7. Air Quality Predictive Study

7.1 INTRODUCTION

Air quality is an important environmental factor in ensuring the conservation of local vegetation, wildlife, and human health. The Brucejack Gold Mine Project (the Project) activities will result in air emissions to the ambient environment. The change in ambient air quality needs to be assessed to ensure conservation of the environment and compliance with federal and British Columbia (BC) regulations. The assessment will include a determination of the future condition of the ambient air quality, which includes the impact of emissions from the Project and existing baseline conditions.

In order to assess air quality, meteorological conditions need to be considered. Meteorology is also a major consideration for the design, construction, and maintenance of the proposed development. Information on meteorological conditions, such as wind and air temperature, is required for air dispersion modelling in order to determine the Project's potential air quality changes as these conditions have a large effect on the dispersion of pollutants in the atmosphere. Solar radiation and precipitation data also provide information for the design of water management infrastructure and water balance calculations.

Meteorological conditions in the Project region are expected to have high spatial variability due to complex topography, and regional gradients in key climate parameters such as precipitation and air temperature; therefore, obtaining baseline meteorological conditions is essential.

7.2 REGULATORY AND POLICY FRAMEWORK

Managing air quality is a partnership between multiple government jurisdictions and stakeholders including federal, provincial, regional, and municipal governments, along with international joint organizations.

The *Canadian Environmental Protection Act* (CEPA; 1999), which came into force on March 31, 2000, is an important part of Canada's federal environmental legislation aimed at preventing pollution and protecting the environment and human health. CEPA also regulates emission sources that lie beyond provincial authorities, such as motor vehicles and fuel, marine vessels, railways, and off-road engines (BC Air Quality 2013).

The *Environmental Management Act* (EMA; 2003) and Waste Discharge Regulation (BC Reg. 320/2004) are the most important pieces of legislation for air quality in BC. The EMA was enacted in July 2004, which replaced the *Waste Management Act* and the *Environment Management Act* (1996) and brought provisions from both of these acts into one statute (BC MOE 2013a). The EMA provides a more flexible authorization framework, increases enforcement options, and uses modern environmental management tools (BC MOE 2013a). The Waste Discharge Regulation, under the EMA, stipulates that it is applicable to mining and mining activities such as clearing, burning, and incineration; this regulation also explicitly sets out enforceable fees for discharge that multiply when maximum concentrations are exceeded (BC Reg. 320/2004). Many codes of practice and regulations are also in development and review under the EMA, which include but are not limited to the Hazardous Waste Regulation, Open Burning Smoke Control Regulation, and Small Electrical Power Generating Facility Code of Practice.

Ambient air quality objectives are non-statutory limits that provincial or federal governments place on the level of contaminants in the atmosphere in order to guide decisions to protect human health and the environment. Discharge levels of fugitive dust and air contaminants, as well as ambient air quality objectives (in particular for dustfall) may also be explicitly written into a waste discharge air permit.

The federal and provincial ambient air quality criteria are summarized in Table 7.2-1. The national ambient air quality objectives (NAAQOs) are the benchmark against which impact assessments of anthropogenic activities on air quality are made in Canada. The first NAAQOs developed in the mid-1970s consisted of a three-tiered approach (maximum desirable, acceptable, and tolerable levels). The subsequent new NAAQOs framework, introduced in the National Air Pollution Surveillance data report for the year 2000, specified two levels developed through extensive scientific assessment:

- a reference level, which is the level above which there are demonstrated effects on human health, and/or the environment; and
- an Air Quality Objective, which reflects a specific level of protection for the general population and environment and also considers aspects of technical feasibility (Environment Canada 2013a).

Table 7.2-1. Federal and Provincial Ambient Air Quality Criteria

		Concentrations ($\mu g/m^3$)					
		Canada			BC Objective		
Pollutant	Averaging Time	Maximum Desirable	Maximum Acceptable	Maximum Tolerable	Level A	Level B	Level C
SO_2	1-hour	450	900	-	450	900	900-1,300
	24-hour	150	300	800	160	260	260
	Annual	30	60	-	25	50	80
NO_2	1-hour	-	400	1,000		-	
	24-hour	-	200	300		-	
	Annual	60	100	-		-	
CO	1-hour	15,000	35,000		14,300	28,000	35,000
	8-hour	6,000	15,000	20,000	5,500	11,000	14,300
TSP	24-hour	-	120	400	150	200	260
	Annual	60	70	-	60	70	75
PM_{10}	24-hour		-		-	50	-
$PM_{2.5}$	24-hour	30[a] , 28[d] (2015) and 27 [d](2020)				25[b]	
	Annual	10[d] (2015) and 8.8[d] (2020)				8[c]	

Notes: (-) dash indicates not applicable
[a] Annual 98th percentile value, averaged over three consecutive years. Canada-wide standard published by CCME.
[b] Based on annual 98th percentile value.
[c] BC objective of 8 $\mu g/m^3$ and planning goal of 6 $\mu g/m^3$ was established in 2009.
[d] CAAQS adopted in 2013 and will become effective in 2015 and 2020.

The group of pollutants referred to as criteria air contaminants (CACs) are regulated, which include:

- sulphur dioxide (SO_2);
- nitrogen dioxide (NO_2);
- carbon monoxide (CO);
- total suspended particulates (TSP);

- suspended particulates with diameter less than 10 micrometres (μm; PM_{10});
- suspended particulates with diameter less than 2.5 μm ($PM_{2.5}$);
- volatile organic compounds (VOC); and
- ozone (O_3).

The original objectives have not been formally revised to the new two-level system. In the interim, SO_2, NO_2, CO, and O_3 are being compared with the existing desirable and acceptable NAAQOs. The NAAQOs are set by the federal government based on recommendations from a National Advisory Committee and Working Group on Air Quality Objectives and Guidelines, and are consistent with the philosophy of the CEPA.

The Province also has the authority to develop air quality standards and guidelines, regulate point and area sources, and require the preparation of airshed management plans (BC MOE 2013a). The BC air quality objectives are similar to those from NAAQOs; however, some pollutants are only regulated by either the federal or the provincial government. For example, a PM_{10} objective is set for BC, but is not included in the NAAQOs, while objectives for NO_2 were not published for BC. The Canadian Council of Ministers of the Environment (CCME), composed of Canada's federal, provincial, and territorial environment ministers, developed Canada-wide Standards (CWS) for $PM_{2.5}$ and O_3 in 2000 pursuant to the Canada-wide Accord on Environmental Harmonization (CCME 1998) and its Canada-wide Environmental Standards Sub-Agreement. The CWS are a step toward the long-term goal of minimizing the risk posed to human health and the environment. Since BC is a member of the CCME, a 24-hour $PM_{2.5}$ CWS of 30 μg/metre $(m)^3$ (based on the annual 98th percentile averaged over three consecutive years), is being implemented in BC. The new Canadian Ambient Air Quality Standards (CAAQS), developed collaboratively by Health Canada; Environment Canada; the provinces and territories; and stakeholders from industry, health, environmental, and aboriginal organizations through a consensus-based process steered by the CCME, was adopted in 2013. The new standards will become effective in 2015 and 2020 and supersede the CWS.

In 2009, new ambient air quality criteria for $PM_{2.5}$ were developed in BC. They are non-statutory limits guided by the Air Action Plan and the BC government's commitment to "… lead the world in sustainable environment management with the best air and water quality…" (BC MOE 2013b). The development of the new criteria was originally led by the British Columbia Ministry of Environment (BC MOE), followed by the British Columbia Ministry of Healthy Living and Sport. The 24-hour $PM_{2.5}$ objective of 25 μg/m^3, based on an annual 98th percentile, is more stringent than the CWS and future CAAQS for $PM_{2.5}$. BC also established an annual average objective of 8 μg/m^3 and a planning goal of 6 μg/m^3 to keep the air clean and the environment healthy.

Regional and municipal governments also develop bylaws to control emissions such as open burning and vehicle idling. In the Regional District of Kitimat-Stikine where the Project is located, there are currently no anti-idling or open-burning bylaws; however, it is expected that regional governments will be notified if open burning will take place (Alderson 2007).

The Pollution Control Objectives for the Mining, Smelting, and Related Industries of British Columbia (BC MOE 1979) developed dustfall objectives ranging from 1.7 to 2.9 milligrams per $decimetre^2$ per day (mg/dm^2/day), averaged over 30 days. The aim of the objectives is to protect the quality of BC's environment for the benefit of present and future citizens of this province, intending to minimize the changes of known or potential harmful changes in receiving environments (BC MOE 1979).

In addition to the federal, provincial, and regional/municipal regulation and criteria on emission sources, and ambient air concentrations, there is also a BC Model Guideline (BC MOE 2008). The guideline is intended to provide information for practitioners and for those who use model outputs for decision-making. Details on model approach for source type, model domain and receptor spacing, and interpretation of the model output are provided in the document. The Project's Air Dispersion Conceptual Model Plan (included in Appendix 7-C, Conceptual Model Plan) is used to predict the potential air quality changes of the Project against provincial and federal ambient air quality objectives and has been prepared based on the best practices from the BC Model Guideline.

7.3 BASELINE CHARACTERIZATION

7.3.1 Regional Overview

7.3.1.1 Meteorology

The Project lies in a transition zone between the wet Pacific coastal region and the drier interior of BC. The regional meteorological and hydrological climates of northwestern BC are primarily dominated by weather systems coming from the west that develop over the Pacific Ocean, and are also influenced by orographic effects caused by the local mountainous topography and glaciers. This results in interactions between incoming weather systems and local topography that produce a degree of spatial variability in snowfall and rainfall. Based on a regional precipitation model, mean annual precipitation in the Project area is expected to range from 1,000 to 2,200 millimetres (mm; Wang et al. 2006).

The Environment Canada Climate Trends and Variations Bulletin for Northern BC shows that precipitation during most seasons between 2010 and 2012 were lower than the average values of the past 65 years, with the winter seasons having a precipitation departure of 32% to 15% less precipitation than average (Environment Canada 2013b). The summer of 2011, however, was much wetter than normal (+40%), and had the highest rank of the 65 years.

Generally, strong winds occur during all seasons at high elevations, blowing from the northeast, east, and southeast during cold months and from the south, southwest, and west during warmer months. Winds at low elevations are funnelled through valleys with a light to moderate down-valley flow of Arctic air during cold months and a light up-valley flow of warm Pacific air at other times.

The Project lies within the Cassiar Iskut-Stikine Land and Resource Management Plan (CIS LRMP; BC ILMB 2000) and the Nass South Sustainable Resource Management Plan (SRMP; BC MFLNRO 2012) boundaries. The CIS LRMP encompasses 5.2 million hectares in northwestern BC and extends from Ningunsaw Pass in the south to Dease Lake in the north, and from the Alaska border in the west to the Chukachida River in the east. Biological diversity within the Nass South SRMP area is the result of disturbance regime, regional climate, geography, and soil interacting to create unique ensembles of plant communities. The Project area contains the Boreal Altai Fescue Alpine, Coastal Mountain-Heather Alpine, Engelmann Spruce - Subalpine Fir, Mountain Hemlock, and Interior Cedar Hemlock Biogeoclimatic Ecosystem Classification (BEC) Zones. The goal of the Nass South SRMP is to ensure economic and environmental sustainability. To meet this goal, a series of management objectives for water, biodiversity, botanical forest products, wildlife, fish, cultural heritage, and timber have been developed by Nass South SRMP. Monitoring and ongoing assessment of the objectives in the Nass South SRMP are being implemented. The CIS LRMP also has various goals to maintain the structure and function of riparian habitat, and suitable soil/climate combinations for cultivated crops. Monitoring and adaptive management are essential tools for both plans to help ensure these goals are met.

7.3.1.2 Air Quality

The air quality in the area proposed for the Project and elsewhere in northwestern BC is mainly unaffected by anthropogenic sources, reflecting the region's remoteness and the localized nature and lack of sources of anthropogenic air emissions.

The CIS LRMP provides management direction, research and inventory priorities, economic strategy priorities, and implementation and monitoring of the area, but no specific objectives or strategies directly relate to air quality. The plan indicated that the CIS LRMP area has very high biodiversity values, supporting healthy populations of many species, some of which are threatened or endangered in other parts of the province. Therefore, biodiversity of the plants, animals, and other living organisms, and the evolutionary and functional processes that link them, should be preserved. Clean air is required to achieve a healthy environment to sustain natural ecosystems. Although there is no specific objective or goal set to regulate ambient air quality, the CIS LRMP indicated clean air as one of its competitive advantage, so it is understood that clean air in the area is valued.

Similarly, the Nass South SRMP does not include any specific goal or plan directly related to air quality. Biodiversity including old-growth and seral stage forests, and wildlife are considered in the plan. Air quality is an important factor in sustaining a healthy environment for biodiversity.

An airshed is generally described as an area where the movement of air can be hindered by local geographical features such as mountains, and by weather conditions, which result in air movement occurring in a similar manner within the area defined by the airshed. The Project area does not fall under any specifically regulated airshed, although it has geographical features that would hinder the movement of air.

7.3.2 Historical Activities

Long before the arrival of European settlers, the area around Stewart was used by First Nations people. At the turn of the 19th century, European prospectors made promising discoveries of gold and silver in the region, and a sizable gold rush followed. In 1918, the discovery of high-grade ore at the Silbak-Premier property led to the development of one of the richest mineral deposits in BC. During the peak mining era, more than 150 mining properties were being worked in the region.

Several historic and current human activities are within close proximity to the proposed Project Area. These include mining exploration and production, hydroelectric power generation, forestry, and road construction and use.

The Granduc Mine was a copper mine located approximately 25 km south of the Project that operated from 1970 to 1978 and 1980 to 1984. The mine included underground workings, a mill site near Summit Lake, and an 18.4-km tunnel connecting them. In addition, a 35-km all-weather access road was built from the communities of Stewart, BC and Hyder, Alaska to the former mill site near Summit Lake. The area of the former mill site near Summit Lake is currently used as staging for several mineral exploration projects in the region. The terminus of the Granduc Access Road is 25 km south of the proposed Brucejack Mine Site and is currently used by mineral exploration traffic and tourists accessing the Salmon Glacier viewpoint.

The Sulphurets Project was an advanced underground exploration project of Newhawk Gold Mines Ltd. located at the currently proposed Brucejack Mine Site. Underground workings were excavated between 1986 and 1990 as part of an advanced exploration and bulk sampling program. Reclamation efforts following the Newhawk advanced exploration work included deposition of waste rock and ore within Brucejack Lake.

The exploration phase of the proposed Brucejack Gold Mine Project commenced in 2011 and has included a drilling program, bulk sample program, construction of an exploration access road from Highway 37 to the west end of Bowser Lake, and rehabilitation of an existing access road from the west end of Bowser Lake to Brucejack Mine Site.

In 2010, construction began on the Long Lake Hydroelectric Project, which is located approximately 42 km south of the Project (CEA Agency 2012). It includes redevelopment of a 20-m-high rockfill dam located at the head of Long Lake, and a new 10-km-long 138-kV transmission line.

Historical forestry activities occurred within the immediate Project area between Highway 37 and Bowser Lake, south of the Wildfire Creek and Bell-Irving River confluence. Additional details regarding historic and current human activities nearby the Project are included in Section 7.10 below.

The Project is approximately 25 km southeast of Barrick Gold's recently closed Eskay Creek Mine. The ambient air quality in the area may have been affected while Eskay Creek Mine was active. Since the Eskay Creek Mine closed in 2008, the ambient air quality conditions have been restored due to natural air dispersion processes.

The construction of the Long Lake Hydroelectric project components began in July 2010 and was completed in November 2013. The project construction would have generated limited air emissions, but ambient air quality conditions have been restored due to natural air dispersion processes.

7.3.3 Baseline Studies

7.3.3.1 Meteorology

The purpose of a meteorological study for proposed resource development projects is to characterize the atmospheric environment in its current state and to develop an understanding of the potential impacts (BC MOE 2012). The objective of the meteorology baseline program was to collect information on the existing meteorological conditions prior to project commencement. The objective was achieved by:

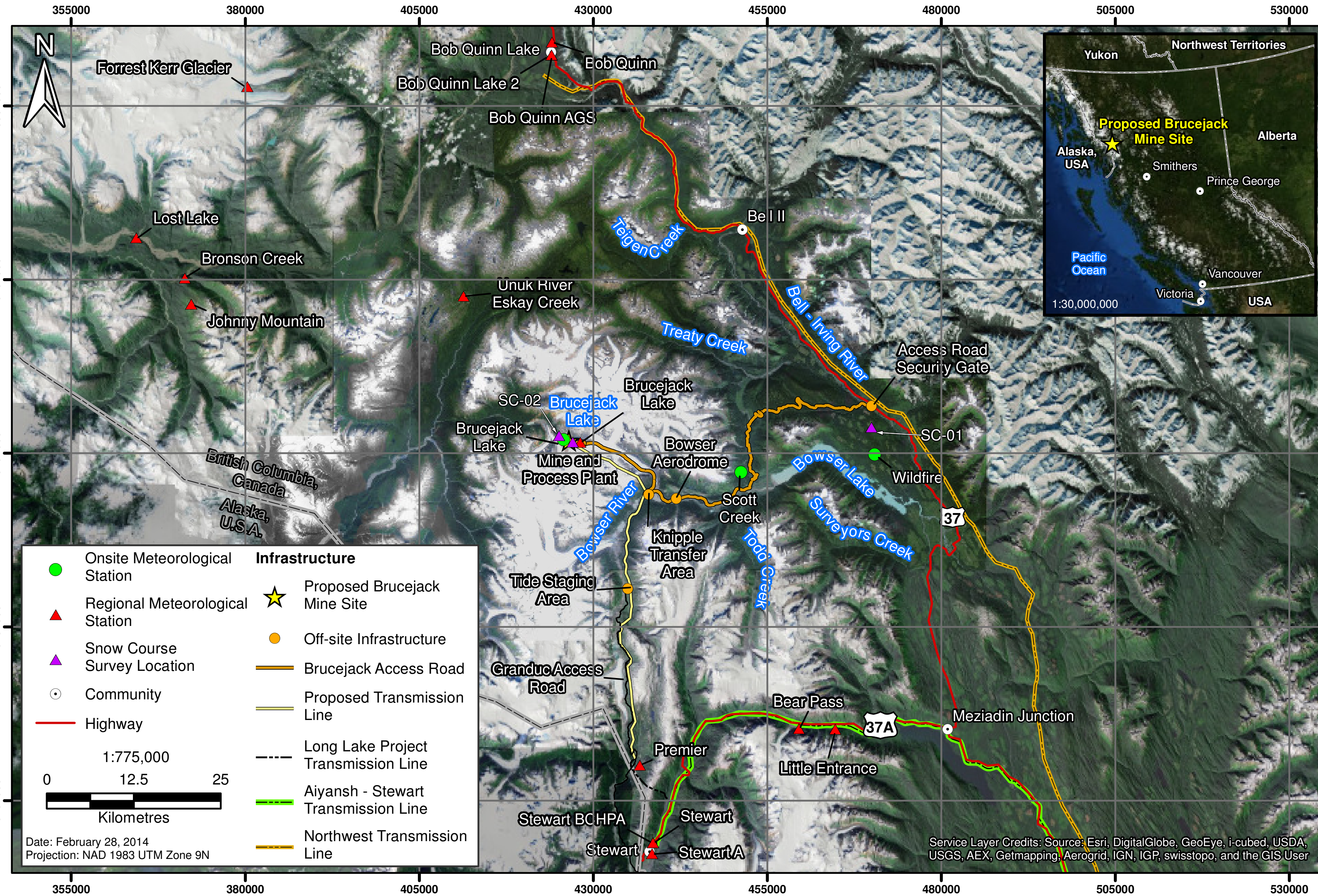
- installation of meteorological stations that monitor meteorological parameters at several locations; and
- comparison of Project-specific data to Environment Canada's long-term datasets.

