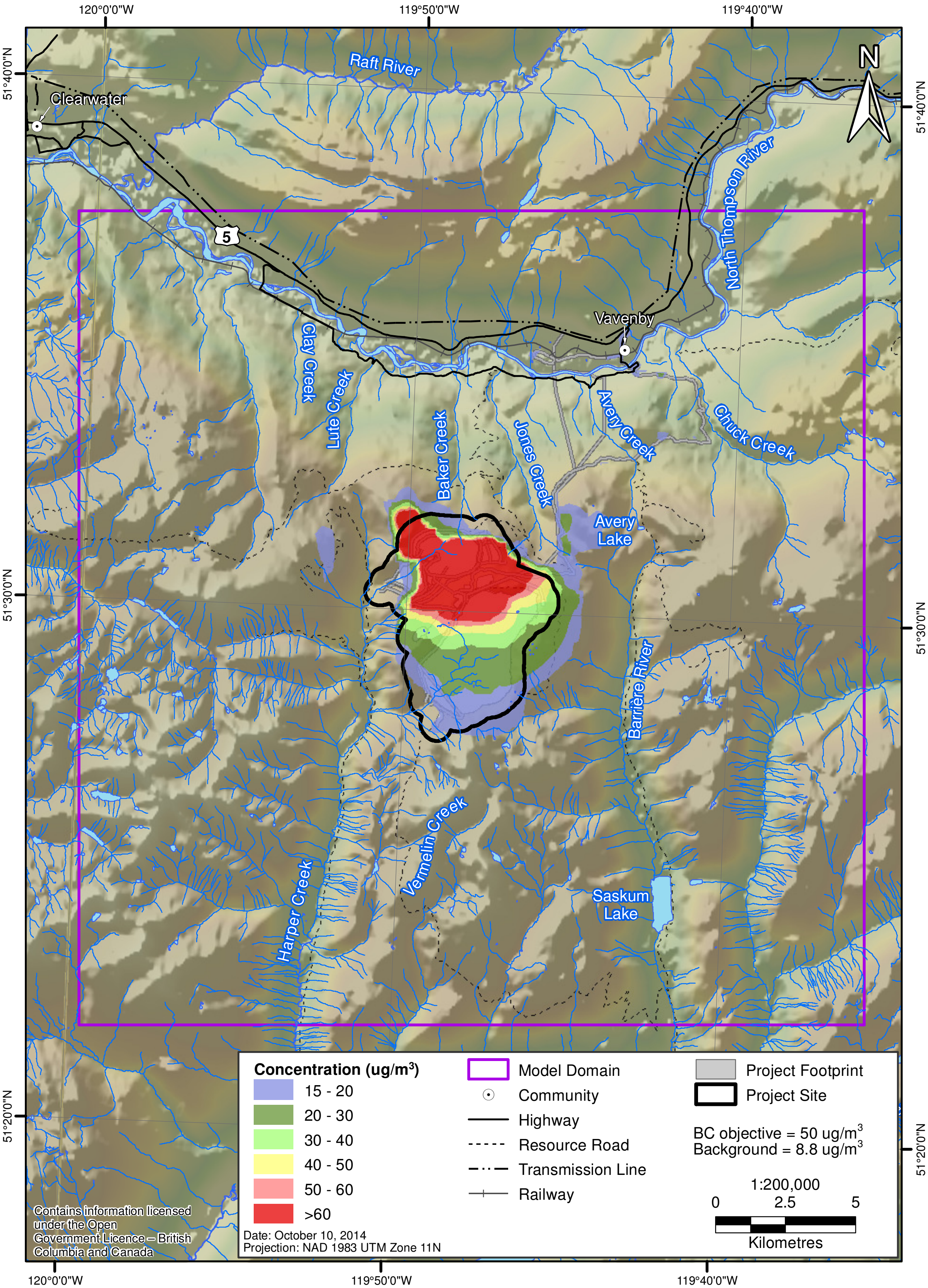
Table 9.5-9. PM_{10} Sources

Phase	Averaging Period	Objective	Background	Maximum Predicted Concentrations (Project + Background)		
				Non-fugitive	Fugitive	Total[a]
Construction	24-hour	50	8.8	19.3	**100.2**	**106.2**

[a] Predicted maximum concentrations will occur at different locations; therefore, the sum of the maximum non-fugitive and fugitive concentrations does not equal the total.

Figure 9.5-2

Predicted Maximum Total 24-hour PM_{10} Concentrations (Construction)



$PM_{2.5}$

Predicted maximum 24-hour and annual average $PM_{2.5}$ concentrations are well below the objectives, at all locations modelled. The maximum predicted 24 hour concentration of 15.8 µg/m³ is 63% of the objective and the maximum predicted annual concentration of 6 µg/m³, which includes a background of 3.2 µg/m³, is 75% of the objective.

Dust Deposition

Dustfall monitoring from operating mine sites show that peak dustfall rates may exceed the BC MOE limits close to the sources (Pomeroy 2007). However, these studies show that dust levels fall rapidly with distance from the project boundaries, such that background levels are acceptable. It was shown for another open pit mining project that the monthly dustfall decreased by two thirds, from 4 mg/dm²/day at the edge of the pit to 1.3 mg/dm²/day at approximately 400 m off the pit, still within the property boundary (AMEC 2011).

Modelled dust deposition rates are predicted to be above the most stringent BC objective, however they are below the upper limit objective of 2.9 mg/dm²/day. Elevated deposition rates are expected to occur along the northwestern edge of the mine site and along the access road. The extent of increased dustfall deposition is expected to be limited due to the fast settling nature of large particles. The maximum predicted 30 day deposition is 2.5 mg/dm²/day, of which 0.6 mg/dm²/day is attributed to the background levels.

To examine the nature of the predicted levels, a frequency analysis was completed. It was predicted that these elevated dustfall levels outside of the Project Site will occur during six months of the year. These levels are expected to occur during the summer months; during the winter months the roads will be frozen, and therefore will not be producing appreciable quantities of dust.

The elevated dustfall values are primarily due to fugitive dust sources, and as discussed earlier, the dust emission factors have larger uncertainties. Fugitive dust, however, is easier to mitigate than non-fugitive sources. The model has been run assuming road watering; however, there are many other mitigation measures which can be employed for fugitive dust which would reduce dustfall levels. Other means of emission control are described in Section 9.5.3, Measures to Mitigation Emission Sources, and the Air Quality Management Plan (Section 24.2).

Operations

The maximum model results for Operations are presented in Table 9.5-10 below. The contour figures are provided in the relevant sections below, and in Appendix 9-E, CALPUFF Contour Plots.