Data Sources

Long-term historical data sets are available from several stations in the region that have been operated by Environment Canada's Meteorological Services of Canada (MSC) branch, including a station which was in operation from 1988 to 1990 near Brucejack Lake. Figure 7.3-1 shows the location of these and additional regional meteorological stations, as well as Snow Course Survey locations, with respect to the Project. Three Project-specific meteorological stations are also shown on the same figure. Historical data from these MSC stations can be found in Appendix 7-A, 2012 Meteorology Baseline Report.

The British Columbia Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO) and British Columbia Ministry of Transportation and Infrastructure (BC MOTI) also have weather stations in the region, but the data are only collected on a seasonal basis for forest fire forecasting and to schedule road maintenance. In addition, the BC MFLNRO and BC MOTI quality assurance / quality control program for their weather station is not comparable to the MSC programs.

Figure 7.3-1
Locations of On-site and Regional Meteorological Stations, and On-site Snow Course Surveys



Methods and Baseline Study Area

The Project baseline meteorological study began in the fall of 2009 and has been ongoing since that time. Three Project-specific meteorological stations, namely Brucejack Lake, Scott Creek, and Wildfire Creek meteorological stations shown in Plates 7.3-1 to 7.3-3, were set up and operated in accordance with Environment Canada guidelines (2004). The meteorological monitoring program started with the commissioning of the Brucejack Lake meteorology station in 2009, followed by commissioning of the Scott Creek meteorology station in July 2010, and Wildfire Creek meteorology station in August 2011. Each of the meteorological stations consist of a standard 10-m tall meteorology tower with instruments to measure wind speed and wind direction, air temperature, barometric pressure, relative humidity, snow depth, net radiation, solar radiation, and precipitation. The sensors heights were decided referencing the Air Monitoring Site Selection and Exposure Criteria (E. Taylor, pers. comm.).

Plate 7.3-1. Brucejack Lake meteorological station, October 2012.

All meteorological data were reviewed after collection to remove or correct any erroneous values. The screening criteria used were set by the United States Environmental Protection Agency (US EPA; 2000) and Environment Canada (2004), together with professional judgement. Any erroneous data were marked as missing and after data were screened, the recorded hourly and daily values were analysed and processed into daily and monthly summaries. Detailed information on methodology and sensors used can be found in Appendix 7-A, 2012 Meteorology Baseline Report.

Plate 7.3-2. Scott Creek meteorological station, March 2012.

Plate 7.3-3. Wildfire Creek meteorological station, September 2012.

7.3.3.2 Air Quality

The objective of the air quality baseline program was to collect information on the existing ambient conditions prior to project commencement. The objective was achieved by:

- obtaining background concentrations of suspended particulates representative for the area of the proposed Project based on literature sources;
- installing six dustfall stations in the area of the proposed Project to collect data on dust deposition;
- installing two Passive Air Sampling Systems (PASS) stations in the area of the proposed Project to collect data on ambient NO_2, SO_2, and O_3 levels; and
- comparing the amount of dustfall deposition and ambient concentrations of NO_2, SO_2, and O_3 to applicable guidelines.

<u>Data Sources</u>

There is currently no standardized policy for baseline air quality monitoring in BC for environmental assessment projects (BC MOE 2012). The best available estimates of ambient background air quality concentrations are published by the Canadian Air and Precipitation Monitoring Network, a non-urban air quality monitoring network with siting criteria designed to ensure that the measurement locations are regionally representative (i.e., not affected by local sources of air pollution). There are currently 28 measurement sites in Canada and one in the United States. The closest Canadian Air and Precipitation Monitoring Network site to the Project is the Saturna station, off the southern tip of Vancouver Island in the middle of the Strait of Georgia. Although the station is almost 1,000 km southeast of the Project, it provides the best estimate of background concentrations available for British Columbia. Daily measurements of SO_2 concentrations are available from the Saturna monitoring station from 1996 to 2002 (1997 missing). The average annual SO_2 concentration for that period was reported as 2.3 μg/m^3. The background concentrations collected at the Saturna station, and monitoring concentrations from other projects in the area, are summarized in Table 7.3-1.

Table 7.3-1. Summary of Ambient Air Quality Concentrations from Other Sources

Pollutant	Averaging Period	Concentration (μg/m^3)			
		Saturna	Diavik	Galore	Kitsault
SO_2	1-hour	-	4.0	-	-
	24-hour	-	4.0	-	-
	Annual	2.3	2.0	-	-
NO_2	1-hour	-	21	-	-
	24-hour	-	21	-	-
	Annual	-	5.0	-	-
CO	1-hour	-	100	-	-
	8-hour	-	100	-	-
TSP	24-hour	-	10	-	3.5
	Annual	-	10	-	-
PM_{10}	24-hour	-	10	3.4	2.5
$PM_{2.5}$	24-hour	-	-	1.3	2.3
	Annual	-	-	-	-

The Diavik Diamond Mine (Diavik) is in the Northwest Territories, located about 300 km northeast of Yellowknife. In the Diavik Diamond Mine Environmental Assessment (Cirrus Consultants 1998), ambient background concentrations were estimated based on surveys and assumptions. These ambient concentrations, shown in Table 7.3-1, including SO_2, NO_2, CO, TSP, and PM_{10}, are considered to be typical background concentrations for remote areas with few anthropogenic sources.

The Galore Creek Copper-Gold-Silver Project (Galore), approximately 100 km northwest of the Project, collected samples of PM_{10} and $PM_{2.5}$ concentrations in July 2005 (Rescan 2006). Sixteen 24-hour samples of PM_{10} were collected and concentrations ranged from 1.4 to 5.6 μg/m^3 with an average of 3.4 μg/m^3; and a total of thirteen 24-hour $PM_{2.5}$ samples were collected and concentrations ranged from 0.8 to 2.6 μg/m^3 with an average of 1.3 μg/m^3. Dustfall was also monitored at the Galore area. In 2012, with one outlier removed from the results, the average for each of the five sites ranged from 0.09 to 0.96 mg/dm^2/day (Rescan 2013a). Dust deposition rates from other sources are summarized in Table 7.3-2.

Table 7.3-2. Summary of Dustfall Deposition Rates from Other Sources

Averaging Period	Deposition Rate (mg/dm^2/day)			
	KSM Project	Galore	Kitsault	Schaft Creek Mine Project
30-day	0.12 ~ 1.22	0.09 ~ 0.96	0.46	0.13 ~ 0.93

Kitsault Mine Project (Kitsault) is located on the northwest coast of BC approximately 140 km north of Prince Rupert and 130 km south of the Project. The baseline monitoring data showed that the highest dustfall rate was 0.46 mg/dm^2/day in July 2009 (AMEC 2011). Ambient particulate levels were monitored at the site from October 8, 2010 to October 12, 2010 at five locations. The overall average 24-hour concentrations were 3.5 μg/m^3 for TSP, 2.5 μg/m^3 for PM_{10} and 2.3 μg/m^3 for $PM_{2.5}$.

The KSM Project, immediately adjacent to the Project, monitored dust deposition rates from June 2008 to October 2011 at five to ten locations, depending on the year (Rescan 2013b). The deposition rates varied from below the detection limit of 0.1 mg/dm^2/day to 3.75 mg/dm^2/day. The background dust deposition level, calculated as the 98th percentile of measurements taken, was determined to be 1.34 mg/dm^2/day. The average dustfall deposition rate for individual stations measured between 2008 and 2011 ranged from 0.12 to 1.22 mg/dm^2/day.

Dustfall was also monitored at the Schaft Creek Mine Project in 2007 (July, August, and September) and 2008 (June, July, August, and November) at eight locations. Dust deposition rates ranged from below detection limit of 0.1 mg/dm^2/day to 2.5 mg/dm^2/day, and the average for each station ranged from 0.18 to 0.93 mg/dm^2/day.

A technical document about background concentration of ozone in BC (McKendry 2006) indicated background ozone concentration to be in the range of 40 to 80 μg/m^3 (20 to 40 parts per billion) in the province. Ozone background of 60 μg/m^3 is used in this assessment. The predominant wind direction in the Project area is from the east and east-southeast.

Methods and Baseline Study Area

The dustfall stations DF4 and DF5 were located approximately 2 km upwind and downwind from the proposed Mine Site at the Brucejack Lake area, while DF6 was located off the upwind-downwind axis. Dustfall stations DF1, DF2, and DF3 were located at the Wildfire Creek area in a similar fashion, albeit in relation to previously considered infrastructure. The two PASS were installed at the Brucejack Lake and Wildfire Creek areas on the DF2 and DF5 dustfall stations. On July 18, 2012 after the first month of monitoring, station DF2-PASS1 was relocated 640 m southwest of the original location to facilitate helicopter access by field crews (Figure 7.3-2).

The dustfall monitoring program was developed in accordance with sampling method ASTM D1739-98 (Reapproved 2010). The dustfall monitoring stations collect particles small enough to pass through a 1-mm stainless steel sieve, and large enough to settle by virtue of their weight. The containers used were open-topped cylinders not less than 150 mm in diameter placed at the top of stands at a height of 2 m above ground. The containers were partially filled with deionized water and algaecide to prevent re-suspension of dust and growth of algae in the containers. The containers were surrounded by a windscreen and bird spikes (Plate 7.3-4). The wind screen improves the dustfall collection efficiency and bird spikes were used to minimize contaminants from bird faeces. Sample containers were exposed to the atmosphere for approximately 30 days, after which they were sent to the laboratory for analysis. Each dustfall station was comprised of two sample containers with separate mounts. One of the containers was analyzed for particulates (total, soluble, and insoluble) and anions (sulphate, nitrate, chloride, and ammonia), while the other was analyzed for total metals and various cations. All dustfall samples were analyzed at ALS Environmental Laboratory in Burnaby, BC. Results that are below detection limits were presented as the detection limit in the tables; however, in the calculation of averages, they were assumed to be half of the detection limits.

PASS is a diffusive method that monitors gas or vapour pollutants from the atmosphere at a rate controlled by a physical process such as diffusion through a static air layer or permeation through a membrane, which does not involve the active movement of air through the sampler (Tang 2001). The number of days of contact between the ambient air and the permeation membrane is important as contaminant levels captured by the sampler are proportional to exposure time. The sampling rate was calculated using equations developed in laboratory studies based on temperature, relative humidity, and average wind speed (Tang 2001). For the present study, meteorological conditions were provided using data collected from the Wildfire meteorological station for PASS1 (DF2) and the Brucejack Lake station for PASS2 (DF5), shown on Plate 7.3-5. Both Wildfire and Brucejack Lake stations are operated as part of the environmental baseline studies for the Project. All PASS samples were analyzed by Maxxam Analytics Inc. in Edmonton, Alberta. More information on the monitoring methods can be found in the 2012 Air Quality Baseline (Appendix 7-B, 2012 Air Quality Baseline Report).

Figure 7.3-2

Dustfall and PASS Monitoring Stations

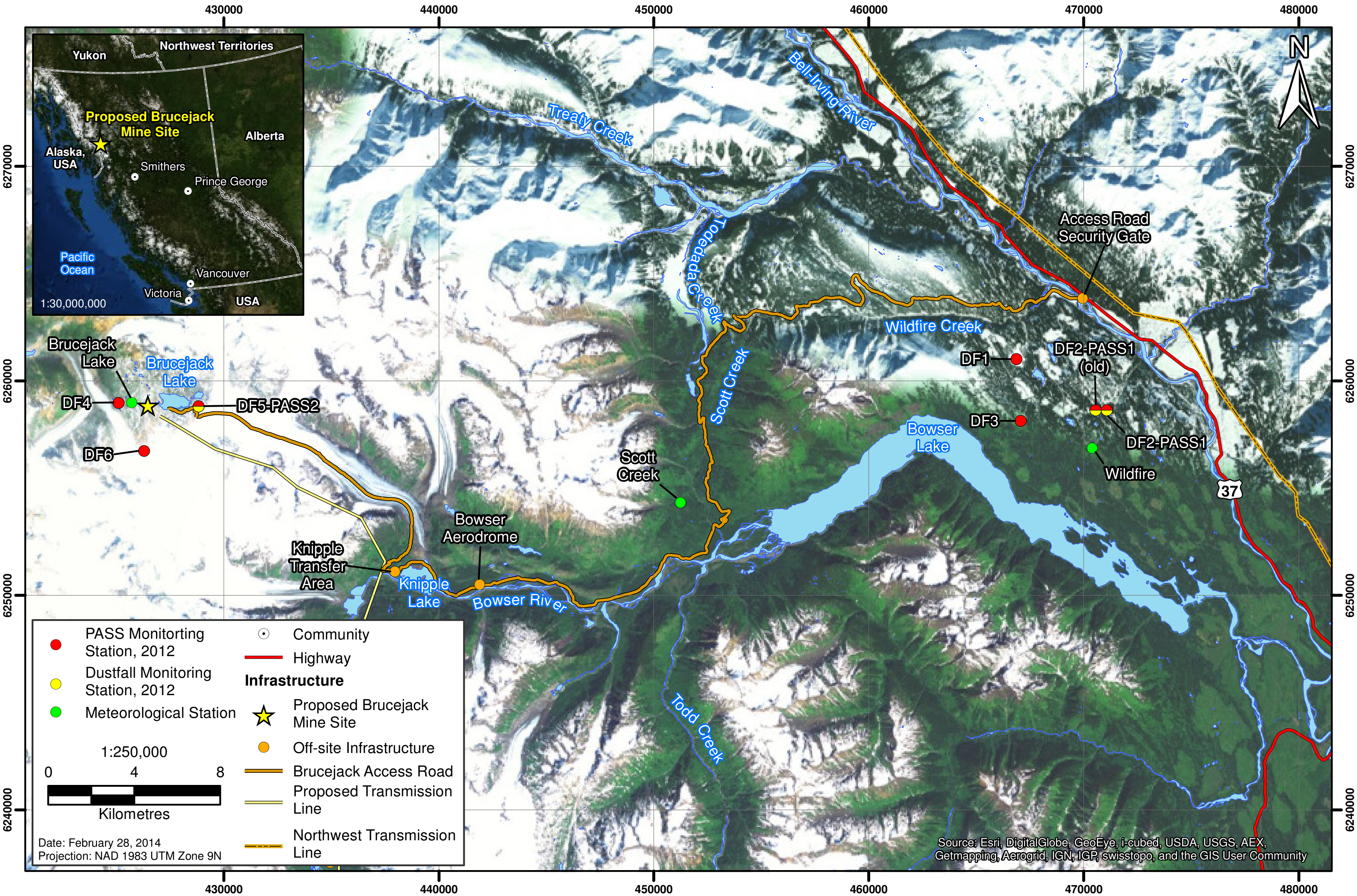


Plate 7.3-4. Dustfall station DF4 (August 4, 2012).

Plate 7.3-5. PASS2 attached to DF5 (August 7, 2012).

7.3.4 Characterization of Baseline Condition

7.3.4.1 Meteorology

Data collected from the three Project-specific meteorological stations were summarized in Appendix 7-A, 2012 Meteorology Baseline Report. In this section, only air temperature, wind speed and direction, and precipitation are discussed since these are relevant parameters for the air dispersion modelling completed as part of this assessment. Other parameters such as solar radiation can be found in Appendix 7-A. On average, the annual temperatures at the Brucejack Lake station were slightly cooler than those recorded at the historical Brucejack Lake MSC station, which operated between 1988 and 1990. However, the duration of collected data from both stations were not long enough to conclude on any long-term trends.

During the period from October 2009 to December 2012, the mean monthly air temperatures for Brucejack Lake station (1,360 metres above sea level; masl) ranged from -10.6 to 8.4°C. The mean monthly air temperatures for Scott Creek station (780 masl) between August 2010 and December 2012 ranged from -9.4 to 13.9°C. Between August 2011 and December 2012, mean monthly air temperatures for Wildfire Creek station (720 masl) ranged from -8.5 to 13.3°C.

Precipitation collection can be affected by wind turbulence causing undercatch of precipitation in the gauge. The GEONOR precipitation gauges used for this project are fitted with Alter wind screens, which reduce wind speed around the gauge and thus decreasing, but not eliminating, the amount of wind-induced undercatch. Despite installation of Alter wind screens, wind-induced undercatch can be substantial (Rasmussen et al. 2012). The precipitation values for the Brucejack Lake, Scott Creek, and Wildfire Creek stations were adjusted for undercatch based on wind speed. Furthermore, a linear equation derived by using orthogonal regression on the historical October 2010 to December 2012 monthly precipitation between Brucejack Lake and Scott Creek stations was also used to estimate missing precipitation data. Missing data recorded at the Wildfire Creek station could not be estimated because the station did not have a strong enough relationship with the other two Project stations.

Based on available data, total monthly precipitation (adjusted) ranged from 33 to 527 mm at Brucejack Lake, 20 to 273 mm at Scott Creek, and 39 to 315 mm at Wildfire Creek. Total annual adjusted precipitation at the Brucejack Lake station was 1,968 mm for 2010, 1,627 mm for 2011, and 1,129 mm for 2012. Total annual precipitation for Scott Creek station was 1,404 mm and 1,073 mm for 2011 and 2012, respectively. Total annual precipitation for Wildfire Creek station was 827 mm in 2012, without gap-filling. It is suspected that a snow bridge formed on the GEONOR sensor at the Wildfire Creek station on November 18, 2012 and therefore, data are considered missing from that time until the end of the year.

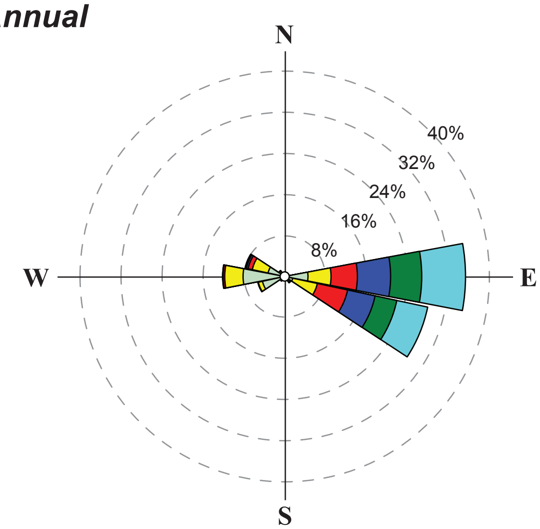
Wind blew predominantly from the east to east-southeast at the Brucejack Lake station with wind speeds exceeding 6 metres per second (m/s) approximately 45% of the time and exceeding 11 m/s approximately 15% of the time over the three full-year data periods (2010 through 2012). While winds blew from the east and east-southeast over 75% of the time during the winter (October to April), they only blew from these directions approximately 49% of the time during the summer (May to September) as shown in Figure 7.3-3.

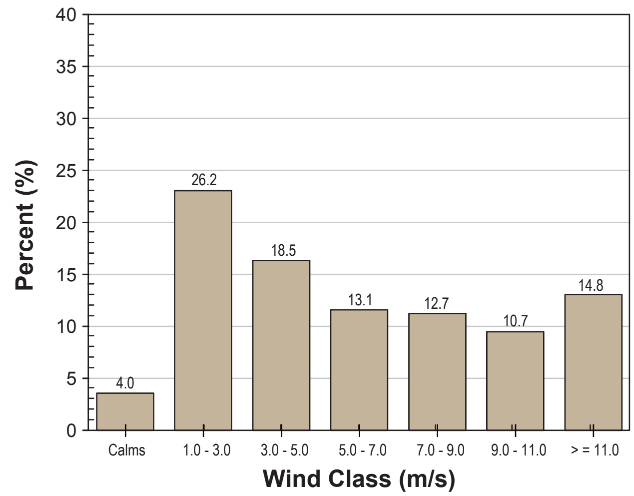
At the Scott Creek station, wind blew predominately from the north and the southwest, with wind speeds exceeding 6 m/s less than 2% of the time (Figure 7.3-4). Wind speeds at the Wildfire Creek station were less than 1 m/s approximately 23% of the time while at the Brucejack Lake station were only 4% of the time (Figure 7.3-5).

Figure 7.3-3

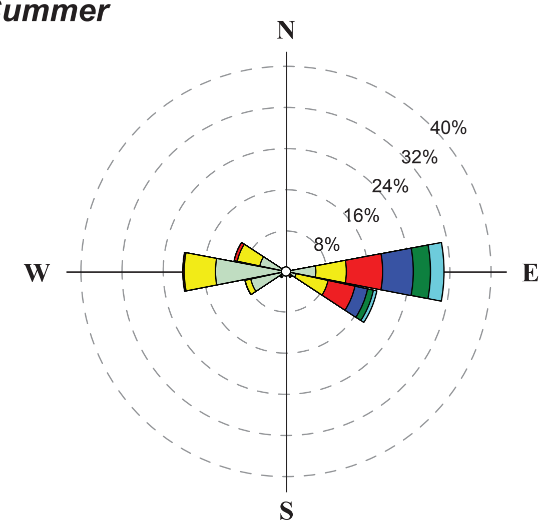
Brucejack Lake Annual, Summer, and Winter Windroses, 2010 to 2012

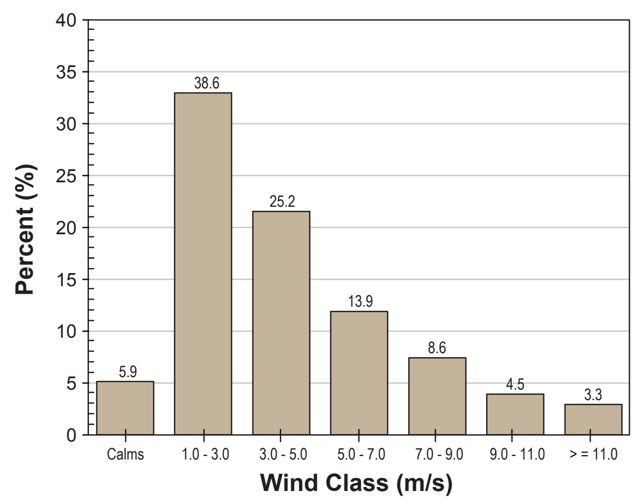
Annual



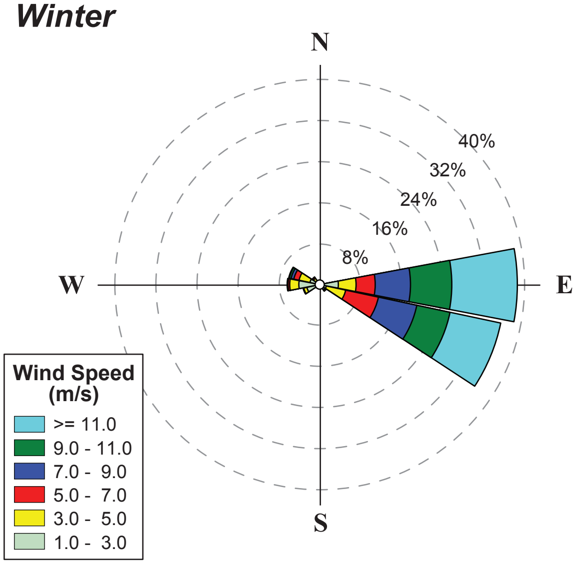


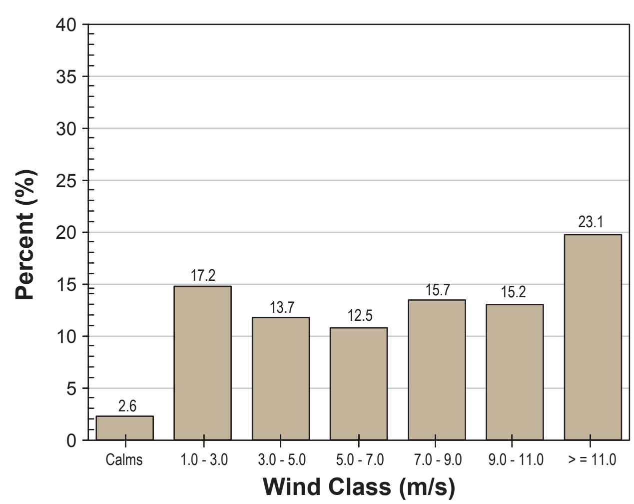
Summer





Winter



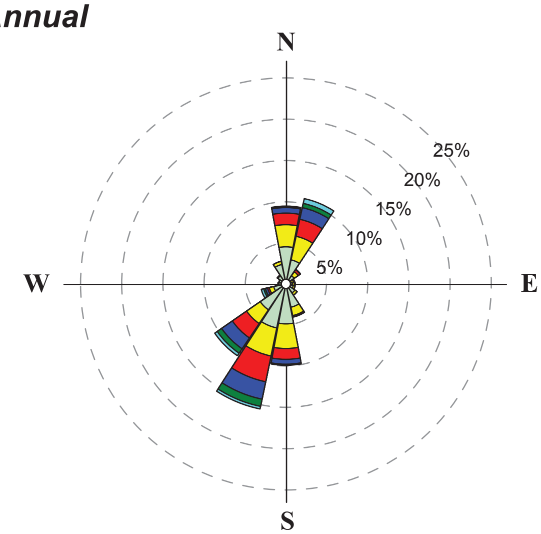


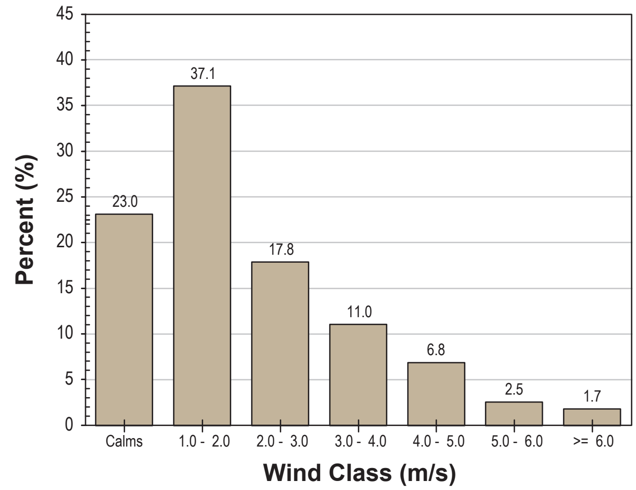
Note: Wind flow is FROM the directions shown. Calms are hourly average wind speeds less than 1 m/s.

Figure 7.3-4

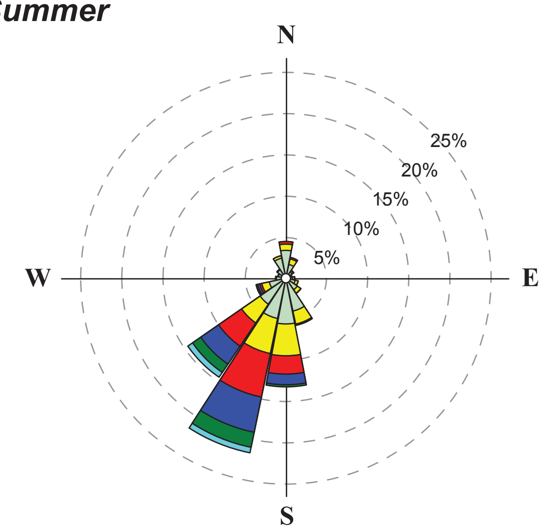
Scott Creek Annual, Summer, and Winter Windroses, 2011 to 2012

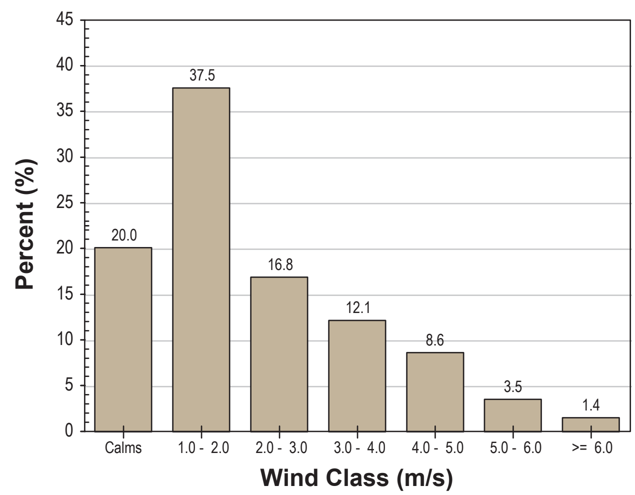
Annual



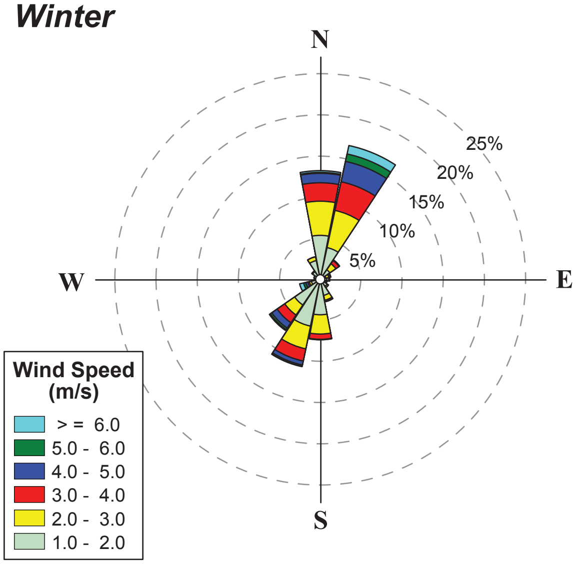


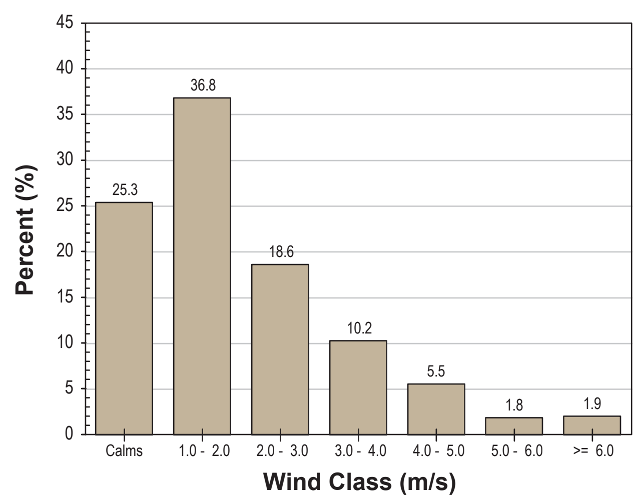
Summer





Winter

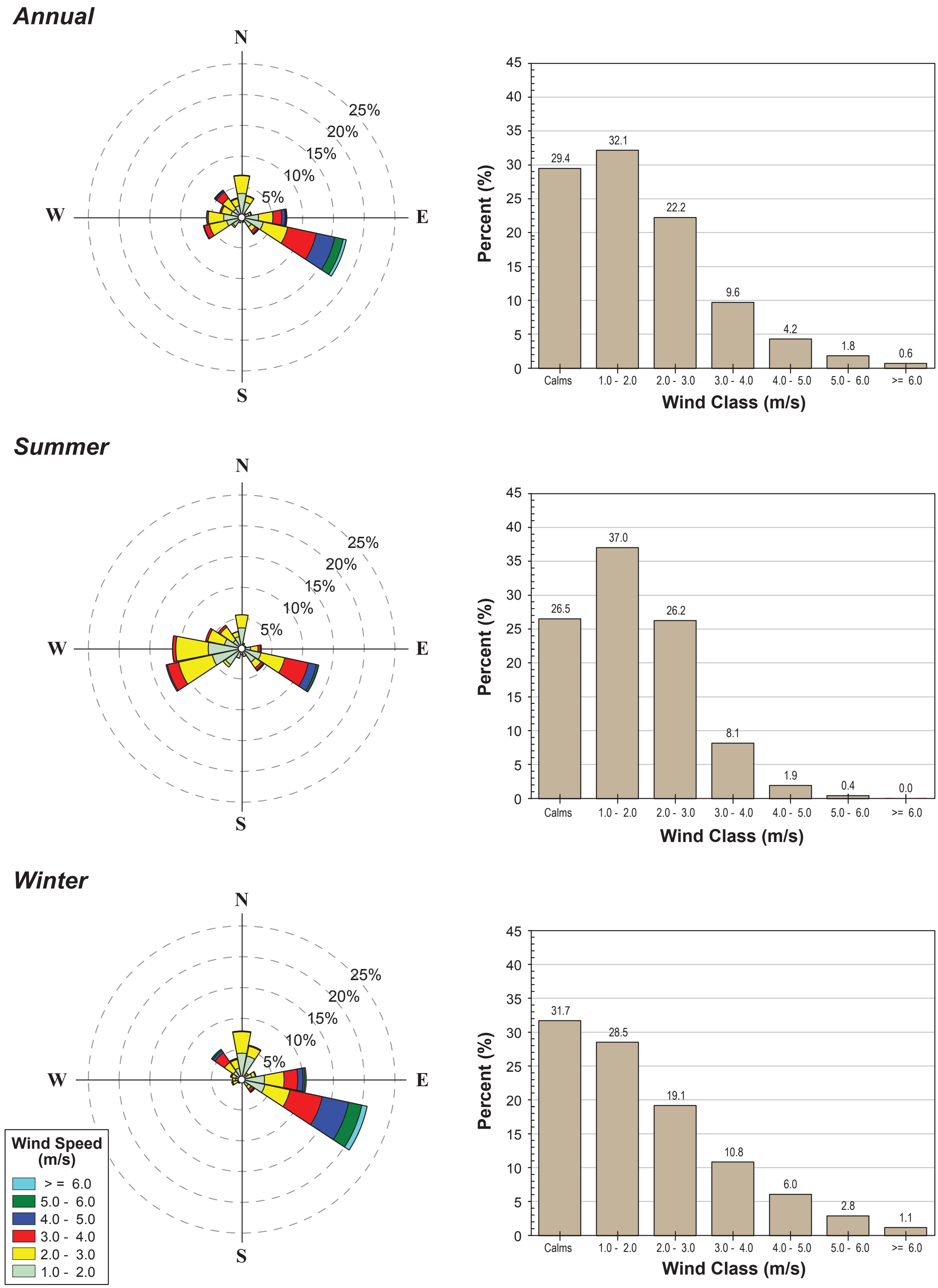




Note: Wind flow is FROM the directions shown. Calms are hourly average wind speeds less than 1 m/s.

Figure 7.3-5

Wildfire Creek Annual, Summer, and Winter Windroses, 2011 to 2012



Note: Wind flow is FROM the directions shown. Calms are hourly average wind speeds less than 1 m/s.

7.3.4.2 Air Quality

Data collection methods can generally be classified as active or passive. Active methods require air to be pumped through collection or analytical devices and require continuous power supplies. If the power to the active sampling device is supplied by a generator, the collected data could potentially be affected by fuel combustion exhaust. The power generator would also require refuelling on a regular basis. For these reasons, active sampling is often not practical in remote areas without electric power supply, which is the case for this Project. Due to the remoteness of the Project area, ambient monitoring for suspended particulate was not conducted. As described in the BC Model Guideline (BC MOE 2008), other monitoring data from areas with similar sources and meteorology may be used if no representative ambient data are available for the site in question. Data presented in the Data Sources section will be used to determine representative background concentrations for the Project.

The results of SO_2, NO_2, and O_3 measurements by the two PASS samplers, expressed as 30-day averages, are summarized in Table 7.3-3. Since there is currently no air quality objective or standard for Canada or BC with a 30-day averaging period, representative background concentrations with hourly, daily, and annual averaging periods are still required for SO_2 and NO_2. Note that due to improper sampling preparation, July data were voided.

Table 7.3-3. Ambient Concentrations of SO_2, NO_2, and O_3

	Concentration (µg/m³)					
	PASS1			PASS2		
Period	**SO_2**	**NO_2**	**O_3**	**SO_2**	**NO_2**	**O_3**
August 2012	<0.26	<0.19	21.60	<0.26	0.38	57.33
September 2012	<0.26	<0.19	18.65	<0.26	7.90	Missing[a]
Average	**0.13**	**0.09**	**20.12**	**0.13**	**4.14**	**57.33**

Note: Values below detection limits were assumed to be half of the detection limit in the calculation of averages.
[a] O_3 canister was found to be missing from the PASS shelter.

The only available 1-hour and 24-hour SO_2 concentrations (4.0 µg/m³) are from Diavik (Table 7.3-1). Comparing the Project 30-day average SO_2 concentration of 0.13 µg/m³ to the annual concentrations of 2.3 and 2.0 µg/m³ from the Saturna station and Diavik, ambient SO_2 concentrations at the Project area are much lower. The concentrations from Diavik are conservatively assumed to represent the Project area (Table 7.3-4). The 30-day NO_2 concentrations of 0.09 µg/m³ was measured at the Project's proposed Mine Site while the concentration of 4.1 µg/m³ was measured within 5 km from Highway 37. In comparison with the background concentrations from Diavik, the NO_2 concentrations at the Project area would also have been much lower. The concentrations from Diavik are conservatively assumed to represent the Project area.

Table 7.3-4. Summary of Ambient Air Quality Concentrations Representative of the Project Area

Pollutant	Averaging Period	Baseline Concentration (µg/m³)	Source
SO_2	1-hour	4.0	Diavik
	24-hour	4.0	Diavik
	Annual	2.0	Diavik
NO_2	1-hour	21	Diavik
	24-hour	21	Diavik
	Annual	5.0	Diavik

(continued)

Table 7.3-4. Summary of Ambient Air Quality Concentrations Representative of the Project Area (completed)

Pollutant	Averaging Period	Baseline Concentration (μg/m^3)	Source
CO	1-hour	100	Diavik
	8-hour	100	Diavik
TSP	24-hour	10	Diavik
	Annual	10	Diavik
PM_{10}	24-hour	3.4	Galore
$PM_{2.5}$	24-hour	1.3	Galore
	Annual	1.3	Galore

There are currently no CO ambient concentrations available other than Diavik and therefore the background concentrations from Diavik are assumed to represent the Project area.