TSP

Predicted maximum annual TSP concentrations are all below the objective outside of the 'fence line' of the Project Site. The majority of the area outside the Project Site is predicted to be less than 50% of the objective, except a small area in Vavenby at the intersection between McCorrie Road and Vavenby Bridge Road where a maximum concentration of 57.9 µg/m³ is predicted.

Table 9.5-10. Predicted Maximum Concentrations during Operations

Pollutant	Averaging Period	Concentrations (µg/m³) and Dust Deposition Rate (mg/dm²/day)				
		Objective	Background	Maximum Predicted Concentration (Project)	Maximum Predicted Concentration (Project + Background)	Frequency of Levels Predicted to be above Objectives per Year (%)
TSP	24-hour[a]	120	20	**168.9**	**188.9**	**3**
	Annual	60	20	37.9	57.9	-
PM_{10}	24-hour	50	8.8	**165.6**	**174.4**	**24**
$PM_{2.5}$	24-hour [b]	25	3.2	17.7	20.9	-
	Annual	8	3.2	4.3	7.5	-
Dustfall	30-day	1.7	0.6	**3.3**	**3.9**	**67**

Notes:
Levels predicted to be above the most stringent objectives highlighted in bold.
[a] *As a conservative approach, the most stringent values have been used for this assessment. The BC provincial air quality objective is 200 µg/m³.*
[b] *Based on annual 98th percentile value.*

Maximum 24-hour average TSP concentrations, shown in Figure 9.5-3, exceeded the most stringent standard outside of the Project Site, however the concentration is below the maximum acceptable provincial objective of 200 µg/m³. These elevated levels occur at a small area approximately 400 m northwest of the Project Site due to the prevailing wind direction, and at a small area at the intersection between McCorrie Road and Vavenby Bridge Road.

To examine the nature of the predicted levels, a frequency analysis was completed. It was predicted that elevated TSP concentrations outside of the Project Site will occur, during the worst-case scenario, 3% of the time. The model was run for each source separately, and therefore the contribution from different sources could be assessed. This also allowed the results from fugitive and non-fugitive sources to be calculated separately, as fugitive dust emission factors have a lower confidence level. Table 9.5-11 shows the elevated levels outside of the site area were primarily from fugitive sources. The model has been run assuming road watering will be conducted; however, there are many other mitigation measures which can be employed for fugitive dust which would reduce 24-hour TSP concentrations. Other means of emission control are described in Section 9.5.3, Measures to Mitigation Emission Sources, and the Air Quality Management Plan (Section 24.2).

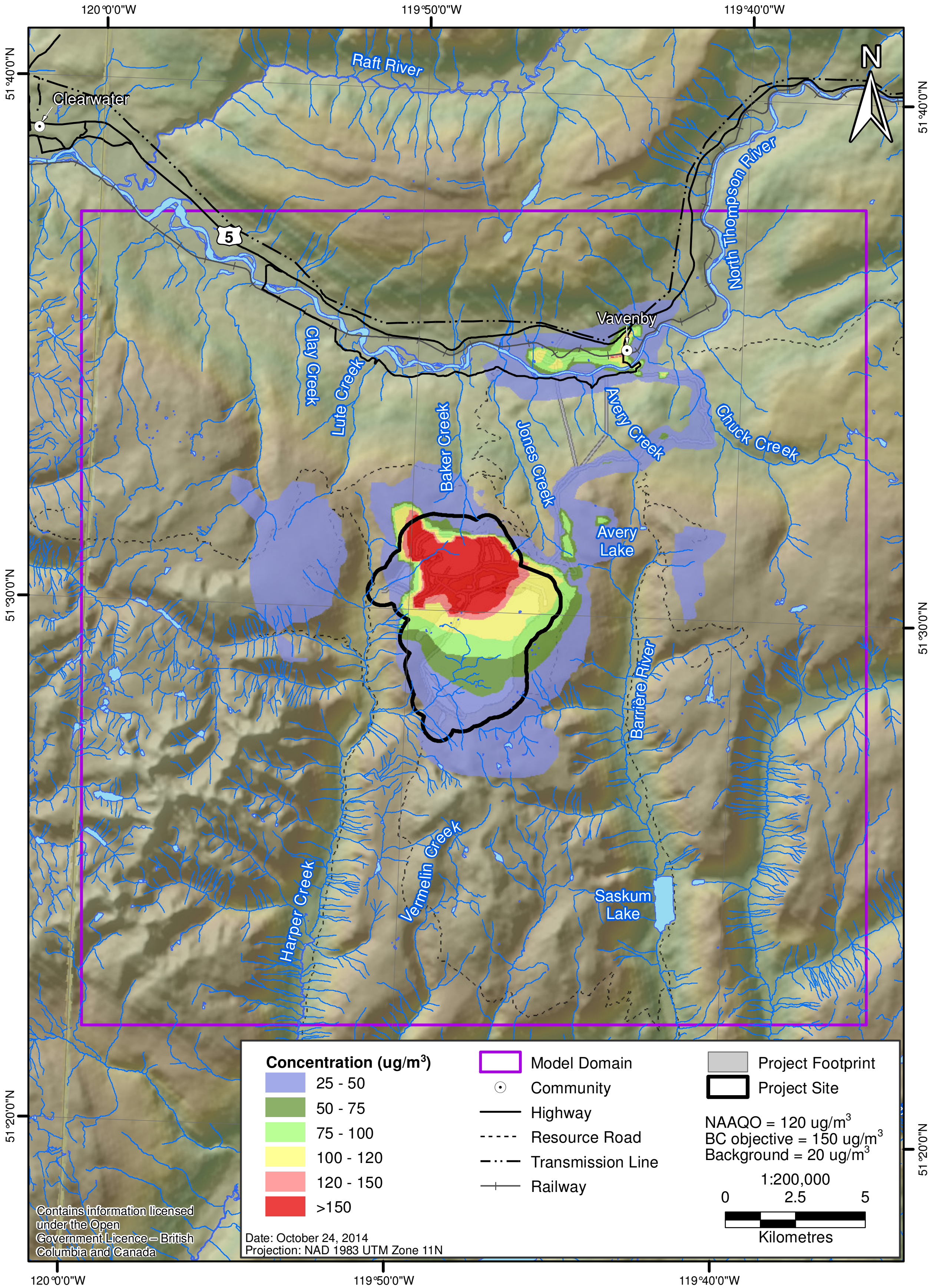
Table 9.5-11. TSP Sources

Phase	Averaging Period	Objective	Background	Maximum Predicted Concentrations (Project + Background)		
				Non-fugitive	Fugitive	Total[a]
Operations	24-hour	120	20	26.5	**188.7**	**188.9**

Notes:
Levels predicted to be above the most stringent objective highlighted in bold.
[a] *Predicted maximum concentrations will occur at different locations; therefore, the sum of the maximum non-fugitive and fugitive concentrations does not equal the total.*

Figure 9.5-3

Predicted Maximum Total 24-hour TSP Concentrations (Operation)



PM_{10}

Maximum 24-hour average PM_{10} concentrations were predicted to report above the objective outside of the Project Site, however only at a small area approximately 700 m northwest of the Project Site due to the prevailing wind direction, shown in Figure 9.5-4.).

To examine the nature of the predicted levels, a frequency analysis was completed. It was predicted that the elevated PM_{10} levels outside of the Project Site will occur, during the worst-case scenario, 24% of the time. The model was run for each source separately, and therefore the contribution from different sources could be assessed. This also allowed the results from fugitive and non-fugitive sources to be calculated separately, as fugitive dust emission factors, mainly from unpaved road dust, have a lower confidence level. Table 9.5-12 shows the elevated levels predicted outside of the Project Site were primarily from fugitive sources. The model has been run assuming road watering will be conducted; however, there are many other mitigation measures which can be employed for fugitive dust which would reduce 24-hour PM_{10} concentrations. Other means of emission control are described Section 9.5.3, Measures to Mitigation Emission Sources, and in the Air Quality Management Plan (Section 24.2).

Table 9.5-12. PM_{10} Sources

Phase	Averaging Period	Objective	Background	Maximum Predicted Concentrations (Project + Background)		
				Non-fugitive	Fugitive	Total[a]
Operation	24-hour	50	8.8	15.3	**170.1**	**174.4**

[a] *Predicted maximum concentrations will occur at different locations, therefore the sum of the maximum non-fugitive and fugitive concentrations does not equal the total.*

$PM_{2.5}$

Predicted maximum annual average $PM_{2.5}$ concentrations were below the objectives, at all locations modelled. The majority of the area outside the Project Site is predicted to be less than 63% of the objective, except a small area to the northwest of the Project Site where a maximum concentration of 7.5 $\mu g/m^3$ is predicted.

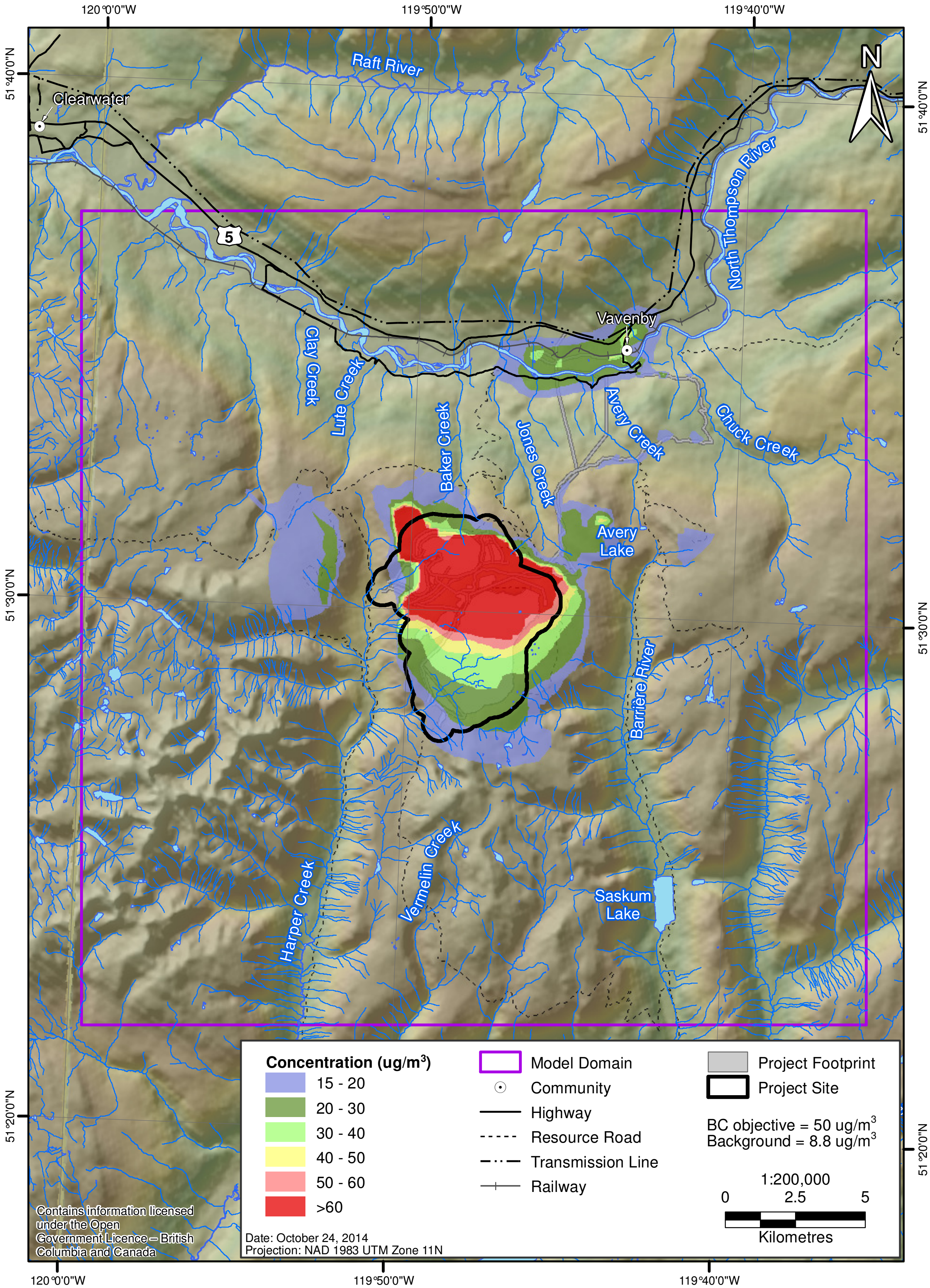
Predicted maximum 24-hour and annual average $PM_{2.5}$ concentrations were below the objectives, at all locations modelled. The majority of the area outside the Project Site is predicted to be less than 40% of the objective, except a small area to the northwest of the Project Site where a maximum concentration of 20.9 $\mu g/m^3$ is predicted.

Dust Deposition

Dustfall monitoring from operating mine sites show that peak dustfall rates may exceed the BC MOE limits close to the sources during operation (Pomeroy 2007). However, these studies show that dust levels fall rapidly with distance from the project boundaries such that background levels are acceptable.