For suspended particulates, a wider range of concentration variation was observed between Diavik and Kitsault. Thirty 24-hour samples were collected for Diavik, while for Kitsault the monitoring durations for TSP, PM_{10}, and $PM_{2.5}$ were each approximately 7.5 hours. Due to the short sampling period at Kitsault, data collected from Diavik are deemed to be a more accurate representation of 24-hour average concentrations and are used to represent the Project area. The Diavik study did not provide clear information on whether the PM_{10} concentration was collected or assumed to be the same as TSP. Since the latter is more likely, PM_{10} concentrations from Galore are assumed to be representative of the Project area. Concentrations of $PM_{2.5}$ from Galore are also selected to represent the Project area. With the absence of an available annual $PM_{2.5}$ concentration, the 24-hour $PM_{2.5}$ concentration from Galore is conservatively assumed to represent the Project's $PM_{2.5}$ annual concentration.

Dustfall results from July to September 2012 are summarized in Table 7.3-5. The average dustfall results in the study were in the range of 0.2 to 0.7 mg/dm^2/day, with the exception of DF1 where the average dustfall deposition rate was 1.53 mg/dm^2/day. There were activities related to the construction of an exploration access road approximately 3 km north of DF1 that may be related to the higher dust deposition results. The highest dustfall level recorded was 2.67 mg/dm^2/day in September 2012 at DF1. The average monthly dustfall in the Project area ranged from 0.4 to 0.73 mg/dm^2/day. Comparing dustfall levels monitored at the other remote areas (shown in Table 7.3-2), the dustfall level at the Project area is on the lower side, but within the same range as the other areas.

Table 7.3-5. Total Dustfall Results at Brucejack Gold Mine Project 2012

	Total Dustfall (mg/dm^2/day)						
Period	**DF1**	**DF2**	**DF3**	**DF4**	**DF5**	**DF6**	**Average**
July 2012	1.27	1.22	0.78	0.33	0.22	0.29	**0.69**
August 2012	0.66	0.55	0.54	0.25	0.19	0.23	**0.40**
September 2012	2.67	0.43	0.37	0.24	0.14	0.52	**0.73**
Average	**1.53**	**0.73**	**0.56**	**0.27**	**0.18**	**0.35**	**-**

The BC Model Guideline (BC MOE 2008) states that if there is more than one representative monitoring site, an acceptable approach is to take the 98th percentile of each site and then take the average of these values to be used as a background level. Since the dustfall level from DF1 in September 2012 may have been affected by local activities, the result is removed when determining the background level to be used with dispersion modelling results. The 98th percentile dustfall rate for each station was calculated and the average value was found to be 0.71 $mg/dm^2/day$.

Acid deposition is the end product of the reaction between sulphur oxides (SO_X), nitrogen oxides (NO_X), and water in the atmosphere. These compounds can be converted to sulphuric acid and nitric acid by reacting with oxygen and water in the air. Acid deposition occurs when these acid-forming pollutants are deposited on the earth's surface. Nitrate and sulphate contents were analyzed as part of the dustfall laboratory analysis.

Acid deposition critical load is a quantitative estimate of an exposure to one or more acid-generating pollutants below which significant harmful effects on specific sensitive elements of the environment do not occur according to present knowledge (Environment Canada 2004). Since nitrate and sulphate have different molecular weights, acid load is calculated using conversions based on charge equivalency. The results are summarized in Table 7.3-6. Generally, the acid deposition rate in the Project area was between 47 and 178 equivalency per hectare per year (eq/ha/year), with the median ranging from 52 to 113 eq/ha/year. The average median load across six dustfall sampling locations was 79 eq/ha/year.

Table 7.3-6. Calculated Acid Deposition Load

	Acid Deposition Load (eq/ha/year)						
Period	**DF1**	**DF2**	**DF3**	**DF4**	**DF5**	**DF6**	**Median**
July 2012	103	60	52	80	87	113	**83**
August 2012	79	59	47	84	86	77	**78**
September 2012	76	77	52	84	77	178	**77**
Median	**79**	**60**	**52**	**84**	**86**	**113**	**-**

Note: value below detection limit is assumed to be half of detection limit in the calculation from rate to equivalency.

7.4 ESTABLISHING THE SCOPE OF THE PREDICTIVE STUDY

This section includes a description of the scoping process used to identify potentially-affecting intermediate components that are a pathway to other receptor Valued Components (VCs), and to select assessment boundaries. Scoping is fundamental to focusing the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS) on those issues where there is the greatest potential to cause significant adverse effects. The scoping process for the assessment of air quality consisted of the following three steps:

- *Step 1:* scoping process to select intermediate components, sub-components, and indicators based on a consideration of the Project's potential to interact with and/or change air quality;
- *Step 2:* consideration of feedback on the results of the scoping process; and
- *Step 3:* defining assessment boundaries for air quality.

These steps are described in detail below.

7.4.1 Selecting Intermediate Components

Issues scoping is undertaken to focus the Application/EIS on the issues of highest concern. To be considered for assessment, a component must be of recognized importance to society, the local community, or the environmental system, and there must be a perceived likelihood that the component will be affected by the proposed Project. Intermediate components are specific attributes of the biophysical environment that if changed (i.e., there is a positive or negative change in the baseline condition), act as a pathway to pass on those changes to other components of the environment, thereby having the potential to also affect or change the baseline condition of receptor VCs. Intermediate components are scoped during consultation with key stakeholders, including Aboriginal communities and the EA Working Group[1]. Consideration of certain components may also be a legislated requirement, or known to be a concern because of previous project experience.

Air quality was identified as an intermediate component as a result of the scoping process, with changes to the following CACs identified as air quality indicators:

- NO_2;
- SO_2;
- CO;
- TSP;
- PM_{10};
- $PM_{2.5}$;
- dustfall; and
- acid deposition.

A description of potential changes of the Project on air quality, relevant mitigation measures, and predicted changes to air quality are provided in this chapter. The determination of significance of changes to air quality is considered in:

- Chapter 10, Surface Water Hydrology Predictive Study;
- Chapter 11, Terrain and Soils Predictive Study;
- Chapter 13, Assessment of Potential Surface Water Quality Effects;
- Chapter 16, Assessment of Potential Terrestrial Ecology Effects;
- Chapter 17, Assessment of Potential Wetlands Effects;
- Chapter 18, Assessment of Potential Wildlife Effects; and
- Chapter 21, Assessment of Potential Health Effects.

Air quality can directly result in change in soil and vegetation quality and terrestrial ecology. Change in vegetation would affect wildlife and also consequently change the quality of country foods. Dust deposition can alter water quality and wetlands. Degradation of air quality can also directly affect human health through inhalation.

7.4.1.1 Potential Interactions between the Project and Intermediate Components

As described in Chapter 6, Assessment Methodology, a scoping exercise was conducted during the development of a draft Application Information Requirements to explore potential Project interactions with candidate intermediate components and receptor VCs, and to identify the key potential adverse

[1] The EA Working Group is a forum for discussion and resolution of technical issues associated with the proposed Project, as well as providing technical advice to the BC EAO and CEA Agency, which remain ultimately responsible for determining significance. It comprises representatives of provincial, federal, and local government, and Aboriginal groups.

effects associated with these interactions. The results of the scoping exercise were circulated for review and comment by the EA Working Group, and feedback from that process has been integrated into the Application/EIS.

Table 7.4-1 provides an impact scoping matrix of Project components and physical activities that have a possible or likely interaction with air quality. A full impact scoping matrix for all candidate intermediate and receptor VCs is provided in Table 6.4-1 in Chapter 6, Assessment Methodology.

Interactions between the Project and air quality were assigned a colour code as follows:

- not expected (white);
- possible (grey); and
- likely (black).

Table 7.4-1. Interaction of Project Components and Physical Activities with Air Quality

Project Components and Physical Activities by Phase	Air Quality
Construction Phase	
Activities at existing adit	
Air transport of personnel and goods	
Avalanche control	
Chemical and hazardous material storage, management, and handling	
Construction of back-up diesel power plant	
Construction of Bowser Aerodrome	
Construction of detonator storage area	
Construction of electrical tie-in to BC Hydro grid	
Construction of electrical substation at mine site	
Construction of equipment laydown areas	
Construction of helicopter pad	
Construction of incinerators	
Construction of Knipple Transfer Area	
Construction of local site roads	
Construction of mill building (electrical induction furnace, backfill paste plant, warehouse, mill/concentrator)	
Construction of mine portal and ventilation shafts	
Construction of Brucejack Operations Camp	
Construction of ore conveyer	
Construction of tailings pipeline	
Construction and decommissioning of Tide Staging Area construction camp	
Construction of truck shop	
Construction and use of sewage treatment plant and discharge	
Construction and use of surface water diversions	
Construction of water treatment plant	
Development of the underground portal and facilities	
Employment and Labour	

(continued)

Table 7.4-1. Interaction of Project Components and Physical Activities with Air Quality (continued)

Project Components and Physical Activities by Phase	Air Quality
Construction Phase *(cont'd)*	
Equipment maintenance/machinery and vehicle refueling/fuel storage and handling	
Explosives storage and handling	
Grading of the mine site area	
Helicopter use	
Installation and use of Project lighting	
Installation of surface and underground crushers	
Installation of transmission line and associated towers	
Machinery and vehicle emissions	
Potable water treatment and use	
Pre-production ore stockpile construction	
Procurement of goods and services	
Quarry construction	
Solid waste management	
Transportation of workers and materials	
Underground water management	
Upgrade and use of exploration access road	
Use of Granduc access road	
Operation Phase	
Air transport of personnel and goods and use of aerodrome	
Avalanche control	
Backfill paste plant	
Back-up diesel power plant	
Bowser Aerodrome	
Brucejack Access Road use and maintenance	
Brucejack Operations Camp	
Chemical and hazardous material storage, management, and handling	
Concentrate storage and handling	
Contact water management	
Detonator storage	
Discharge from Brucejack Lake	
Electrical induction furnace	
Electrical substation	
Employment and Labour	
Equipment laydown areas	
Equipment maintenance/machine and vehicle refueling/fuel storage and handling	
Explosives storage and handling	
Helicopter pad(s)	
Helicopter use	
Knipple Transfer Area	

(continued)

Table 7.4-1. Interaction of Project Components and Physical Activities with Air Quality (continued)

Project Components and Physical Activities by Phase	Air Quality
Operation Phase (*cont'd*)	
Machine and vehicle emissions	
Mill building/concentrators	
Non-contact water management	
Ore conveyer	
Potable water treatment and use	
Pre-production ore storage	
Procurement of goods and services	
Project lighting	
Quarry operation	
Sewage treatment and discharge	
Solid waste management/incinerators	
Subaqueous tailings disposal	
Subaqueous waste rock disposal	
Surface crushers	
Tailings pipeline	
Truck shop	
Transmission line operation and maintenance	
Underground backfill tailings storage	
Underground backfill waste rock storage	
Underground crushers	
Underground: drilling, blasting, excavation	
Underground explosives storage	
Underground mine ventilation	
Underground water management	
Use of mine site haul roads	
Use of portals	
Ventilation shafts	
Warehouse	
Waste rock transfer pad	
Water treatment plant	
Closure Phase	
Air transport of personnel and goods	
Avalanche control	
Chemical and hazardous material storage, management, and handling	
Closure of mine portals	
Closure of quarry	
Closure of subaqueous tailings and waste rock storage (Brucejack Lake)	
Decommissioning of Bowser Aerodrome	
Decommissioning of back-up diesel power plant	

(continued)

Table 7.4-1. Interaction of Project Components and Physical Activities with Air Quality (completed)

Project Components and Physical Activities by Phase	Air Quality
Closure Phase (*cont'd*)	
Decommissioning of Brucejack Access Road	Grey
Decommissioning of camps	Grey
Decommissioning of diversion channels	Grey
Decommissioning of equipment laydown	Grey
Decommissioning of fuel storage tanks	Grey
Decommissioning of helicopter pad(s)	Grey
Decommissioning of incinerators	Grey
Decommissioning of local site roads	Grey
Decommissioning of Mill Building	Grey
Decommissioning of ore conveyer	Grey
Decommissioning of Project lighting	Grey
Decommissioning of sewage treatment plant and discharge	Grey
Decommissioning of surface crushers	Grey
Decommissioning of surface explosives storage	Grey
Decommissioning of tailings pipeline	Grey
Decommissioning of transmission line and ancillary structures	Grey
Decommissioning of underground crushers	Grey
Decommissioning of waste rock transfer pad	Grey
Decommissioning of water treatment plant	Grey
Employment and Labour	White
Helicopter use	Grey
Machine and vehicle emissions	Grey
Procurement of goods and services	White
Removal or treatment of contaminated soils	Grey
Solid waste management	Grey
Transportation of workers and materials (Mine Site and access roads)	Grey
Post-closure Phase	
Discharge from Brucejack Lake	White
Employment and Labour	White
Environmental monitoring	White
Procurement of goods and services	White
Subaqueous tailings and waste rock storage	White
Underground mine	White

Notes:
White = interaction not expected between Project components/physical activities and an intermediate VC
Grey = possible interaction between Project components/physical activities and an intermediate VC
Black = likely interaction between Project components/physical activities and an intermediate VC

Interactions coded as not expected (white) are considered to have no potential for adverse effects on a VC/indicator, and are not considered further.

7.4.1.2 Consultation Feedback on Intermediate Components

Air quality was not explicitly raised as a concern or issue during consultation and engagement; however, air quality was identified in the EIS Guidelines and Application Information Requirements in order to support the assessments of other receptor VCs.

The Brucejack Gold Mine Project Air Quality Conceptual Model Plan (Appendix 7-C) was prepared in August 2013 after discussion with the BC MOE in February 2013. The Model Plan outlines the scope of the dispersion model, including the sources and pollutants to be modelled, as well as the approach in dispersion model of these sources. Comments from the ministry were received in September 2013 and addressed on February 26, 2014. The model plan was approved on March 17, 2014.

7.4.1.3 Summary of Intermediate Components Included/Excluded in the Application/EIS

Table 7.4-2 summarizes the results of the impact-matrix and consultation feedback. Air quality was identified as an intermediate component that will be changed by many of the Project components as listed in Table 7.4-1. The Aboriginal Group, Government, and Public/Stakeholders are interested in the changes on the intermediate component. As air quality is the only intermediate component identified, no other intermediate component was excluded from this assessment.

Table 7.4-2. Air Quality Intermediate Components Included in the Application/EIS

Intermediate Component	Identified by*				Rationale for Inclusion
	AG	G	P/S	IM	
Air Quality		X		X	Air quality is a concern in general for all human health as well as effects to the environment. Air quality was identified in the EIS Guidelines and Application Information Requirements in order to support the assessment of other receptor VCs.

**AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder; IM = Impact Matrix*

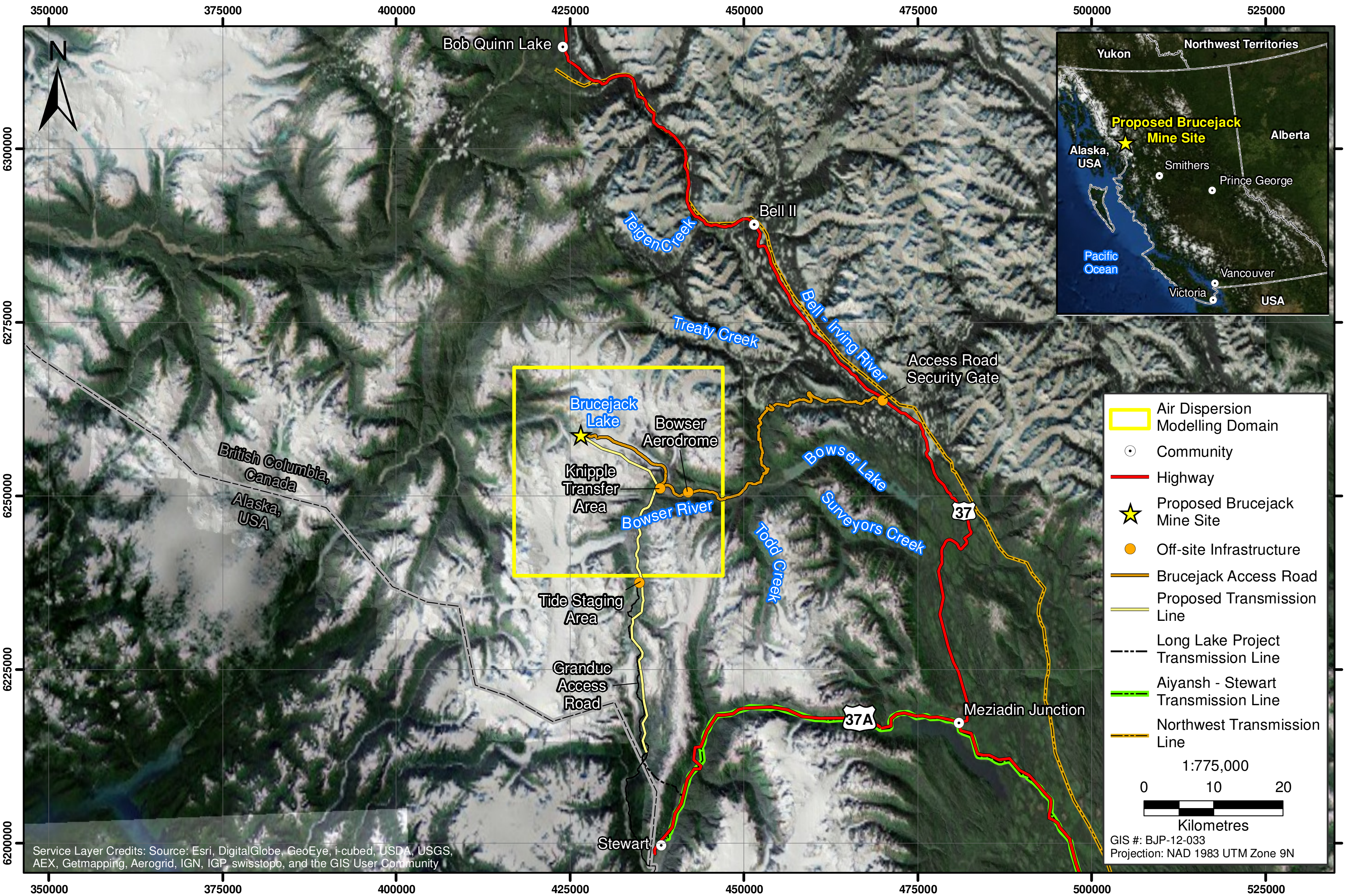
7.4.2 Predictive Study Boundaries

Assessment boundaries define the maximum limit within which the predictive study is conducted. They encompass the areas within and times during which the Project is expected to interact with the intermediate components, as well as the constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these boundaries is an integral part of the assessment process for air quality. The definition of study boundaries encompasses all possible direct, indirect, and induced changes on air quality, as well as the trends in processes that may be relevant.

7.4.2.1 Spatial Boundaries

The Regional Study Area (RSA) for this study is defined as the model domain where dispersion modelling will be conducted. The RSA is a 30 km by 30 km square centred at the Brucejack Mine Site (Figure 7.4-1). This area is expected to be sufficiently large to include all isopleths that represent 10% of the air quality objectives. A Local Study Area (LSA), typically defined as the footprint plus a buffer distance, is not defined for this assessment. The fence line of the Project is defined as the perimeter of disturbed area where public access is restricted. A gate will be placed at the Highway 37 entrance to the access road. The fence lines defined for the three main components of the Project (Brucejack Mine Site, Knipple Transfer Area, and Bowser Aerodrome) are rectangles approximately 500 m from the Project infrastructure.