Figure 9.5-4

Predicted Maximum Total 24-hour PM_{10} Concentrations (Operation)



Modelled dust deposition rates were predicted to be above the most stringent BC objective approximately 200 m north west of the Project Site and along the access road. The extent of increased dustfall deposition is expected to be limited due to the fast settling nature of large particles. The maximum 30 day deposition is 3.9 $mg/dm^2/day$, of which 0.6 $mg/dm^2/day$ is attributed to the background levels.

To examine the nature of the predicted levels, a frequency analysis was completed. It was predicted that the elevated dustfall levels outside of the Project Site will occur for a maximum of 67% of the year. The elevated levels to the northwest of the Project Site will occur over a maximum of five months, and along the road the elevated levels will occur over a maximum period of six months along the unpaved access road, and a maximum of eight months near the paved road intersections.

The predicted dustfall values are primarily due to fugitive dust sources, and as discussed earlier, the dust emission factors have larger uncertainties. Fugitive dust, however, is easier to mitigate than non-fugitive sources. The model has been run assuming road watering will be conducted; however, there are many other mitigation measures which can be employed for fugitive dust which would reduce dustfall levels. Other means of emission control are described in Section 9.5.3, Measures to Mitigation Emission Sources, and the Air Quality Management Plan (Section 24.2).

9.5.3 Measures to Mitigate Emission Sources

The following section details mitigation and management measures designed to reduce, control, or eliminate adverse Project effects on air quality. Mitigation measures recommended to reduce an adverse effect are technically, environmentally, and economically feasible.

The Project has been designed to reduce adverse effects by optimizing alternatives, incorporating specific design changes, following best practices, and enhancing project benefits. Further details can be found in the Air Quality Management Plan (Section 24.2).

There are two main types of mitigation and management measures that will be implemented to address air quality issues associated with the Project: emission reduction measures at the source and fugitive dust reduction measures. The majority of measures will be relevant for all phases of the Project and for all pollutants. The mitigation methods that have been selected are listed in Table 9.5-13. The mitigation measures included in the modelling are discussed in the modelling methodology in Section 9.5.2.2. The anticipated effectiveness of each mitigation measure is defined in Chapter 8, as follows:

- **Low effectiveness:** after implementation of the mitigation measure, there is still a major change in the indicator, VC, or discipline from the baseline condition.
- **Moderate effectiveness:** after implementation of the mitigation measure, there is a measurable change in the indicator, VC, or discipline from the baseline condition.
- **High effectiveness:** after implementation of the mitigation measure, there is no change in the indicator, VC, or discipline from the baseline (e.g., it returns to its original condition before the construction of the Project), or an environmental enhancement is evident.

Table 9.5-13. Proposed Mitigation Measures and their Effectiveness

Air Quality			
Potential Effect	**Proposed Mitigation Measure**	**Mitigation Effectiveness** *(Low/Moderate/High/ Unknown)*	**Residual Effect** *(Y/N)*
Increase in emissions	Energy efficiency measures will be implemented.	Moderate	Y
	Procurement policies to identify fuel and equipment specifications will be implemented.	Moderate	Y
	All mobile and stationary equipment will be regularly serviced to maintain efficiency.	Moderate	Y
	Vehicle and equipment idling will be minimized subject to equipment type and seasonality .	High	Y
	Vehicles will be driven at designated speeds on site roads.	Moderate	Y
	Emission control systems (baghouse, wall vent, air recirculation, extractor hood and fan, and wet scrubber) will be used on point source emissions.	Moderate	Y
	Recycling and waste segregation program will be implemented.	Moderate	Y
Increase in fugitive dust	Decommissioned areas will be reclaimed and re-vegetated.	High	Y
	Vehicles will be driven at designated speeds on site roads.	Moderate	Y
	All-weather roads will be regularly compacted and kept in good repair.	Moderate	Y
	Roadways will be watered during dry conditions.	Moderate	Y
	Materials which are likely to generate dust will be conditioned with water where practical prior to transfer.	Moderate	Y
	Windbreaks will be erected where necessary.	Moderate	
	Concentrate loads carried by vehicles will be enclosed or covered.	Moderate	Y
	Crushing facility, lime silo bin vent and bucking room will be equipped with a dust suppression/collection system.	Moderate	Y
	Conveyors and discharge from crushers onto conveyors or into other equipment will be enclosed as far as is practicable.	Moderate	Y
	The discharge heights from the crushers onto conveyers, and conveyors onto stockpiles will be minimized to the extent practical.	Moderate	Y
	Blasting will be timed where possible to coincide with calm weather.	Moderate	Y

Due to the nature of emissions, mitigation measures can typically reduce emission levels; however, the above definitions focus only on the residual effect compared to baseline conditions. Unless the source is eliminated completely, the effectiveness of the mitigation measures as defined above may still indicate measurable change in air quality compared to the baseline conditions. For example, mitigation measures for a stack may reduce the emissions drastically; however, the residual emissions after mitigation will still indicate a change from the baseline conditions. For this reason, using the above definitions, mitigation methods can only ever be of low or moderate effectiveness without completely removing the source of emissions.

9.5.4 Characterizing Residual Effects on Air Quality

Predicted changes or residual effects are those adverse effects remaining after the implementation of mitigation measures, and are therefore the potential consequences of the Project on air quality. After the application of mitigation measures, the following residual effects are predicted to occur for the VC air quality:

- elevated TSP, PM_{10}, and $PM_{2.5}$ concentrations; and
- elevated dust deposition levels.

The potential for effects has been assessed using a quantitative modelling approach. Air quality modelling predictions outside of the development area boundary are compared to standards and objectives. Air quality standards or criteria for industrial settings are defined by occupational health and safety codes. The following sections characterize the effects of the Project on air quality for each of the pollutants during Construction and Operations.

In order to determine the significance of residual effect for air quality, residual effects need to be characterized. The characterization of the residual effect is based on the magnitude, geographic extent, duration, frequency, reversibility of the effect, and resiliency of the receiving environment. The attributes for air quality are summarized in Table 9.5-14 and will be used to characterize air quality residual effects; however, professional judgement has also been used in the determination.

The residual effects for $PM_{2.5}$ and TSP are predicted to have a medium magnitude during the Construction Phase, as the modelled results are below the relevant objectives; however, they are approaching the limits of natural variation. The residual effects for PM_{10} and dust deposition are predicted to have a high magnitude during the construction phase, as the modelled results are above the relevant objectives. The residual effects for $PM_{2.5}$ during the operation phase are predicted to have a medium magnitude as the modelled results are below the relevant objectives; however, they are approaching the limits of natural variation. The residual effects for TSP, PM_{10}, and dust deposition during operation, are predicted to have a high magnitude as the modelled results are over the relevant objectives.

The geographic extent of CAC emissions is local as the effects are contained within a few kilometres from the source. For all pollutants, the duration is classified as short term for the Construction Phase and medium term for the Operation Phase. Air quality concentrations will be lower than the predicted levels for much of the time; however, as a worst-case approach, residual effects are considered to be regular and at peak levels for the entire Project duration (both Construction and Operation). The effects are reversible as the concentrations will return to baseline levels as soon as the pollutant sources are removed. The baseline condition in the area is somewhat affected by anthropogenic activities, such as the Vavenby Sawmill and current transportation activities; therefore, the receiving environment is considered to have a neutral resilience to an increase in emissions.

Table 9.5-14: Definitions of Residual Effects Characterization Criteria for Air Quality

Timing*	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Resiliency
When will the effect begin?	*How severe will the effect be?*	*How far will the effect reach?*	*How long will the effect last?*	*How often will the effect occur?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population? Will it be able to adapt to or absorb the change?*
Construction phase	**Negligible:** no detectable change from baseline conditions.	**Discrete:** perceptible effect is limited to area within metres from the source.	**Short term:** effect lasts less than 2 years (i.e., during the Construction phase of the Project).	**One Time:** effect is confined to one discrete event.	**Reversible:** effect can be reversed.	**High:** the receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.
Operations phases (Stages 1 and 2)	**Low:** differs from the average value for baseline conditions but remains within the range of natural variation and below a guideline or threshold value. (Table 9.2-1).	**Local:** perceptible effect is limited to a few kilometres from the sources.	**Medium term:** effect lasts from 2 to 30 years (i.e., during the Operations phases of the Project).	**Sporadic:** effect occurs rarely and at sporadic intervals.	**Partially Reversible:** effect can be partially reversed.	**Neutral:** the receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.
Closure phase	**Medium:** differing from the average value for baseline conditions and approaching the limits of natural variation, but below or equal to threshold value (Table 9.2-1).	**Regional:** effect occurs throughout the RSA beyond 5 km from the source.	**Long term:** effect lasts from 30 to 37 years (e.g., during the Closure phase of the Project).	**Regular:** effect occurs on a regular basis.	**Irreversible:** effect cannot be reversed, is of permanent duration.	**Low:** the receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.
Post-Closure phase	**High:** differing from baseline conditions and exceeding threshold values so that there will be a detectable change beyond the range of natural variation (Table 9.2-1).	**Beyond regional:** effect extends beyond the RSA.	**Far future:** effect lasts more than 37 years (e.g., during the Post-Closure phase and beyond).	**Continuous:** effect occurs constantly.		

9.5.4.1 *Summary of Residual Effects on Air Quality*

During the Construction phase, the magnitude is medium to high, geographic extent is local, frequency is regular, and duration is short term. During the Operations phase, the magnitude is medium to high, geographic extent is local, frequency is regular, and duration is medium term. The air quality impact is considered reversible with neutral resiliency. The residual effect was characterized in the previous sections and is summarized in Table 9.5-15.

Table 9.5-15. Summary of Residual Effects on Air Quality

Valued Component	Project Phase (Timing of Effect)	Cause-Effect	Mitigation Measure(s)	Residual Effect
Air quality	Construction Operation 1 Operation 2	Emission sources Fugitive dust sources	Emission reduction measures, e.g., baghouses. Fugitive dust reduction measures, e.g. road watering.	Increase in TSP, PM_{10}, $PM_{2.5}$, and dust deposition

9.5.4.2 *Likelihood of Air Quality Residual Effect*

The likelihood of a residual effect occurring can be expressed as a measure of probability. The likelihood of a residual effect does not influence the determination of significance; rather, it identifies the risk of an effect occurring. Likelihood is determined according to the attributes identified in Table 9.5-16 below.

Table 9.5-16. Attributes of Likelihood of Air Quality Effects

Probability Rating	Quantitative Threshold
High	> P80 (effect has > 80% chance of effect occurring)
Moderate	P40 - P80 (effect has 40 - 80% chance of effect occurring)
Low	< P40 (effect has < 40% chance of effect occurring)

It is expected that when equipment and vehicles are operating, or while mining operations are taken place, fugitive and non-fugitive emissions are generated. The probability of an increase in emissions observed during the Project's Construction and Operations phases is more than 80%; therefore, the likelihood of air quality residual effect is considered high.

9.5.4.3 *Significance of Residual Effects on Air Quality*

The significance determination follows a two-step process. First, the severity of residual effects is ranked according to a minor, moderate, and major scale (see Chapter 8, Figure 8.6-1) which is based on a consideration of the residual effects characterization criteria rankings (i.e., magnitude, text, frequency etc.). Residual effects with low or a medium magnitude are considered minor in scale; residual effects with high magnitude, but with emission sources that can be mitigated is considered moderate; and residual effects with a high magnitude, combined with difficult to mitigate emission sources, is considered major. The significance of residual effects is determined using the ratings below:

- **Not Significant (minor, moderate)**: residual effects have low or medium magnitude, are local to regional geographic extent, have short- or medium-term duration, could occur at any frequency, are reversible or partially reversible in either the short or long-term, and have minor or moderate scale. The effect on air quality is either indistinguishable from background conditions, or distinguishable at the individual level.
- **Significant (major):** residual effects have high magnitude, are regional or beyond regional geographic extent, their duration is long term or far future, and they occur at all frequencies. Residual effect on air quality is consequential and is irreversible with major scale.

The residual effects of the project on air quality during both the Construction and Operations phases are considered not significant (moderate), as the effects are, at worst, of high magnitude, medium duration, albeit regular, with local geographic extent and neutral resiliency. The effects are also fully reversible.

9.5.5 Confidence and Uncertainty

Confidence, which can also be understood as the level of uncertainty associated with the assessment, is a measure of how well residual effects are understood and the confidence associated with the baseline data, modelling techniques used, assumptions made, effectiveness of mitigation, and resulting predictions.

Uncertainty exists in every prediction of future change; however, the approach used to assess the effects on air quality was developed to incorporate quantitative data from baseline reports, where available, and air quality modelling, therefore providing a robust, transparent, and defensible approach to the effects assessment. The methodology used to calculate fugitive dust emissions was taken from provincial and federal guidelines and scientific papers. There are, however, uncertainties associated with the fugitive dust emission factors. There is also uncertainty associated with the how the model predicts dust deposition. The confidence is therefore high for non-fugitive results, and moderate for fugitive results. The overall confidence in the magnitude of the residual air quality effects assessment is, therefore, high for TSP, PM_{10}, and $PM_{2.5}$ and moderate for dust deposition.

9.5.6 Summary of the Residual Effects for Air Quality

Residual effect for air quality is summarized in Table 9.5-17, including the associated characterization criteria, significance, likelihood, and confidence in the determination.