Figure 7.4-1
Brucejack Air Dispersion Modelling Domain



During consultation with the BC MOE (B. Weinstein, pers. comm.), it was discussed that traffic on the unpaved Brucejack Access Road is expected to be relatively low, with emissions addressed through appropriate fugitive dust mitigation management plans. However, in order to be thorough in the assessment, the emissions associated with the traffic along the access road within the RSA are included in the assessment, including road dust. The BC MOE had also agreed that modelling is not required along the proposed transmission line route since the transmission line operation will not be a source of emissions. During the Construction phase, emissions associated with the transmission line will also be temporal and sporadic and no stationary source was planned.

7.4.2.2 Temporal Boundaries

A temporal boundary is the period of time when the Project has an effect on the environment. The temporal boundaries per phase of the Project include the following:

- Construction: 2 years;
- Operation: 22 year run-of-mine life;
- Closure: 2 years (includes project decommissioning, abandonment, and reclamation activities); and
- Post-closure: minimum of 3 years (includes ongoing reclamation activities and post-closure monitoring).

7.4.3 Identifying Key Potential Effects on Air Quality

The only change considered in this chapter is air quality. The purpose of this section is to identify the key project components and physical activities that will potentially change air quality (Table 7.4-3).

Table 7.4-3. Ranking Potential Effects on Air Quality

Project Components and Physical Activities by Phase	Air Quality
Construction Phase	
Activities at existing adit	● (green)
Air transport of personnel and goods	● (yellow)
Avalanche control	● (green)
Chemical and hazardous material storage, management, and handling	○
Construction of back-up diesel power plant	● (yellow)
Construction of Bowser Aerodrome	● (yellow)
Construction of detonator storage area	● (yellow)
Construction of electrical tie-in to BC Hydro grid	● (green)
Construction of electrical substation at mine site	● (yellow)
Construction of equipment laydown areas	● (yellow)
Construction of helicopter pad	● (yellow)
Construction of incinerators	● (yellow)
Construction of Knipple Transfer Area	● (yellow)
Construction of local site roads	● (yellow)
Construction of mill building (electrical induction furnace, backfill paste plant, warehouse, mill/concentrator)	● (yellow)
Construction of mine portal and ventilation shafts	● (yellow)

(continued)

Table 7.4-3. Ranking Potential Effects on Air Quality (continued)

Project Components and Physical Activities by Phase	Air Quality
Construction Phase (*cont'd*)	
Construction of Brucejack Operations Camp	🟡
Construction of ore conveyer	🟡
Construction of tailings pipeline	🟡
Construction and decommissioning of Tide Staging Area construction camp	🟡
Construction of truck shop	🟡
Construction and use of sewage treatment plant and discharge	🟡
Construction and use of surface water diversions	🟡
Construction of water treatment plant	🟡
Development of the underground portal and facilities	🟡
Employment and Labour	○
Equipment maintenance/machinery and vehicle refuelling/fuel storage and handling	○
Explosives storage and handling	○
Grading of the mine site area	🟡
Helicopter use	🟡
Installation and use of Project lighting	🟢
Installation of surface and underground crushers	🟢
Installation of transmission line and associated towers	🟢
Machinery and vehicle emissions	🟡
Potable water treatment and use	○
Pre-production ore stockpile construction	🟡
Procurement of goods and services	○
Quarry construction	🟡
Solid waste management	🟢
Transportation of workers and materials	🟡
Underground water management	○
Upgrade and use of exploration access road	🟡
Use of Granduc Access Road	🟡
Operation Phase	
Air transport of personnel and goods and use of aerodrome	🟡
Avalanche control	🟢
Backfill paste plant	○
Back-up diesel power plant	🟢
Bowser Aerodrome	○
Brucejack Access Road use and maintenance	🟡
Brucejack Operations Camp	○
Chemical and hazardous material storage, management, and handling	○
Concentrate storage and handling	🟡
Contact water management	○

(continued)

Table 7.4-3. Ranking Potential Effects on Air Quality (continued)

Project Components and Physical Activities by Phase	Air Quality
Operation Phase (*cont'd*)	
Detonator storage	○
Discharge from Brucejack Lake	○
Electrical induction furnace	● (yellow)
Electrical substation	○
Employment and Labour	○
Equipment laydown areas	○
Equipment maintenance/machine and vehicle refueling/fuel storage and handling	○
Explosives storage and handling	○
Helicopter pad(s)	○
Helicopter use	● (yellow)
Knipple Transfer Area	● (yellow)
Machine and vehicle emissions	● (yellow)
Mill building/concentrators	● (yellow)
Non-contact water management	○
Ore conveyer	● (yellow)
Potable water treatment and use	○
Pre-production ore storage	○
Procurement of goods and services	○
Project lighting	○
Quarry operation	● (green)
Sewage treatment and discharge	○
Solid waste management/incinerators	● (yellow)
Subaqueous tailings disposal	○
Subaqueous waste rock disposal	○
Surface crushers	● (yellow)
Tailings pipeline	○
Truck shop	○
Transmission line operation and maintenance	○
Underground backfill tailings storage	○
Underground backfill waste rock storage	○
Underground crushers	● (yellow)
Underground: drilling, blasting, excavation	● (yellow)
Underground explosives storage	○
Underground mine ventilation	● (yellow)
Underground water management	○
Use of mine site haul roads	● (yellow)
Use of portals	● (green)
Ventilation shafts	○

(continued)

Table 7.4-3. Ranking Potential Effects on Air Quality (continued)

Project Components and Physical Activities by Phase	Air Quality
Operation Phase (*cont'd*)	
Warehouse	○
Waste rock transfer pad	○
Water treatment plant	○
Closure Phase	
Air transport of personnel and goods	●
Avalanche control	●
Chemical and hazardous material storage, management, and handling	○
Closure of mine portals	○
Closure of quarry	●
Closure of subaqueous tailings and waste rock storage (Brucejack Lake)	○
Decommissioning of Bowser Aerodrome	●
Decommissioning of back-up diesel power plant	●
Decommissioning of Brucejack Access Road	●
Decommissioning of camps	●
Decommissioning of diversion channels	●
Decommissioning of equipment laydown	●
Decommissioning of fuel storage tanks	●
Decommissioning of helicopter pad(s)	●
Decommissioning of incinerators	●
Decommissioning of local site roads	●
Decommissioning of Mill Building	●
Decommissioning of ore conveyer	●
Decommissioning of Project lighting	●
Decommissioning of sewage treatment plant and discharge	●
Decommissioning of surface crushers	●
Decommissioning of surface explosives storage	●
Decommissioning of tailings pipeline	●
Decommissioning of transmission line and ancillary structures	●
Decommissioning of underground crushers	●
Decommissioning of waste rock transfer pad	●
Decommissioning of water treatment plant	●
Employment and Labour	○
Helicopter use	●
Machine and vehicle emissions	●
Procurement of goods and services	○
Removal or treatment of contaminated soils	●
Solid waste management	●
Transportation of workers and materials (Mine Site and access roads)	●

(continued)

Table 7.4-3. Ranking Potential Effects on Air Quality (completed)

Project Components and Physical Activities by Phase	Air Quality
Post-closure Phase	
Discharge from Brucejack Lake	○
Employment and Labour	○
Environmental monitoring	○
Procurement of goods and services	○
Subaqueous tailings and waste rock storage	○
Underground mine	○

Notes:
○ = No interaction anticipated.
● = Negligible to minor adverse effect expected; implementation of best practices, standard mitigation, and management measures; no monitoring required, no further consideration warranted.
● = Potential moderate adverse effect requiring unique active management/monitoring/mitigation; warrants further consideration.
● = Key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.

7.4.3.1 Construction

The main sources of air emissions during the Construction phase are fuel combustion in equipment and machinery, vehicles, and helicopters used for the construction of the Project components. The main sources of fugitive dust are from use of the access road, and transport of the waste rock, ore, and overburden.

7.4.3.2 Operation

During the Operation phase, the main sources of emissions are from fuel combustion in equipment and machinery, vehicles, and helicopters used for the operation of the Project. Note that helicopter usage has been included in the model but the usage is limited primarily for emergency purposes. Exhaust from underground equipment is also emitted through the portals from the underground mine. Fugitive dust emissions from the road, transport of waste rock, ore, and overburden during the mining operation and other ore processes are the main sources of dust.

7.4.3.3 Closure

During the Closure phase, decommissioning of components that are sources of fugitive emissions and tailpipe emissions from equipment are the main non-fugitive sources. The emissions during the Closure phase are expected to be limited and intermittent.

7.4.3.4 Post-closure

During the Post-closure phase, no significant source of emissions is expected. There may be vehicle tailpipe emissions during the maintenance of environmental monitoring equipment; however, the emissions are considered negligible compared to emissions during the Construction and Operation phases.

Since the Project changes on air quality during the Closure and Post-closure phases will be limited and intermittent, changes in air quality during these phases are expected to be much less than during the Construction and Operation phases. For this reason, the air quality predictive study focuses on the Construction and Operation phases of the Project when the majority of emissions will occur.

7.5 PREDICTIVE STUDY METHODS FOR AIR QUALITY

In this section, predictive changes from Project components on air quality, including mitigation measures already incorporated in the Project design (see Section 7.7), are assessed using quantitative methods. The assessment:

- estimates the Project-related emissions within the RSA originating from Project components and activities;
- predicts the dispersal of Project-related emissions through the atmosphere, using quantified dispersion modelling;
- adds the predicted incremental concentrations/deposition rates to baseline levels to determine predicted air quality concentrations with the Project in place; and
- compares the predicted concentrations and deposition rates at key locations with relevant air quality criteria.

7.5.1 Air Emission Inventory

An air emission inventory was prepared for the major sources within the RSA. Emissions were estimated using the best available data for the Construction and Operation phases. Since the Construction phase is expected to last two years, the assessment of the Construction phase captures the worst case by conservatively assuming periodic activities such as blasting will be completed in one year. During the Operation phase, the production rate and activity levels are not expected to vary significantly year by year; therefore, the emissions included in the assessment of the Operation phase is representative of the entire 22 years of operation.

7.5.1.1 Construction

During the Construction phase, there are five main mining or development activities that are sources of air emissions:

- generators and incinerators;
- mining equipment and vehicle tailpipe emissions;
- helicopters;
- road dust; and
- other mining activities such as bulldozing and blasting.

<u>Generators and Incinerators</u>

Before the Project is connected to the transmission line at Long Lake Hydro Substation, the Brucejack Mine Site, Knipple Transfer Area, and Bowser Aerodrome require diesel generators. For the assessment, each generator is assumed to be 500 kilowatts (kW). There will be two at the Brucejack Mine Site, two at the Knipple Transfer Area, and one at the Bowser Aerodrome. The generator emissions were estimated based on the NONROAD model. US EPA has developed the NONROAD2008 model to provide emission factors for creating accurate and reproducible non-road emission inventories. NONROAD2008 provides emission estimates based on fuel-use in a diverse collection of vehicles and equipment. The load factor for generators of 0.43 was taken from NONROAD2008. To be conservative, the generators were assumed to be operating 24 hours a day and 365 days a year. See Table 7.6-1 for the annual emission rates.

There will be one incinerator at the Brucejack Mine Site in order to incinerate camp waste. In the current design, the camp will have a capacity of 440 workers (Chapter 5, Project Description, Table 5.16-1). Camp incinerator emissions were estimated based on information from the Snap Lake Diamond Mine EIS (De Beers 2001), which uses a camp incinerator model CA-600 from EcoWaste Solution for a camp size of 260 people. From the emission factor estimated, based on the Snap Lake Diamond Mine's incinerator, emissions from the Brucejack Camp were calculated. See Table 7.6-1 for emissions from diesel generators and the camp incinerators.

Mining Equipment

In this section, mining equipment includes all equipment used for this Project except stacks and aircraft. This may include mobile and non-mobile equipment such as water trucks, drills, and dozers. Emissions from mining equipment were determined based on horsepower rating, utilization factor for each piece of equipment, and emission factors from the NONROAD2008 model. See Table 7.6-2 for a summary of exhaust tailpipe emissions from each piece of equipment. Various pieces of equipment on the list also contribute to fugitive dust emissions. Although the planned working days in a year during Construction is 312 days, it is assumed that activities will occur 365 days in a year to capture the worst hour and worst day in a year. Note that purpose-designed vehicles for winter conditions were conservatively assumed to be used throughout the year.

Helicopters

Helicopter emissions were estimated based on the emission factors for average aircraft (domestic average fleet) for each landing and takeoff (IPCC 2000). However, suspended dust emissions are not available in the report. Emission factors for $PM_{2.5}$ were obtained from US EPA (B. Maeroff, pers. comm.). Emission factors for TSP and PM_{10} were estimated using the California Emission Inventory and Report System speciation profile for aircraft. During the Construction phase, it was assumed that there will be five trips per day. See Table 7.6-3 for the total annual emissions from helicopters.

Road Dust

In addition to tailpipe emissions due to fuel combustion, vehicles also create fugitive dust in a process known as entrainment. When vehicles travel on an unpaved surface, the force of the wheels on the road surface causes pulverization of the surface material. Particles are then lifted and dropped from the rolling wheels, and the turbulent wake behind the vehicle continues to act on the airborne particles and road surface after the vehicle has passed. Equipment units whose main function is to transport materials are included in the fugitive road dust estimation (see Table 7.6-4). Vehicle speeds on unpaved roads were assumed to be between 15 to 30 km/hour, depending on the equipment type. Fugitive unpaved road dust emissions at the mine area, transfer station, aerodrome and the access road were estimated based on emission factors in AP-42 Chapter 13.2.2 (US EPA 2006a). Silt content of the road was assumed to be 6.9% for overburden (US EPA 1998). Since the road will be watered to mitigate road dust, the calculation was performed assuming that watering the road will achieve at least a 2% moisture ratio, which will reduce fugitive dust emissions by 75% (US EPA 2006a). Note that this source will only emit fugitive road dust from unpaved dirt road and not from the glacier road. Also, the model did not account for the winter period when the road is frozen or covered in snow and not subject to road dust at all; therefore, estimates of dust from unpaved roads would be overestimates during the winter months. Speeds of large tracked vehicles were modeled at 30 km/hour but they travel at 10 to 15 km/hour, resulting in an overestimation of dust from these vehicles.

Mining Activities

Many mining activities, such as bulldozing, grading, drilling, and blasting cause fugitive dust emissions. Emission factors for dust emissions were obtained from AP-42 Section 11.9 (US EPA 1998). Although this section of AP-42 was prepared for surface coal mines, it provides a more thorough emission factor estimation methodology than other mining sectors and is considered to be a conservative source of emission factors as coal mining operations are typically dustier than metal mining. The emission factors for overburden from this document have often been adopted to represent mining activities. The emission factor for bulldozing has been estimated based on the hours of operation, assuming the moisture content is 7.9% with silt content of 6.9% (US EPA 1998). To be conservative, grading of the access road is assumed to be one trip per day.

Drilling is required to place explosives in the ground. Fugitive dust emissions from drilling were calculated based on emission factors from AP-42 Section 11.9 (US EPA 1998), assuming 300 drill holes per blast, and 230 blasts per year at the Brucejack Mine Site and 70 blasts at the quarry. Since there are no estimated emission factors for PM_{10} and $PM_{2.5}$, speciation ratios from Source 3 in Appendix B.2 of AP-42 (US EPA 1996) that deals with generalized particle size distribution were used. Pollutants emitted from blasting depend on the type of explosives used. Blasting is a source of fugitive dust and emission factors from AP-42 (US EPA 1998) were used assuming each blast affects an area of 700 m^2. The explosives to be used are emulsions of ammonium nitrate. In this calculation, the emissions factors for ammonium nitrate with fuel oil were adopted. For each blast, 8,250 kilograms (kg) of explosive is required at both the Brucejack Mine Site and the quarry. Blasting is not expected to occur year-round during the Construction phase. In the assessment, blasting at the Mine Site is assumed to occur during the first year of construction between July and the following February, while blasting at the quarry during the first year of construction is assumed to occur between March and April.

In order to construct the Brucejack Mine Site, aggregates are required from the quarry borrow source. The rocks obtained from the quarry will be crushed on-site. Since the total amount of aggregate required is 293,510 m^3 with a density of 2.12 tonne/m^3 (3,568 pounds per yard^3 from AP-42 Section 11.9) and an assumed void space of 0.1, the crushing rate is 63,840 kg/hour. The borrow material will be crushed by a primary jaw crusher, screened, and crushed by a secondary cone crusher. Emissions factors from AP-42 Section 11.19 for stone processing operations tertiary crushing were adopted for both the jaw crusher and cone crusher and emission factors for screening are also included (US EPA 2004).

Stockpiles are also sources of fugitive dust emissions. When material is dumped and loaded onto a stockpile, particles are easily disaggregated and released to the atmosphere. Open stockpiles are also subject to wind erosion where particles are blown by high-speed winds. The fastest-mile method is typically used to estimate emissions from open stockpiles using the magnitude of wind gusts (US EPA 2006b). Assuming threshold friction velocity of 1.02 m/s and roughness height of 0.3 centimetres for overburden as suggested by the US EPA, wind erosion occurs only when wind speeds exceed 19.2 m/s at 10 m above ground. Pre-production ore storage is proposed at the Mine Site and also clean aggregate from the quarry will be stockpiled. There are 13 hours in one year of wind speed greater than 19.2 m/s recorded by the Brucejack meteorological station in 2012. There may be wind erosion when fast wind gusts occur; however, the instances are very limited. Emissions from the transfer of material onto the pile will be much more significant and therefore are included in the assessment.

Emissions from aggregate storage operations vary with moisture content and mean wind speed and are based on the amount of material transferred. The total emissions were calculated based on the total amount of aggregate required for the construction of the Brucejack Mine Site (293,510 m^3). See Table 7.6-5 for a summary of emissions associated with mining activities during Construction.

7.5.1.2 Operation

During the Operation phase, there are seven main mining or development activities that are sources of air emissions:

- emissions from underground mining activities through air raises;
- generators and incinerators;
- ore processing;
- mining equipment and vehicle tailpipe emissions;
- helicopters (emergency only);
- road dust; and
- other mining activities such as bulldozing and blasting.

Emissions from Underground Mining Activities through Air Raises

During the Operation phase, most of the mining activities will occur underground. Ore from the underground mine will pass through a primary crusher underground in order to reduce fugitive dust emissions. Emissions from diesel equipment and crushers will be emitted to the air through the air raises. Based on diesel equipment that will operate underground, the concentrations of pollutants from the air raises were provided by AMC Consultants; see Table 7.6-7 for a summary. Emissions of PM_{10} and $PM_{2.5}$ were estimated from TSP using dust speciation from AP-42 Appendix B.2 (US EPA 1996). During hours of blasting, additional pollutants will be emitted through the air raises.

Fugitive dust from underground may also be emitted through air raises. Due to the configuration of the air raises and the nature of fugitive dust, it is likely that the majority of fugitive dust will remain underground. To be conservative, dust concentrations from the underground mine are assumed to be the same as those from a coal mine. Dust concentrations from different areas of underground coal mines were sampled and only a few samples showed concentration above 3 mg/m^3 (Önder et al. 2009). Therefore, the fugitive dust concentration from air raises is assumed to be 3 mg/m^3. Emissions of PM_{10} and $PM_{2.5}$ were estimated based on dust speciation from AP-42 Appendix B.2 (US EPA 1996).