9.6 Cumulative Effects Assessment

9.6.1 Scoping Cumulative Effects

Cumulative effects are the result of Project-related residual effects interacting with the residual effects of other human actions (i.e., anthropogenic developments, projects, or activities) to produce a combined effect. The methodology used for the cumulative effects assessment (CEA) follows the approach outlined in Chapter 8, Section 8.7.

Table 9.5-17. Summary of Key Effects, Mitigation, Residual Effects Characterization Criteria, Likelihood, Significance, and Confidence

Key Effect	Mitigation Measures	Summary of Residual Effects Characterization Criteria *(Magnitude, Geographic Extent, Duration, Frequency, Reversibility, Resiliency)*	Likelihood *(High, Moderate, Low)*	Significance of Adverse Residual Effects: Scale *(Minor, Moderate, Major)*	Significance of Adverse Residual Effects: Rating *(Not Significant; Significant)*	Confidence *(High, Moderate, Low)*
Increase in TSP, PM_{10};, $PM_{2.5}$, and dust deposition during Construction phase	Emission reduction measures, e.g., baghouses. Fugitive dust reduction measures, e.g. road watering.	Medium-high magnitude Local geographic extent Short-term duration Regular frequency Reversible Neutral resiliency	High	Moderate	Not Significant	Moderate - High
Increase in TSP, PM_{10};, $PM_{2.5}$, and dust deposition during Operations phases	Emission reduction measures, e.g., baghouses. Fugitive dust reduction measures, e.g., road watering.	Medium-high magnitude Local geographic extent Medium-term duration Regular frequency Reversible Neutral resiliency	High	Moderate	Not Significant	Moderate - High

9.6.1.1 *Valued Components and Project-related Residual Effects*

Two residual effects were identified in the project effects assessment: an increase in particulate concentrations and an increase in dust deposition levels during Construction and Operations. The cumulative effect on air quality levels will be compared to criteria previously used to compare to Project-related effects.

9.6.1.2 *Defining Assessment Boundaries*

Similar to the Project-related effects, assessment boundaries define the maximum limit within which the CEA is conducted. Boundaries relevant to air quality are described below. The definition of these assessment boundaries is an integral part of the air quality CEA, and encompasses possible direct, indirect, and induced changes of the Project on air quality.

The temporal boundaries for the identification of physical projects and activities have been categorized into past, present, and reasonably foreseeable projects and are defined as follows.

- **Past**: no longer operational projects and activities that were implemented in the past 50 years. This temporal boundary takes into account any far-future effects from past projects and activities.[1]
- **Present**: active and inactive projects and activities; and
- **Future**: certain projects and activities that will proceed, and reasonably foreseeable projects and activities that are likely to occur. These projects are restricted to those that 1) have been publicly announced with a defined project execution period and with sufficient project details for assessment, and/or 2) are currently undergoing an environmental assessment, and/or 3) are in a permitting process.

Pollutant levels will return to baseline levels after Project emission sources are removed. Therefore, the air quality CEA only considers projects with construction and/or operation phases that overlap with the Project phases. As such, past projects or activities will not be considered, and the assessment will focus on existing and potential future sources of air quality.

Air quality impacts from the Project are expected to occur within 10 km of the emission source as previously mentioned; however, impacts from larger sources could extend further. In order to take account of potential sources outside of the LSA, the air quality CEA focuses on projects and activities within 50 km of the Project, which coincides with the Project's RSA. Figure 9.6-1 shows the location of the CEA boundary.

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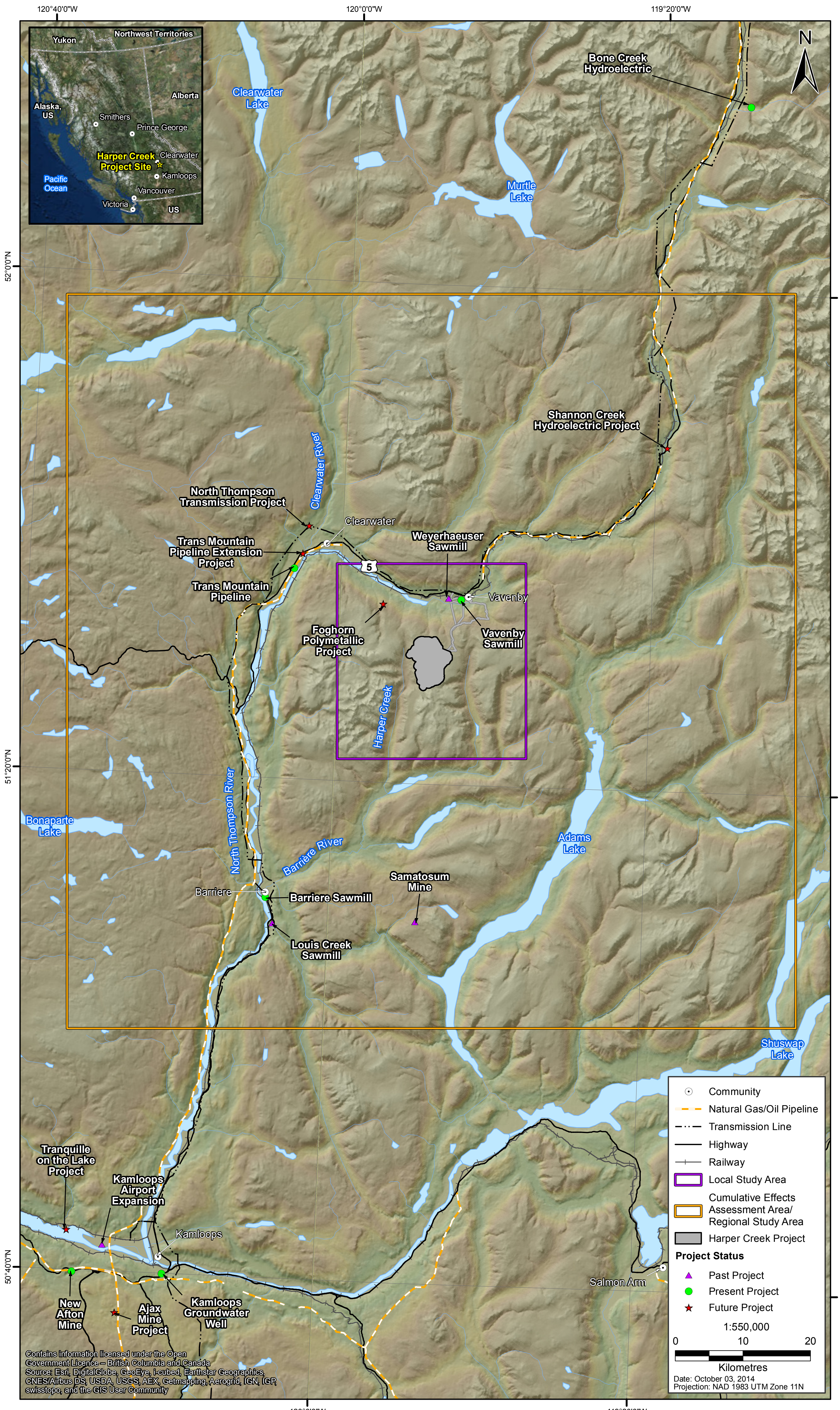
[1] Far future effects are defined as effects that last more than 37 years, as per Table 8.6-2, Attributes for Characterization of Residual Effects.