Generators, Incinerators, and Heaters

During the Operation phase, the Brucejack Mine Site will be connected to the Brucejack Transmission Line. In the previous design, the Knipple Transfer Area and Bowser Camp will be using diesel generators. In the current design, workers will be moving to the Knipple Transfer Area during the Operation Phase and the total number of workers expected at the Knipple Transfer Area is not expected to increase from the previous design. The Bowser camp will be decommissioned prior to the Operation phase.

Generators (500 kW each) that operated during the Construction phase will continue to be used at the Knipple Transfer Area during the Operation phase. The model was conducted using the previous design which included one generator at the Bowser Camp which will no longer be a source of emissions. The generator emissions were estimated using the same method described in Section 7.5.1.1 above.

There will be an incinerator at the Brucejack Mine Site. The incinerator emissions in this assessment were estimated based on the camp capacity, including an incinerator at Knipple Camp, however, an incinerator at Knipple Camp is no longer planned. Camp incinerator emissions were estimated using the same method described in Section 7.5.1.1 above. See Table 7.6-8 for a summary of emissions from diesel generators and the camp incinerators.

At the portal air intake, heaters will be installed. The heaters will be hybrid electric and propane heaters operating at 9 million British thermal units per hour each and will only operate if the ambient temperature drops below 2°C. Although the heaters are hybrid and will be partly powered by electricity, they were assessed assuming they were fueled by propane only for worst-case scenario. Emission factors from AP-42 Section 1.5 for liquefied petroleum gas combustion were used for the calculation (US EPA 2008).

Ore Processing

From the underground jaw crusher, ore will be transferred to the surface via transfer conveyor. The material will drop into a mill feed surge bin and be conveyed to the SAG mill followed by a ball mill. Emissions from these processes will be collected by two baghouses. In the refinery process, an electrical induction furnace will be used and a scrubber will be installed to reduce emissions.

Emission levels for baghouses were obtained from the Procedure for Preparing an Emission Summary and Dispersion Modelling Report (Ontario MOE 2009), suggesting 20 mg/m^3 of air can be assumed for the outlet of a baghouse. Emissions of PM_{10} and $PM_{2.5}$ were estimated using speciation from AP-42 Appendix B-2 (US EPA 1996) for fabric filters (see Table 7.6-9)

Electric induction was stated to have negligible emissions for CO and SO_2; therefore, only the NO_X emission factor for electric arc furnaces was used (US EPA 2003). Particulate emission factors for scrubbers were assumed to be the same for TSP, PM_{10}, and $PM_{2.5}$. Sulphur content in the gravity concentrate is approximately 15 to 20%. To be conservative, it is assumed that all sulphur will be converted to SO_2 and discharged to the air with a scrubber control efficiency of 90% (US EPA 2000).

Mining Equipment

Emissions from equipment were determined based on horsepower rating, utilization factor, and emission factors from the NONROAD2008 model. Note that many pieces of equipment, such as snowmobiles, operate only during the winter (approximately October to April), while the water truck only operates during the non-winter season (April to October). In this assessment, it was assumed that all other equipment operates year-round to be conservative. See Table 7.6-10 for a summary of emissions.

Helicopters

The helicopter emissions were estimated using the same method described in the Construction phase emission inventory section assuming three landings and takeoffs per day; see Table 7.6-11 for the total emissions. Note that during the Operation phase, helicopter activities are expected only for emergency purposes but conservatively included in this assessment.

Road Dust

Unpaved road dust during the Operation phase was assessed using the same method described in Section 7.5.1.1 above; see Table 7.6-12 for a summary of the vehicle list.

Mining Activities

During the Operation phase, mining activities such as grading and bulldozing are still sources of fugitive dust emissions (see Table 7.6-13). Drilling and blasting on the surface is not expected. Emissions from underground blasting were accounted for in emissions from the air raises.

7.5.2 Air Emissions Dispersion Modelling

CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model that is capable of simulating the effect of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. In order to perform dispersion modelling using CALPUFF, meteorological data were processed by CALMET. CALMET data were created using on-site observation data from three meteorological stations (Brucejack Lake, Scott Creek, and Wildfire Creek). MM5 prognostic data were also provided to characterize upper air conditions. The three meteorological stations are permanent 10-m towers. The MSC guidelines (Environment Canada 2004) were used as a reference for installation and operation of the meteorological stations. Detailed information on the meteorological stations can be found in Appendix 7-B, 2012 Air Quality Baseline Report. The observational data from the stations and MM5 prognostic data were used to create a CALMET output file with a resolution of 0.5 km. The CALMET output was checked for quality assurance purposes following recommendations outlined in the BC Model Guideline (BC MOE 2008).

The dispersion modelling was performed in accordance with the BC Model Guideline (BC MOE 2008) and as described in the model plan (Appendix 7-A). Building downwash effects have been included for stacks where appropriate. The current layout of the Brucejack Mine Site is shown in Figure 7.5-1 and building heights are presented in Table 7.5-1.

Table 7.5-1. Building Heights

Building Description	Building Height (m)
Mill building	25
Portal structure	3.5
Brucejack Camp	9.4
Camp at Knipple Transfer Area	3.8
Skii km Lax Ha Lodge at aerodrome	7
Staff house at aerodrome[1]	3.5
Kitchen/dining at aerodrome[1]	3.5
Washroom at aerodrome[1]	3.5
Cabins at aerodrome[1]	3.5

[1] This building will not remain during the Operation phase of the Project.

In the atmosphere, NO_X primarily comprises NO and NO_2. In order to compare to the NO_2 objective in BC, the Ozone Limiting Method (OLM) outlined in the BC Model Guideline (BC MOE 2008) was used to convert modelled NO_X concentrations to NO_2 concentrations assuming an ozone background of 60 $\mu g/m^3$, as discussed in Section 7.3.3.

In the dispersion model, fugitive dust is modelled separately as larger uncertainties associated with fugitive dust emission factors exist. With fugitive dust emissions modelled separately, dispersion model results from non-fugitive emissions can be assessed with higher confidence when comparing with the objectives. In the results section of the assessment, the total dust concentrations, including both fugitive and non-fugitive sources, are presented. The CALPUFF switches configure the method and assumptions used in the model. The CALPUFF model switches used in the Project are detailed in Table 7.5-2. All of the switches were configured in accordance with the BC Model Guideline (BC MOE 2008).

Figure 7.5-1
Brucejack Gold Mine Project: Layout of Mine and Mill Surface Infrastructure

ERM

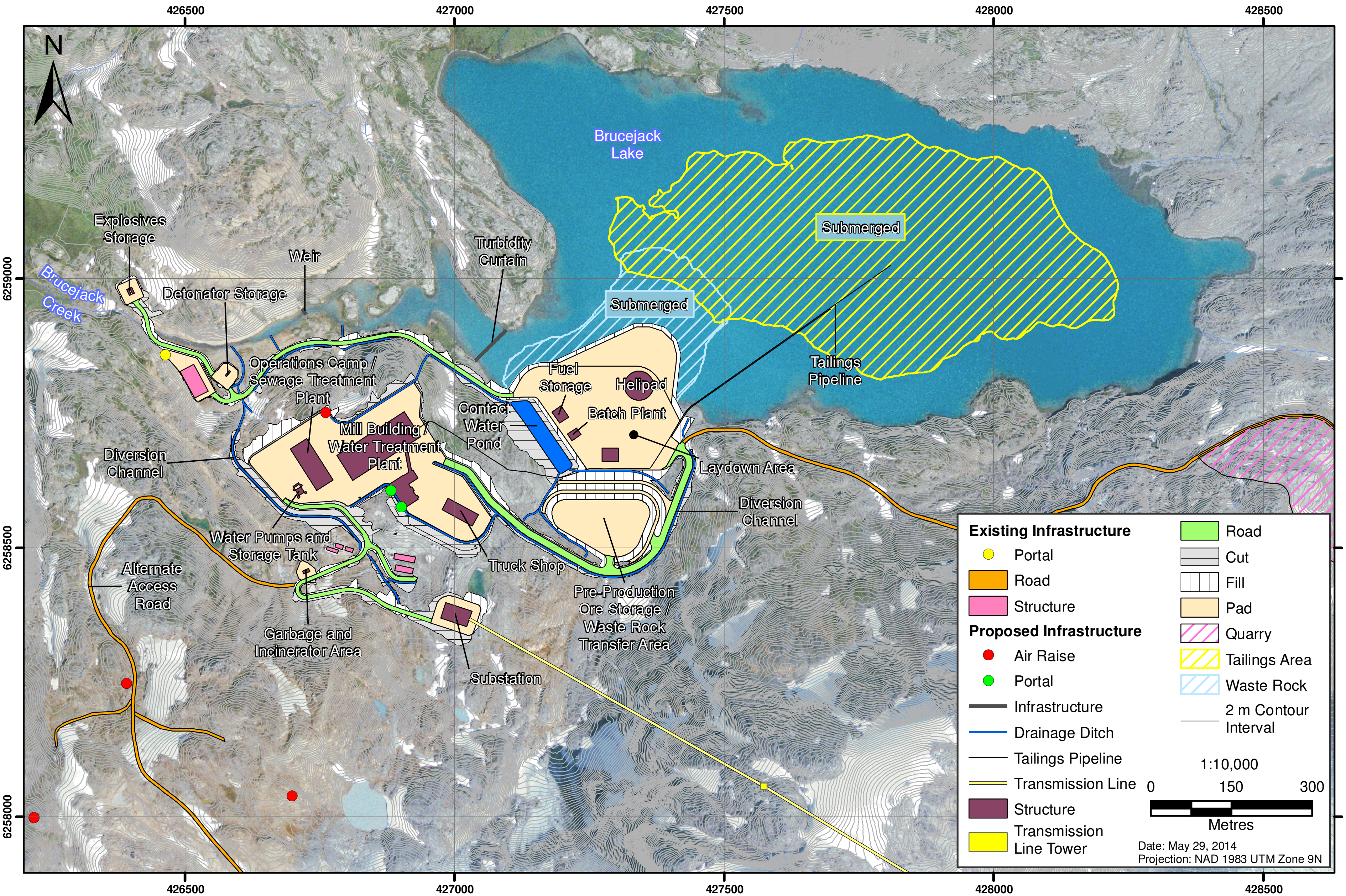


Table 7.5-2. CALPUFF Model Switch Settings

Parameter	Default	Project	Explanation and Justification
MGAUSS	1	1	
MCTADJ	3	3	
MCTSG	0	0	
MSLUG	0	0	
MTRANS	1	1	
MBDW	2	2	
MTIP	1	1	
MSHEAR	0	0	
MSPLIT	0	0	
MCHEM	1	1	
MAQCHEM	0	0	
MWET	1	1 for non-fugitive sources; 0 for fugitive sources	Wet removal not considered for fugitive dust to provide conservative results
MDRY	1	1	
MDISP	2 or 3	2	
MTURBVW	3	3	
MDISP2	2	2	
MROUGH	0	0	
MPARTL	1	1	
MTINV	0	0	
MPDF	0 or 1	1	
MSGTIBL	0	0	
MBCON	0	0	
MFOG	0	0	
MREG	0	0	

The nested receptor grid spacing was configured according to the BC Model Guideline Section 6.2 (BC MOE 2008). Sensitive receptors were determined by consultation with vegetation, wildlife, wetland, and human health scientists. Moreover, locations of cabins that are used for hunting or other activities were also included in the model to assess impact on traditional usage of the area. The nested receptors used in the models are:

- 20-m receptor spacing along the plant boundary (fence line);
- 50-m spacing within 500 m of fence line;
- 250-m spacing within 2 km from the fence line;
- 500-m spacing within 5 km from the fence line; and
- 1,000-m spacing for the remainder of the RSA.

Emission sources described in Section 7.5.1 were modelled as point, area, and volume sources. Point sources include stacks such as generators, incinerators, baghouses, scrubbers, and air raises. Area sources were used to model equipment emissions that are not stationary and may be used at different locations at varying times. Volume sources were used to model material handling, including bulldozing around the stockpile, outdoor crushing and screening, and blasting. Table 7.5-3 summarizes the stack dispersion modelling parameters.

Table 7.5-3. Point Sources Dispersion Modelling Parameters

Phase	Source	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exhaust Temperature (°C)
Construction	Generators (all)	10	0.3	23.6	400
	Incinerator	6	0.36	57.8	1,000
Operation	Generators (all)	10	0.3	23.6	400
	Incinerator	6	0.36	57.8	1,000
	Air raise 1 (VOK exhaust)	0.1	3.3	4.1	5
	Air raise 3 (VOK exhaust)	0.1	3.3	4	5
	Air raise 4 (crusher exhaust)	0.1	2.7	2.9	5
	Air raise 5 (west zone exhaust)	0.1	3.3	2.8	5

Since the CALPUFF model is not able to model point sources without a stack, a pseudo stack height of 0.1 m was adopted for the dispersion of air raises. Moreover, CALPUFF can only handle stacks with circular diameters. Equivalent diameter is the diameter of a circular outlet that gives the same pressure loss as an equivalent rectangular outlet. Equivalent diameters of the air raises were used as stack diameters in the model.

For road dust, modelling parameters were estimated based on recommended area source configurations outlined in the Haul Road Workgroup Final Report (US EPA 2012). Based on the most frequently used vehicle (pickup truck), the vehicle height is approximately 2 m. The plume height is calculated to be 1.7 multiplied by vehicle height with release height of half of the plume height. The plume dispersion coefficient sigma z for road dust was estimated based on plume height divided by 2.15 as suggested. The geometric mass mean diameter and standard deviation for fugitive dust sources are presented in Table 7.5-4. Initial sigma z for the volume sources were calculated by the length of the side of the volume source divided by 4.3.

Table 7.5-4. Size Parameters for Dry Deposition of Particles

Pollutant Name	Geometric Mass Mean Diameter (μm)	Geometric Standard Deviation (μm)
TSP	10	4
PM_{10}	2	2
$PM_{2.5}$	0.48	2

Chemical transformation is included as part of the dispersion model and the method used is MESOPUFF II scheme as suggested in the BC Model Guideline. The chemical transformation scheme allows the estimation of acid deposition using diffusivity, Henry's Law coefficient, liquid/frozen scavenging coefficients, and background ammonia concentrations. MESOPUFF II scheme includes SO_2, SO_4, NO_X, HNO_3, and NO_3. The results of these pollutants are then added, based on the acidity, to calculate acid deposition.

7.6 PREDICTIVE STUDY RESULTS FOR AIR QUALITY

7.6.1 Air Emission Inventory

7.6.1.1 Construction

As discussed in Section 7.5.1.1, there are five main mining or development activities that are sources of air emissions. The emissions were estimated based on methods described in the earlier section and the emission inventory is presented in Table 7.6-1 for generators and incinerators, Table 7.6-2 for tailpipe emissions from equipment, Table 7.6-3 for helicopter emissions, Table 7.6-4 for road dust, and Table 7.6-5 for other mining activities. Emissions from all sources during the Construction phase are summarized in Table 7.6-6.

Table 7.6-1. Annual Emissions from Stacks during Construction

	Annual Emissions (tonne/year)						
Source	**NO_X**	**SO_2**	**CO**	**VOC**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Brucejack Mine Site diesel generator 1	10.0	0.01	3.03	0.74	0.45	0.45	0.44
Brucejack Mine Site diesel generator 2	10.0	0.01	3.03	0.74	0.45	0.45	0.44
Knipple Transfer Area diesel generator 1	10.0	0.01	3.03	0.74	0.45	0.45	0.44
Knipple Transfer Area diesel generator 2	10.0	0.01	3.03	0.74	0.45	0.45	0.44
Bowser Aerodrome diesel generator	10.0	0.01	3.03	0.74	0.45	0.45	0.44
Brucejack Camp incinerator	0.77	0.00	0.00	0.01	9.27	4.63	3.09
Total	**51**	**0**	**15**	**4**	**12**	**7**	**5**

Note: numbers may not add up due to rounding.

7.6.1.2 Operation

There are seven main mining or activities that are sources of air emissions during the Operation phase. The emissions were estimated based on methods described in the earlier section and the emission inventory is presented in Table 7.6-7 for underground air raises, Table 7.6-8 for generators, incinerators and heaters, Table 7.6-9 for ore processing activities, Table 7.6-10 for tailpipe from mining equipment, Table 7.6-11 for helicopters, Table 7.6-12 for road dust, and Table 7.6-13 for other mining activities. Table 7.6-14 summarizes all emissions associated with the Operation phase.

Note that VOC emissions are quantified in the previous sections; however, the emissions are very low compared to most other contaminants. The only contributor of VOC emissions is from fuel combustion exhaust and no significant source of VOC is expected for the Project. Therefore, VOC emission will not be included in the dispersion model or discussed in the next section.

7.6.2 Predicted Dispersion Model Results for Construction Phase

In this section, maximum ground level concentrations and depositions predicted from the dispersion model are presented (Table 7.6-15).

7.6.2.1 Nitrogen Dioxide

The dispersion model results for NO_2 for all averaging periods are shown in Table 7.6-15. The NO_2 concentrations were estimated from NO_X using the OLM with a 60 µg/m^3 ozone background concentration assumed. Note that the OLM assumes NO_X contains 10% NO_2 and 90% NO, which reacts with ozone to form NO_2. This method also assumes either NO (90% of NO_X) or ozone reacts completely to NO_2, which is conservative and not as realistic as the ambient ratio method; however, ambient ratio method requires at least one year of representative ambient hourly NO and NO_2 monitoring data, which is not available in this area. As a result, only conservative OLM can be used to predict maximum NO_2 concentrations.

Table 7.6-2. Annual Equipment Tailpipe Emissions during Construction

Type of Equipment	Number of Units	Fuel Type	Power (kW)	NO_x	SO_2	CO	VOC	TSP	PM_{10}	PM_{25}
Brucejack Mine Site Construction										
30T CAT 730 Haul Trucks	4	Diesel	300	7.99	0.02	3.00	0.91	0.48	0.48	0.46
Dozer CAT D8T	2	Diesel	300	6.67	0.01	2.67	0.51	0.40	0.40	0.39
Loaders CAT 988H	2	Diesel	550	14.80	0.02	8.19	1.00	0.90	0.90	0.87
Grader CAT 14M	1	Diesel	260	2.83	0.01	1.13	0.22	0.17	0.17	0.17
Drills Atlas ROC L8	3	Diesel	500	22.89	0.02	7.95	1.56	1.11	1.11	1.07
Excavators CAT 374D	2	Diesel	480	9.18	0.02	5.55	0.76	0.59	0.59	0.57
Back Hoe CAT 450F	2	Diesel	150	2.01	0.00	1.03	0.30	0.20	0.20	0.19
Mobile Heavy Crane LTM 1160 (160t)	1	Diesel	600	9.83	0.01	2.02	0.65	0.35	0.35	0.34
Mobile light Cranes LTM 1035 (35t)	2	Diesel	210	2.98	0.01	0.66	0.28	0.14	0.14	0.13
Pickers	2	Diesel	150	3.46	0.01	1.16	0.32	0.23	0.23	0.22
Man Lifts (Genie)	4	Diesel	30	1.16	0.00	1.26	0.34	0.18	0.18	0.18
Welding Units	4	Diesel	75	2.46	0.00	1.70	0.43	0.29	0.29	0.28
Pickup trucks	16	Diesel	260	27.70	0.08	10.40	3.14	1.66	1.66	1.61
Quads	16	Gas	20	1.55	0.01	10.98	14.98	0.18	0.18	0.17
Telehandler CAT TL1255C	2	Diesel	150	2.52	0.00	1.34	0.39	0.23	0.23	0.23
Buses	3	Diesel	100	1.40	0.01	0.48	0.22	0.10	0.10	0.09
Water Truck	1	Diesel	100	0.47	0.00	0.16	0.07	0.03	0.03	0.03
Fuel Truck	1	Diesel	100	0.47	0.00	0.16	0.07	0.03	0.03	0.03
Ambulance	1	Diesel	100	0.47	0.00	0.16	0.07	0.03	0.03	0.03
Fire Truck	1	Diesel	100	0.47	0.00	0.16	0.07	0.03	0.03	0.03
Snowmobiles	10	Gas	20	2.07	0.02	2.33	3.18	1.17	1.17	1.07
Compressors	4	Diesel	100	3.70	0.01	0.95	0.34	0.23	0.23	0.23
Printoh Beast Snowcat #1	1	Diesel	388	2.01	0.02	1.44	1.65	1.13	1.13	1.04
Printoh Beast Snowcat #2	1	Diesel	388	2.01	0.02	1.44	1.65	1.13	1.13	1.04
Bobcat UTV 3400XL	1	Diesel	18	0.04	0.00	0.31	0.43	0.01	0.01	0.00
T140 Bobcat Surfwood Equipment	1	Diesel	36	0.14	0.00	0.06	0.01	0.01	0.01	0.01
Hitachi 200 Zaxis excavator – Wajax Equipment	1	Diesel	110	0.41	0.00	0.18	0.05	0.04	0.04	0.04

(continued)

Table 7.6-2. Annual Emissions from Equipment Tailpipes during Construction (continued)

Type of Equipment	Number of Units	Fuel Type	Power (kW)	NO_x	SO_2	CO	VOC	TSP	PM_{10}	PM_{25}
Brucejack Mine Site Construction *(cont'd)*										
Morooka 2200 - Handlers Equipment - 2007	1	Diesel	173	0.73	0.00	0.39	0.11	0.07	0.07	0.07
Morooka 800 - Handlers Equipment - 1995	1	Diesel	66	0.30	0.00	0.33	0.06	0.05	0.05	0.05
Morooka 4000 - Handlers Equipment - 1996	1	Diesel	294	1.23	0.00	0.74	0.16	0.10	0.10	0.10
Cat D6K LGP Dozer - Finning	1	Diesel	92	0.39	0.00	0.17	0.04	0.04	0.04	0.04
Hitachi 200 Zaxis Excavator -Wajax Equipment	1	Diesel	110	0.41	0.00	0.18	0.05	0.04	0.04	0.04
Pisten Bully 600 Polar 2011 #1 - Oakcreek Golf and Turf	1	Diesel	360	2.00	0.00	0.80	0.15	0.12	0.12	0.12
Pisten Bully 600 Polar 2010 #1 - Oakcreek Golf and Turf	1	Diesel	360	2.00	0.00	0.80	0.15	0.12	0.12	0.12
Caterpillar D8T - Finning Equipment	1	Diesel	259	1.44	0.00	0.58	0.11	0.09	0.09	0.08
All-Track AT80 - 2012 - All Track Service	1	Gas	132	0.32	0.00	2.07	1.65	0.04	0.04	0.03
Foremost Chieftan C - 2000	1	Diesel	224	1.35	0.00	0.54	0.10	0.08	0.08	0.08
Formost Nodwell 110 - 2000	1	Diesel	179	0.76	0.00	0.26	0.08	0.05	0.05	0.05
ATV's - Canam	4	Gas	61	0.59	0.00	3.81	3.05	0.07	0.07	0.06
ATV - Polaris Rangers	4	Gas	45	0.44	0.00	2.81	2.25	0.05	0.05	0.05
ATV - John Deer Gators	1	Gas	37	0.09	0.00	0.58	0.46	0.01	0.01	0.01
ATV - Canam Side by side	1	Gas	53	0.13	0.00	0.83	0.66	0.01	0.01	0.01
Snowmobiles - Skidoo Skandiks	6	Gas	44	1.37	0.01	1.40	2.11	0.77	0.77	0.71
Snowmobiles - Skidoo Summits	2	Gas	45	0.47	0.00	0.48	0.45	0.26	0.26	0.24
Kubota RTV 1140 - c/w BC Mines ROPS & Ansul Fire Suppression	1	Gas	18	0.04	0.00	0.31	0.43	0.01	0.01	0.005
Total				**144**	**0.34**	**81**	**43**	**12**	**12**	**11**
Knipple Glacier, Knipple Transfer Area, Brucejack Access Road, and Bowser Aerodrome Construction										
Husky	4	Diesel	330	10.85	0.01	4.69	0.75	0.66	0.66	0.64
30T CAT 730 Haul Trucks	2	Diesel	300	2.00	0.01	0.75	0.23	0.12	0.12	0.12
Dozer CAT D8T	4	Diesel	300	6.67	0.01	2.67	0.51	0.40	0.40	0.39
Loaders CAT 988H	2	Diesel	550	7.40	0.01	4.09	0.50	0.45	0.45	0.43

(continued)

Table 7.6-2. Annual Emissions from Equipment Tailpipes during Construction (completed)

Type of Equipment	Number of Units	Fuel Type	Power (kW)	NO_x	SO_2	CO	VOC	TSP	PM_{10}	PM_{25}
Knipple Glacier, Knipple Transfer Area, Brucejack Access Road, and Bowser Aerodrome Construction (*cont'd*)										
Grader CAT 14M	3	Diesel	260	4.24	0.01	1.70	0.33	0.26	0.26	0.25
Excavators CAT 374D	2	Diesel	480	4.59	0.01	2.78	0.38	0.30	0.30	0.29
Back Hoe CAT 450F	2	Diesel	150	1.01	0.00	0.52	0.15	0.10	0.10	0.10
Mobile Cranes LTC 1045 (45t)	2	Diesel	210	1.49	0.00	0.33	0.14	0.07	0.07	0.07
Pickers	1	Diesel	150	0.87	0.00	0.29	0.08	0.06	0.06	0.05
Man Lifts (Genie)	1	Diesel	30	0.14	0.00	0.16	0.04	0.02	0.02	0.02
Welding Units	1	Diesel	75	0.31	0.00	0.21	0.05	0.04	0.04	0.04
Pickup trucks	8	Diesel	260	6.93	0.02	2.60	0.79	0.41	0.41	0.40
Quads	4	Gas	20	0.19	0.00	1.37	1.87	0.02	0.02	0.02
Telehandler CAT TL1255C	1	Diesel	150	0.63	0.00	0.33	0.10	0.06	0.06	0.06
Buses	2	Diesel	100	0.47	0.00	0.16	0.07	0.03	0.03	0.03
Water Truck	1	Diesel	100	0.23	0.00	0.08	0.04	0.02	0.02	0.02
Fuel Truck	1	Diesel	100	0.23	0.00	0.08	0.04	0.02	0.02	0.02
Ambulance	1	Diesel	100	0.23	0.00	0.08	0.04	0.02	0.02	0.02
Fire Truck	1	Diesel	100	0.23	0.00	0.08	0.04	0.02	0.02	0.02
Snowmobiles	4	Gas	20	0.41	0.00	0.47	0.64	0.23	0.23	0.21
Generators	2	Diesel	500	14.29	0.02	4.32	1.06	0.65	0.65	0.63
Compressors	2	Diesel	100	0.92	0.00	0.24	0.08	0.06	0.06	0.06
Total				**50**	**0**	**24**	**7**	**3**	**3**	**3**
Grand Total				**193**	**0**	**105**	**49**	**15**	**15**	**14**

Table 7.6-3. Annual Emissions from Aircraft during Construction

Source	Emissions (tonne/year)						
	NO_X	SO_2	CO	VOC	TSP	PM_{10}	$PM_{2.5}$
Helicopter	19	1.5	15	5	0.37	0.36	0.36

Table 7.6-4. Annual Emissions from Unpaved Road Dust during Construction

Source	Units	Speed (km/hour)	Weight (tonne)	Emissions (tonne/year) Fugitive TSP	Fugitive PM_{10}	Fugitive $PM_{2.5}$
Brucejack Mine Site						
30T CAT 730 Haul Trucks	4	15	50.97	20	5.4	0.54
Pickup trucks	16	15	2.7	21	5.7	0.57
Buses	3	15	14.5	8.4	2.3	0.23
Water truck	1	15	25	14	3.9	0.39
Fuel truck	1	15	25	7.1	2.0	0.2
Morooka 2200 - Handlers Equipment – 2007[1]	1	30	18.5	6.2	1.7	0.17
Morooka 800 - Handlers Equipment – 1995[1]	1	30	8.25	4.3	1.2	0.12
Morooka 4000 - Handlers Equipment – 1996[1]	1	30	26.5	7.3	2.0	0.20
Foremost Chieftan C - 2000	1	30	27.7	7.5	2.0	0.20
Formost Nodwell 110 - 2000	1	30	10.4	4.8	1.3	0.13
Pisten Bully 600 Polar 2011 #1 – Oakcreek Golf and Turf	1	30	12.5	5.2	1.4	0.14
Pisten Bully 600 Polar 2010 #1 – Oakcreek Golf and Turf	1	30	12.5	5.2	1.4	0.14
Brucejack Mine Site total				**111**	**30**	**3**
Knipple Transfer Area, Bowser Aerodrome, and Brucejack Access Road						
30T CAT 730 Haul Trucks	2	30	50.97	20	5.4	0.54
Pickup trucks	8	30	2.7	21	5.7	0.57
Buses	2	30	14.5	11	3.1	0.31
Water truck	1	30	25	14	3.9	0.39
Fuel truck	1	30	25	7.1	2.0	0.20
Knipple Transfer Area, Bowser Aerodrome, and Brucejack Access Road Total				**73**	**20**	**2.0**
Grand Total				**184**	**50**	**5**

Note:
Numbers may not add up due to rounding.
[1] *Only expected to travel at 10 km/hr when loaded and 15 km/hr when empty. Conservative speed of 30 km/hr assumed.*

Table 7.6-5. Annual Emissions from Mining Activities during Construction

Sources	Area	Emissions (tonne/year) NO_X	SO_2	CO	VOC	Fugitive TSP	Fugitive PM_{10}	Fugitive $PM_{2.5}$
Bulldozing	Mine Site	-	-	-	-	45	20	15
	Transfer Area	-	-	-	-	22	11	8
Grading	Access Road	-	-	-	-	10	5	3
Blasting and drilling	Mine Site	15	1.9	65	-	42	21a	6a
	Quarry	4	0.5	17	-	11	6a	2a
Material handling	Mine Site	-	-	-	-	0.36	0.17	0.003
Total		**19**	**2.4**	**82**	**-**	**141**	**67**	**39**

[a] *Speciation obtained from AP-42 Appendix B.2 Source 3 (US EPA 1996) for mechanically generated dust from aggregate and unprocessed ore.*
[b] *Numbers may not add up due to rounding.*

Table 7.6-6. Annual Emissions from All Activities during Construction

Sources	Emissions (tonne/year)									
	NO_X	SO_2	CO	VOC	TSP	PM_{10}	$PM_{2.5}$	Fugitive TSP	Fugitive PM_{10}	Fugitive $PM_{2.5}$
Generators and incinerators	51	0	15	4	12	7	5	-	-	-
Mining equipment	193	0.5	105	49	15	15	15	-	-	-
Helicopter	19	1.5	15	5	0.37	0.36	0.36	-	-	-
Road dust	-	-	-	-	-	-	-	**184**	**50**	**5**
Mining activities	19	2.4	82	-	-	-	-	141	67	39
Total	**279**	**4**	**217**	**60**	**28**	**23**	**21**	**325**	**117**	**44**

Note: Numbers may not add up due to rounding.

Table 7.6-7. Concentrations of Pollutants from Air Raises

Sources	Concentrations (mg/m^3)									
	NO_X	SO_2	CO	VOC	TSP	PM_{10}	$PM_{2.5}$	Fugitive TSP	Fugitive PM_{10}	Fugitive $PM_{2.5}$
Diesel equipment[a]	0.31	0.12	0.42	-	0.05	0.048[b]	0.045[b]	-	-	-
Blasting[a]	-	-	7.58	-	-	-	-	-	-	-
Mining operations	-	-	-	-	-	-	-	3[c]	1.5[d]	0.5[d]
Total	**0.31**	**0.12**	**8.0**	**-**	**0.05**	**0.048**	**0.045**	**3**	**1.5**	**0.5**

[a] *Source: AMC Consultants (M. Molavi, pers. comm).*
[b] *Estimated based on TSP with dust speciation from AP-42 Appendix B.2 Source 1 for gasoline and diesel fuel (US EPA 1996).*
[c] *Source: Önder et al. (2009).*
[d] *Estimated based on TSP with dust speciation from AP-42 Appendix B.2 Source 3 for aggregate, unprocessed ore (US EPA 1996).*

Table 7.6-8. Annual Emissions from Generators, Incinerators, and Heaters during Operation

Source	Annual Emissions (tonne/year)						
	NO_X	SO_2	CO	VOC	TSP	PM_{10}	$PM_{2.5}$
Knipple Transfer Area diesel generator 1	10.0	0.01	3.03	0.74	0.45	0.45	0.44
Knipple Transfer Area diesel generator 2	10.0	0.01	3.03	0.74	0.45	0.45	0.44
Bowser Aerodrome diesel generator	10.0	0.01	3.03	0.74	0.45	0.45	0.44
Camp incinerators	1.26	0.00	0.00	0.000	15.2	7.58	5.05
Heaters	19.1	0.11	16.0	1.05	1.45	1.09	0.36
Total	**50**	**0.14**	**25**	**3.3**	**18**	**10**	**6.7**

Table 7.6-9. Annual Emissions from Ore Processing during Operation

Source	Annual Emissions (tonne/year)						
	NO_X	SO_2	CO	VOC	TSP	PM_{10}	$PM_{2.5}$
Baghouses	-	-	-	-	3.85	3.84a	3.82a
Scrubber	0.03b	3.5c	0	0	0.015	0.015d	0.015d
Total	**0.03**	**3.5**	**0**	**0**	**3.87**	**3.86**	**3.84**

[a] *Estimated from TSP using AP-42 Appendix B-2 fabric filter (US EPA 1996).*
[b] *Estimated from electric arc furnace.*
[c] *Estimated based on mass balance and 90% control efficiency.*
[d] *Assumed to be the same as TSP.*

Table 7.6-10. Annual Equipment Tailpipe Emissions during Operation

Equipment	Unit	Fuel Type	Power (kW)	Emissions (tonnes/year)						
				NO_x	SO_2	CO	VOC	TSP	PM_{10}	PM_{25}
Brucejack Mine Site										
Backhoe loader	2	Diesel	75	0.24	0.00	0.14	0.04	0.03	0.03	0.03
Dump truck	1	Diesel	306	0.47	0.00	0.18	0.05	0.03	0.03	0.03
Forklifts	4	Diesel	46	0.96	0.00	0.60	0.07	0.07	0.07	0.07
Mobile crane - 50T	1	Diesel	274	0.50	0.00	0.13	0.03	0.02	0.02	0.02
Boom truck -20T	1	Diesel	205	0.15	0.00	0.04	0.03	0.01	0.01	0.01
Loader F/E	1	Diesel	260	0.80	0.00	0.32	0.06	0.05	0.05	0.05
Truck 1/2 tonne	4	Diesel	224	1.33	0.01	0.31	0.22	0.05	0.05	0.05
HDPE fusion machine	1	Diesel	50	0.11	0.00	0.07	0.01	0.01	0.01	0.01
Flatbed truck	1	Diesel	123	0.13	0.00	0.05	0.02	0.01	0.01	0.01
Forklift (25 t)	1	Diesel	176	0.32	0.00	0.11	0.03	0.02	0.02	0.02
Mechanics truck	1	Diesel	224	0.11	0.00	0.03	0.02	0.00	0.00	0.00
Welding truck	1	Diesel	224	0.11	0.00	0.03	0.02	0.00	0.00	0.00
Pickup trucks	2	Diesel	224	0.67	0.00	0.16	0.11	0.02	0.02	0.02
Buses – On site	3	Diesel	224	1.00	0.00	0.24	0.17	0.03	0.03	0.03
Water truck[b]	1	Diesel	246	0.28	0.00	0.11	0.03	0.02	0.02	0.02
Sewage truck	1	Diesel	149	0.07	0.00	0.02	0.01	0.00	0.00	0.00
Foremost Husky 8	4	Diesel	328	17.6	0.03	7.05	1.29	1.04	1.04	1.01
Printoh Beast Snowcat #1[a]	1	Diesel	112	0.69	0.01	0.71	0.94	0.39	0.39	0.36
Printoh Beast Snowcat #2[a]	1	Diesel	112	1.62	0.02	1.66	1.33	0.91	0.91	0.84
Printoh Beast Snowcat #3[a]	1	Diesel	112	1.62	0.02	1.66	1.33	0.91	0.91	0.84
Bobcat UTV 3400XL	1	Diesel	0	0.02	0.00	0.18	0.20	0.00	0.00	0.00
T140 Bobcat Surfwood Equipment	1	Diesel	37	0.05	0.00	0.02	0.00	0.00	0.00	0.00
Hitachi 200 Zaxis excavator - Wajax Equipment	1	Diesel	119	0.15	0.00	0.07	0.02	0.02	0.02	0.02
Morooka 2200 - Handlers Equipment	1	Diesel	173	0.33	0.00	0.18	0.05	0.03	0.03	0.03
Morooka 800 - Handlers Equipment	1	Diesel	66	0.14	0.00	0.15	0.03	0.02	0.02	0.02
Morooka 4000 - Handlers Equipment	1	Diesel	294	0.57	0.00	0.34	0.07	0.05	0.05	0.04
Cat D6K LGP Dozer – Finning	1	Diesel	93	0.05	0.00	0.02	0.00	0.00	0.00	0.00
Hitachi 200 Zaxis Excavator -Wajax Equipment	1	Diesel	119	0.05	0.00	0.02	0.01	0.01	0.01	0.01
Pisten Bully 600 Polar[a]	1	Diesel	360	0.69	0.00	0.28	0.05	0.04	0.04	0.04
Caterpillar D8T	1	Diesel	259	0.17	0.00	0.07	0.01	0.01	0.01	0.01

(continued)

Table 7.6-10. Annual Emissions from Equipment Tailpipe during Operation (completed)