Figure 9.6-1

Location of Past, Present, and Reasonably Foreseeable Future Projects for the Cumulative Effects Assessment for Air Quality



9.6.1.3 Projects and Activities Considered

Present and reasonably foreseeable future projects and activities within the boundaries described above were considered in the CEA. The project list was developed from a wide variety of information sources including municipal, regional, provincial, and federal government agencies; other stakeholders; and companies' and businesses' websites. The projects and activities considered in the CEA are presented in Chapter 8, Assessment Methodology, in Tables 8.7-1 and 8.7-2, respectively. Figure 9.6-1 shows the past, present, and future projects that fall within the CEA boundary for air quality.

Land use and activities identified within the CEA area includes the following (see figures in Section 8.7 of the Methods chapter):

- Hunting: wildlife management units (15);
- Trapping: trapline tenure (39) and trapline cabin tenure (10);
- Non-commercial recreation: protected area (1 – Dunn Peak Protected Area); provincial park (30). There are also many recreational sites and activities including fishing, camping, hiking, horseback riding, hunting, trail bike riding, snowmobiling, snowshoeing and swimming ;
- Public and commercial recreation tenure: alpine skiing (1), commercial recreation such as commercial wharf, hunting/fishing, guided freshwater recreation, heli-hiking, and heli-ski ; environment conservation and recreation (48); private campground (22, including Clearwater-Birch Island Campground); school/outdoor education facility (3) potential pullout area for snowmobile (2); tourism (3: the Serenity Performing Arts Centre, North Barriere Lake Resort, and Clearwater Ski Hill); and recreational residences (58);
- Mineral Exploration: mineral claims (965); mineral leases (10); and placer claims (24);
- Agriculture: range tenure (58), agricultural land reserve (59) and the Vavenby Trail Ride ;
- Forestry: active cutblocks (2526); community forest (2: Wells Gray Community Forest Corp and Lower North Thompson Community Forest Society);
- Water Use: water intake extraction points (804); groundwater wells not used for human consumption (309) and water licences (1532); and
- Private Lands.

9.6.2 Screening and Analyzing Cumulative Effects

Projects and activities with the potential to interact with the Harper Creek Project, and that may lead to cumulative residual effects on air quality, are identified in Table 9.6-1. The same risk ratings used for Project effects on air quality are used in the CEA, with green indicating low risk interaction, yellow indicating moderate risk interaction, and red indicating a high risk interaction.

The Louis Creek Sawmill, the Samatosum Mine, and the Weyerhaeuser Sawmill are all located within the cumulative study area; however, as past projects there are no emissions to overlap with potential effects from the Project. No further consideration is warranted.

Table 9.6-1. Impact Matrix for Screening and Ranking Potential Cumulative Effects

Residual Effects of the Project on VCs	Past Projects				Present Projects								Reasonably Foreseeable Future Projects							Activities										
	Weyerhaeuser Sawmill	Samatosum Project	Weyerhaeuser Sawmill	Louis Creek Sawmill	Highland Valley Copper	Bone Creek	Trans Mountain Pipeline	Kamloops Groundwater Project	New Afton	Cache Creek Landfill Extension	Vavenby Sawmill	Barriere Sawmill	North Thompson Transmission Project	Ruddock Creek Project	Trans Mountain Pipeline Expansion	Foghorn Project	Tranquille on the Lake	Shannon Creek	Ajax Project	Aboriginal Harvesting	Hunting	Trapping	Fishing	Non-commercial Recreation	Commercial Recreation	Mining and Mineral Exploration	Transportation	Agriculture	Forestry	Water Use
Air Quality																														
Increase in TSP, $PM_{10;}$, $PM_{2.5}$, and dust deposition during construction and operations											●					●										●	●	●	●	

Notes:

● = *Low risk interaction: a negligible to minor adverse effect could occur; no further consideration warranted.*

● = *Moderate risk interaction: a potential moderate adverse effect could occur; warrants further consideration.*

● = *High risk interaction: a key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

The North Thompson Transmission Project, the Trans Mountain Pipeline, the Trans Mountain Pipeline Extension Project, and the Shannon Creek Hydroelectric project are all located within the cumulative study area. It is unlikely there will be emissions associated with the pipeline or hydroelectric projects during operation, although there may be emissions during construction. The emissions during construction are likely to be short lived and localized. The projects are all located well outside the areas predicted to be affected by the Project; therefore, due to the nature of the projects and their distance from the Project, it is not expected that there will be any cumulative effects associated with these projects. No further consideration is warranted.

The Vavenby Sawmill is a source of TSP, PM_{10}, $PM_{2.5}$ emissions and dustfall. The emissions from the sawmill, presented in the Baseline Conditions section (Table 9.4-1), are minimal compared to those from the Project. Also, in 2013 the facility installed a new energy system and electrostatic precipitator (ESP) to provide thermal oil heat to dry kilns in place of the wood-fired direct heating system. This new heat source should significantly reduce particulate emissions from the dry kilns. A new baghouse was also installed in the sawmill to further reduce emissions (Environment Canada 2014a). The permit (3124) owned by the Canadian Forest Products Ltd. Sawmill in Vavenby allows a maximum TSP discharge rate of 115 mg/m^3 for 120 hours per week, 52 week/year from the cyclones and 8,760 hour/year from the kilns. The baghouse is limited to a maximum discharge rate of 20 mg/m^3 for 120 hour/week, 52 week/year. Energy generating systems are limited to 50 mg/m^3 of TSP for 8,760 hour/year. Assuming standard mitigation and management measures are in place, the risk of a cumulative residual effect is considered low.

The only other reasonably foreseeable future project in the RSA is the Foghorn Polymetallic Project. The Foghorn Polymetallic Project is a mineral claim and proposed uranium mine; however, the project is currently on hold due to a provincial ban on uranium exploration and mining. At this point, the project start timeline is unknown. As previously mentioned emissions are eliminated immediately after sources are removed. It is uncertain if the Foghorn Polymetallic Project will start construction before the end of the Project's life of mine. As presented in contour figures provided in Appendix 9-E, there are negligible effects from the Project at the location of the proposed Foghorn Polymetallic Project. Therefore, it is unlikely that the Foghorn Polymetallic Project and Project will interact to create a cumulative residual adverse effect. Due to the low likelihood of a cumulative residual adverse effect, and the unknown timeline of the Foghorn Polymetallic Project, further assessment is not warranted.

Land use activities such as hunting, harvesting, fishing, and utility corridors would produce negligible air emissions, and therefore there is no cumulative interaction. Other land use activities that would interact temporally with air quality include: forestry, agriculture, industrial roads, and mineral exploration. These activities will produce TSP, PM_{10}, $PM_{2.5}$ emissions and dustfall, primarily due to traffic on unpaved roads. The emissions are likely to be short lived and localized. Assuming standard mitigation and management measures are in place, the cumulative impacts are considered negligible. No further consideration is warranted.

Transportation activities will also produce TSP, PM_{10}, $PM_{2.5}$ emissions and dustfall. The primary emission associated with transportation would be dust; however, the dust baseline monitoring included areas near transportation routes and therefore baseline air quality levels already account for existing activities. Additionally, traffic levels will not approach or exceed previous peak levels during the operation of the Weyerhauser Mill in Vavenby, which was generating 40 to 120 one-way trips of logging truck traffic per day on local Forestry Service Roads.

9.6.3 Mitigation Measures

There are no specific mitigation or management measures proposed to explicitly address potential cumulative changes. Mitigation measures provided in Section 9.5.2 and the Air Quality Management Plan are appropriate to mitigate any minor potential cumulative residual effects on air quality that may occur.

9.6.4 Cumulative Residual Effects and Characterization

A negligible or minor low-risk cumulative residual adverse effect on air quality is expected as a result of the interaction of the Project and other activities such as forestry, agriculture, industrial roads, and mineral exploration. Therefore, the predicted cumulative effect remaining after the implementation of Project-specific mitigation measures remains the same as the findings reached for the Project-specific residual effects assessment.

The residual effects for TSP, PM_{10}, $PM_{2.5}$, and dust deposition are predicted to have a medium to high magnitude as the modelled results may exceed the relevant objectives. The geographic extent of emissions is local as the effects are contained within a few kilometres from the source. For all pollutants the duration is classed as medium term, as the emissions will occur throughout Construction and Operations. Air quality concentrations will be lower than the predicted levels for much of the time; however, as a worst-case approach, residual effects are considered to be regular and at peak levels for the entire Project duration. The effects are reversible as the concentrations will return to baseline levels once the pollutant sources are removed. The baseline condition in the area is somewhat affected by anthropogenic activities, such as the Vavenby Sawmill and current transportation activities. The receiving environment is therefore considered to have a neutral resilience to an increase in emissions.

The summary of cumulative residual effects is shown in Table 9.6-2.

Table 9.6-2. Summary of Cumulative Residual Effects on Air Quality

VC	Cause-Effect	Mitigation Measure(s)	Cumulative Residual Effect
Air quality	Emission sources Fugitive dust sources	Emission reduction measures Fugitive dust reduction measures	Marginal increase in TSP, PM_{10}, $PM_{2.5}$, and dust deposition during Construction and Operations

9.6.5 Significance of Cumulative Residual Effects

The risk of air quality interaction is low between the Project and other activities, with medium to high magnitude, short-term duration, and regular frequency during the Construction phase; and medium magnitude, medium-term duration, and regular frequency during the Operations phases, with local geographic extent, reversible effects, and neutral resiliency. Predicted significance of cumulative residual effects on air quality remaining after the implementation of all mitigation measures is therefore the same as the Project-associated effects summarized in Table 9.6-3.

Table 9.6-3. Summary of Key Cumulative Effects, Mitigation, Cumulative Residual Effects Characterization Criteria, Likelihood, Significance, and Confidence

Key Cumulative Effect	Mitigation Measures	Summary of Cumulative Residual Effects Characterization Criteria *(Magnitude, Geographic Extent, Duration, Frequency, Reversibility, Resiliency)*	Likelihood *(High, Moderate, Low)*	Significance of Adverse Cumulative Residual Effects		Confidence *(High, Moderate, Low)*
				Scale *(Minor, Moderate, Major)*	Rating *(Not Significant; Significant)*	
Increase in TSP, PM_{10};, $PM_{2.5}$, and dust deposition during Construction phase	Emission reduction measures, e.g., baghouses. Fugitive dust reduction measures, e.g., road watering.	Medium-high magnitude Local geographic extent Short-term duration Regular frequency Reversible Neutral resiliency	High	Moderate	Not Significant	–Moderate - High
Increase in TSP, PM_{10};, $PM_{2.5}$, and dust deposition during Operations phases	Emission reduction measures, e.g., baghouses. Fugitive dust reduction measures, e.g., road watering.	High magnitude Local geographic extent Medium-term duration Regular frequency Reversible Neutral resiliency	High	Moderate	Not Significant	–Moderate - High

9.6.6 Confidence and Uncertainty

As discussed in Section 9.6.2, although the Foghorn Polymetallic Project is a reasonably foreseeable future project, the project timeline is unknown. Due to the nature of emissions being localized and the ability to return to baseline conditions once the sources are removed, the confidence level for CEA remains the same as that for the determination of significance for Project-associated effects.

9.7 CONCLUSIONS FOR AIR QUALITY

Project residual effects on air quality include the potential for increased CAC emissions and dust deposition. Dispersion modelling was used to determine the magnitude of the effect of Project operations. The results were then compared to relevant standards and objectives. It was determined that the effect of increases in CAC concentrations and dust deposition levels on air quality are considered to be not significant.

A cumulative assessment was carried out in order to assess the combined impacts of the Project with other projects in the area. Three projects and activities were identified as potentially having a cumulative effect: Vavenby Sawmill, the Foghorn Polymetallic Project, and transportation activities related to forestry and mineral exploration; however, they were all considered low risk. The cumulative effect of increases in CACs and dust deposition on air quality are concluded to be not significant.

A summary of key Project and cumulative residual effects is presented in Table 9.7-1.

Table 9.7-1. Summary of Key Project and Cumulative Residual Effects, Mitigation, and Significance for Air Quality

Key Residual Effects	Project Phase	Mitigation Measures	Significance of Residual Effects	
			Project	Cumulative
Increase in TSP, PM_{10};, $PM_{2.5}$, and dust deposition	Construction Operations 1 Operations 2	Emission reduction measures, e.g., baghouses. Fugitive dust reduction measures, e.g., road watering.	Not Significant	Not Significant

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