Equipment	Unit	Fuel Type	Power (kW)	Emissions (tonnes/year)						
				NO_x	SO_2	CO	VOC	TSP	PM_{10}	PM_{25}
Brucejack Mine Site (*cont'd*)										
All-Track AT80	1	Gasoline	0	0.15	0.00	0.97	0.77	0.02	0.02	0.02
Foremost Chieftain C	1	Diesel	224	0.44	0.00	0.15	0.05	0.03	0.03	0.03
Formost Nodwell 110	1	Diesel	179	0.35	0.00	0.12	0.04	0.02	0.02	0.02
ATV - Canam	4	Gasoline	61	0.41	0.00	2.64	3.96	0.05	0.05	0.04
ATV - Polaris Rangers	4	Gasoline	45	0.30	0.00	1.93	2.90	0.03	0.03	0.03
ATV - John Deer Gators	1	Gasoline	37	0.06	0.00	0.40	0.60	0.01	0.01	0.01
ATV - Canam Side by Side	1	Gasoline	53	0.09	0.00	0.57	0.86	0.01	0.01	0.01
Snowmobiles - Skidoo Skandiks[a]	6	Gasoline	45	0.96	0.01	0.99	1.48	0.54	0.54	0.50
Snowmobiles - Skidoo Summits[a]	2	Gasoline	45	0.32	0.00	0.33	0.49	0.18	0.18	0.17
Brucejack Mine Site Total				**34.7**	**0.1**	**23.3**	**17.5**	**4.7**	**4.7**	**4.5**
Knipple Transfer Area										
Mobile Crane - 50T	1	Diesel	274	0.83	0.00	0.21	0.06	0.03	0.03	0.03
Forklift	1	Diesel	46	0.24	0.00	0.15	0.02	0.02	0.02	0.02
Forklift (25 t)	1	Diesel	176	0.32	0.00	0.11	0.03	0.02	0.02	0.02
Water Truck[b]	1	Diesel	246	0.28	0.00	0.11	0.03	0.02	0.02	0.02
Knipple Transfer Area Total				**1.68**	**0.00**	**0.58**	**0.14**	**0.09**	**0.09**	**0.09**
Bowser Aerodrome										
Forklift	2	Diesel	261	2.27	0.00	0.97	0.16	0.14	0.14	0.13
Forklift (10t)	1	Diesel	92	0.23	0.00	0.09	0.02	0.02	0.02	0.02
Grader CAT 14 M	1	Diesel	204	0.18	0.00	0.06	0.02	0.01	0.01	0.01
Bowser Aerodrome Total				**2.68**	**0.00**	**1.12**	**0.20**	**0.17**	**0.17**	**0.17**
Grand Total				**40.8**	**0.1**	**25.6**	**17.9**	**5.1**	**5.1**	**4.8**

[a] *Operates during the winter only (October to April).*
[b] *Operates from April to October only.*

Table 7.6-11. Annual Emissions from Aircraft during Operation

Source	Emissions (tonne/year)						
	NO_X	SO_2	CO	VOC	TSP	PM_{10}	$PM_{2.5}$
Helicopter	11	1	9	3	0.22	0.22	0.21

Table 7.6-12. Annual Emissions from Unpaved Road Dust during Operation

Source	Units	Speed (km/hour)	Emissions (tonne/year)		
			Fugitive TSP	Fugitive PM_{10}	Fugitive $PM_{2.5}$
Brucejack Mine Site					
Dump truck	1	20	10	2.7	0.27
Boom truck -20T	1	20	8.0	2.2	0.22
Truck 1/2 tonne	4	20	9.8	2.7	0.27
Flatbed truck	1	20	2.6	0.7	0.07

(continued)

Table 7.6-12. Annual Emissions from Unpaved Road Dust during Operation (completed)

Source	Units	Speed (km/hour)	Emissions (tonne/year)		
			Fugitive TSP	Fugitive PM_{10}	Fugitive $PM_{2.5}$
Brucejack Mine Site					
Mechanics truck	1	20	2.1	0.6	0.06
Welding truck	1	20	1.8	0.5	0.05
Pickup trucks	2	20	4.9	1.3	0.13
Buses - On-site	3	20	63	17	1.72
Water truck	1	15	10	2.7	0.27
Sewage truck	1	20	4.3	1.2	0.12
Morooka 2200 - Handlers Equipment	1	10	3.9	1.1	0.11
Morooka 800 - Handlers Equipment	1	10	2.7	0.7	0.07
Morooka 4000 - Handlers Equipment	1	10	4.6	1.2	0.12
Brucejack Mine Site Total			**127**	**35**	**3**
Knipple Transfer Area					
Water truck	1	15	10	2.7	0.27
Grand Total			**137**	**38**	**3.8**

Table 7.6-13. Annual Emissions from Mining Activities during Operation

Sources	Area	Emissions (tonne/year)		
		Fugitive TSP	Fugitive PM_{10}	Fugitive $PM_{2.5}$
Bulldozing	Brucejack Mine Site	3.9	0.7	0.4
Grading	Brucejack Access Road	10.1	5.3	3.2
	Bowser Aerodrome	7.8	2.5	0.2
Total		**21.8**	**8.5**	**3.8**

[a] *Speciation obtained from AP-42 Appendix B.2 Source 3 (US EPA 1996) for mechanically generated dust from aggregate and unprocessed ore.*

Table 7.6-14. Annual Emissions during Operation

Sources	Emissions (tonne/year)									
	NO_X	SO_2	CO	VOC	TSP	PM_{10}	$PM_{2.5}$	Fugitive TSP	Fugitive PM_{10}	Fugitive $PM_{2.5}$
Underground mining	19.4	0.2	24.0	1.1	1.5	1.1	0.41	3	1.5	0.5
Generators and incinerators	31.35	0.03	9.09	2.22	16.51	8.93	6.37	-	-	-
Ore processing	0.03	3.5	0	0	3.87	3.86	3.84	-	-	-
Mining Equipment	40.8	0.1	25.6	17.9	5.1	5.1	4.8	-	-	-
Helicopter	11	1	9	3	0.22	0.22	0.21	-	-	-
Road dust	-	-	-	-	-	-	-	**137**	**38**	**3.8**
Mining activities	-	-	-	-	-	-	-	21.8	8.5	3.8
Total	**103**	**5**	**68**	**24**	**27**	**19**	**16**	**159**	**48**	**8**

Table 7.6-15. Maximum Concentration and Deposition Rate during Construction

Pollutant	Averaging Period	Concentrations ($\mu g/m^3$), Dust Deposition ($mg/dm^2/day$) or Acid Deposition (eq/ha/year)					Number of Exceedances	Frequency of Exceedance
		Criteria		Background	Maximum Predicted Concentrations			
		NAAQOs	BC Objective		Project	Project + Background		
NO_2	1-hour	400	-	21	107	128	-	-
	24-hour	200	-	21	72	93	-	-
	Annual	60	-	5	18	23	-	-
SO_2	1-hour	450	450	4	6.0	10.0	-	-
	24-hour	150	160	4	1.6	5.6	-	-
	Annual	30	25	2	0.25	2.25	-	-
CO	1-hour	15,000	14,300	100	1,239	1,339	-	-
	8-hour	6,000	5,500	100	582	682	-	-
TSP	24-hour	120	150	10	97	107	-	-
	Annual	60	60	10	23	33	-	-
PM_{10}	24-hour	-	50	3.4	**80.8**	**84.2**	6	1.6%
$PM_{2.5}$	24-hour	30[a] , 28[d] (2015) and 27[d] (2020)	25[b]	1.3	14.9	16.2	-	-
	Annual	10[d] (2015) and 8.8[d] (2020)	8[c]	1.3	4.9	6.2	-	-
Dust deposition	30-day	-	1.7 to 2.9	0.71	**5.1**	**5.8**	12	100%
Acid deposition	Annual	-	-	79	177	256	-	-

Notes:
Dash (-) indicates information not available or applicable. Bold indicates exceedance over criteria.
[a] Annual 98th percentile value, averaged over three consecutive years. Canada-wide standard published by CCME.
[b] Based on annual 98th percentile value.
[c] BC objective of 8 $\mu g/m^3$ and planning goal of 6 $\mu g/m^3$ was established in 2009.
[d] CAAQS adopted in 2013 and will be in effective in 2015 and 2020.

The highest 1-hour NO_2 concentration (Figure 7.6-1) occurred at the fence line east of the quarry. The maximum predicted 1-hour concentration of 128 μg/m^3 represents about one-third of the NAAQO of 400 μg/m^3. The 80 μg/m^3 contour, representing 20% of the NAAQO, extends approximately 7 km west of the Mine Site fence line.

The highest 24-hour NO_2 concentration of 93 μg/m^3 (Figure 7.6-2) was also predicted at the fence line east of the quarry, representing about half of the NAAQO. Similarly, the 40 μg/m^3 contour representing 20% of the NAAQO extends approximately 6 km west of the Brucejack Mine Site fence line. The highest annual NO_2 concentration of 23 μg/m^3 was predicted at the fence line south of the Knipple Transfer Area, mainly due to the close proximity to the road (Figure 7.6-3). The 15-μg/m^3 contour, representing 25% of the NAAQO, extends less than 1 km east of the Mine Site fence line.

7.6.2.2 Sulphur Dioxide

The dispersion model results for SO_2 outside the mining fence line, summarized in Table 7.6-15, indicates no exceedances for any averaging period. The highest 1-hour SO_2 concentration of 10 μg/m^3 (Figure 7.6-4) and the highest 24-hour SO_2 concentration of 5.6 μg/m^3 (Figure 7.6-5) were predicted north of the Bowser Aerodrome on the fence line, representing approximately 3% of the provincial and federal criteria. The highest annual concentration of 2.25 μg/m^3 (Figure 7.6-6) was predicted to occur east of the Bowser Aerodrome representing less than 8% of the BC objective and is an increase of only 12.5% from the baseline condition.

7.6.2.3 Carbon Monoxide

The highest maximum 1-hour and 8-hour CO concentrations, summarized in Table 7.6-15, were predicted immediately east of the Brucejack Mine Site on the fence line (Figures 7.6-7 and 7.6-8). The maximum predicted concentrations, including background, represent less than 13% of the BC objectives. The 200 μg/m^3 contour for 1-hour maximum, representing less than 2% of the BC objective, extends approximately 7 km west and 6 km east of the Brucejack Mine Site fence line.

7.6.2.4 Total Suspended Particulate

Fugitive dust sources, such as road dust, and non-fugitive dust sources, such as exhaust, were modelled separately; however, the suspended particulate results shown in this chapter represent the results from all dust generating sources. The highest 24-hour TSP concentration of 107 μg/m^3 is less than the NAAQO of 120 μg/m^3 and BC objective of 150 μg/m^3 (Table 7.6-15). The highest maximum 24-hour concentration was predicted to occur along the access road between the Knipple Transfer Area and the Bowser Aerodrome mostly due to the road dust emissions (Figure 7.6-9). The 20 μg/m^3 contour, which represents 17% of the NAAQO, extends only approximately 2.5 km from the Knipple Transfer Area and the Bowser Aerodrome fence lines, and less than 1 km out from the access roads. The highest annual TSP concentration of 33 μg/m^3 was predicted to occur at the fence line north of the Knipple Transfer Area mainly due to the close proximity to the road (Figure 7.6-10). The highest value represents 55% of the NAAQO and BC objective. The 20 μg/m^3 concentration contour, representing 33% of the criteria, extends only approximately 200 m out from each side of the access road.

7.6.2.5 PM_{10}

The predicted maximum 24-hour PM_{10} concentration of 84.2 μg/m^3 exceeds the BC objective of 50 μg/m^3 (Figure 7.6-11 and Table 7.6-15), however, these exceedances are of short duration, two to six days per year at the various sites. At the Brucejack Mine Site, there is no exceedance beyond the fence line. At the Knipple Transfer Area and the Bowser Aerodrome, exceedances extended approximately 500 m west of the fence line at the Knipple Transfer Area. In this area, the highest frequency of exceedance predicted was three days in a year, which is approximately 0.8% of the time.

Figure 7.6-1

Maximum 1-hour NO_2 Concentration during Construction

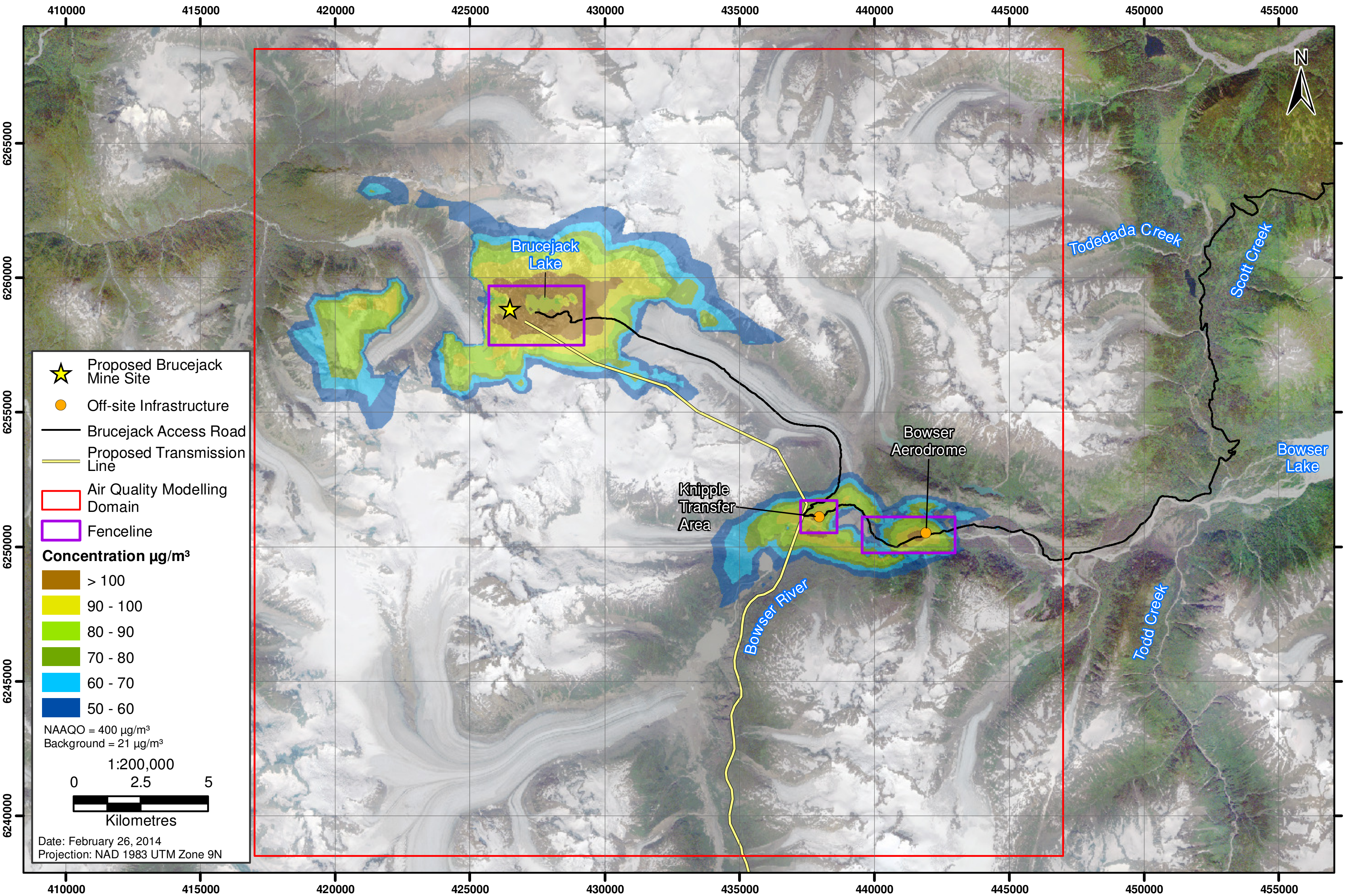


Figure 7.6-2

Maximum 24-hour NO_2 Concentration during Construction

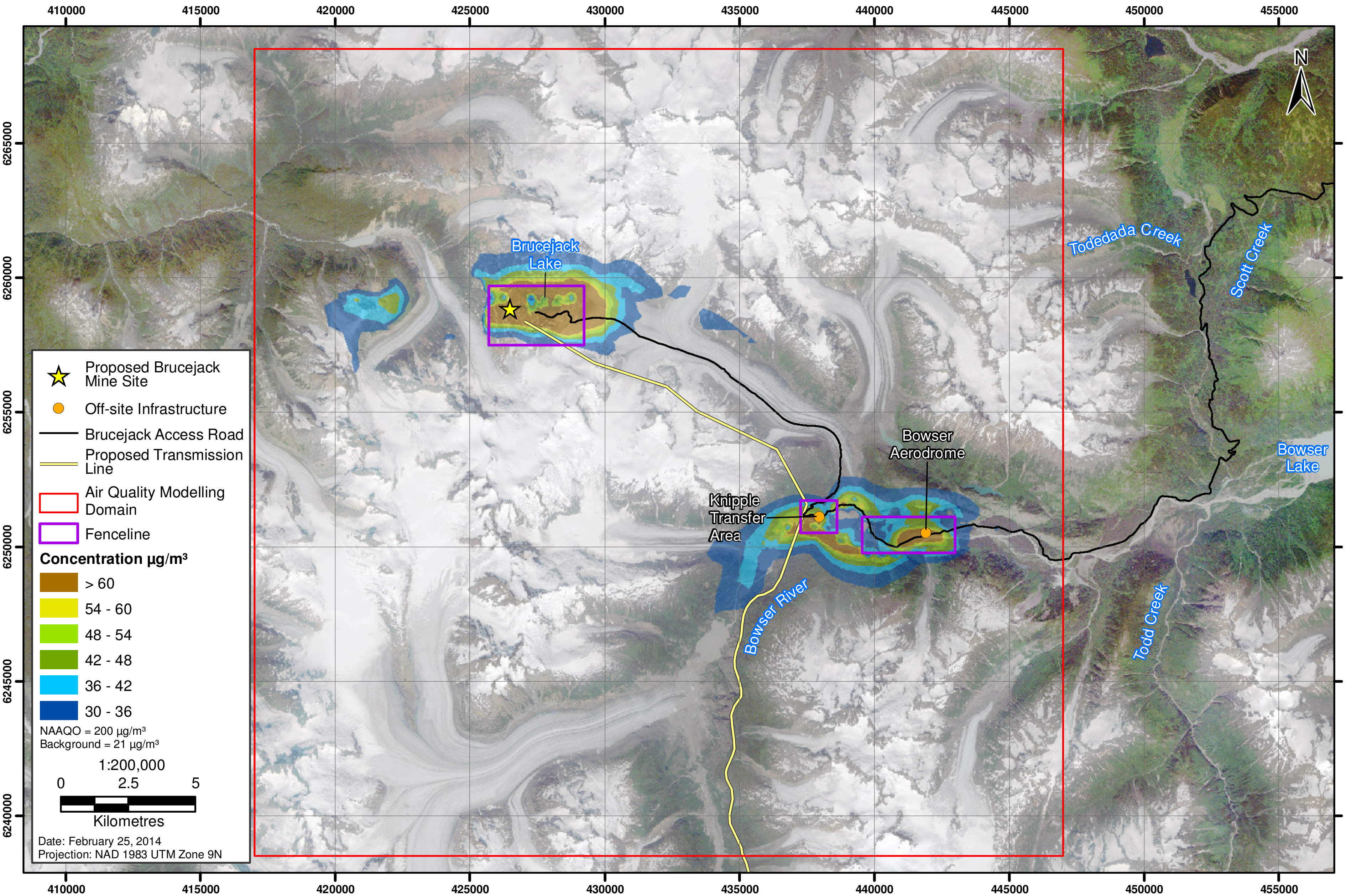


Figure 7.6-3
Annual NO_2 Concentration during Construction

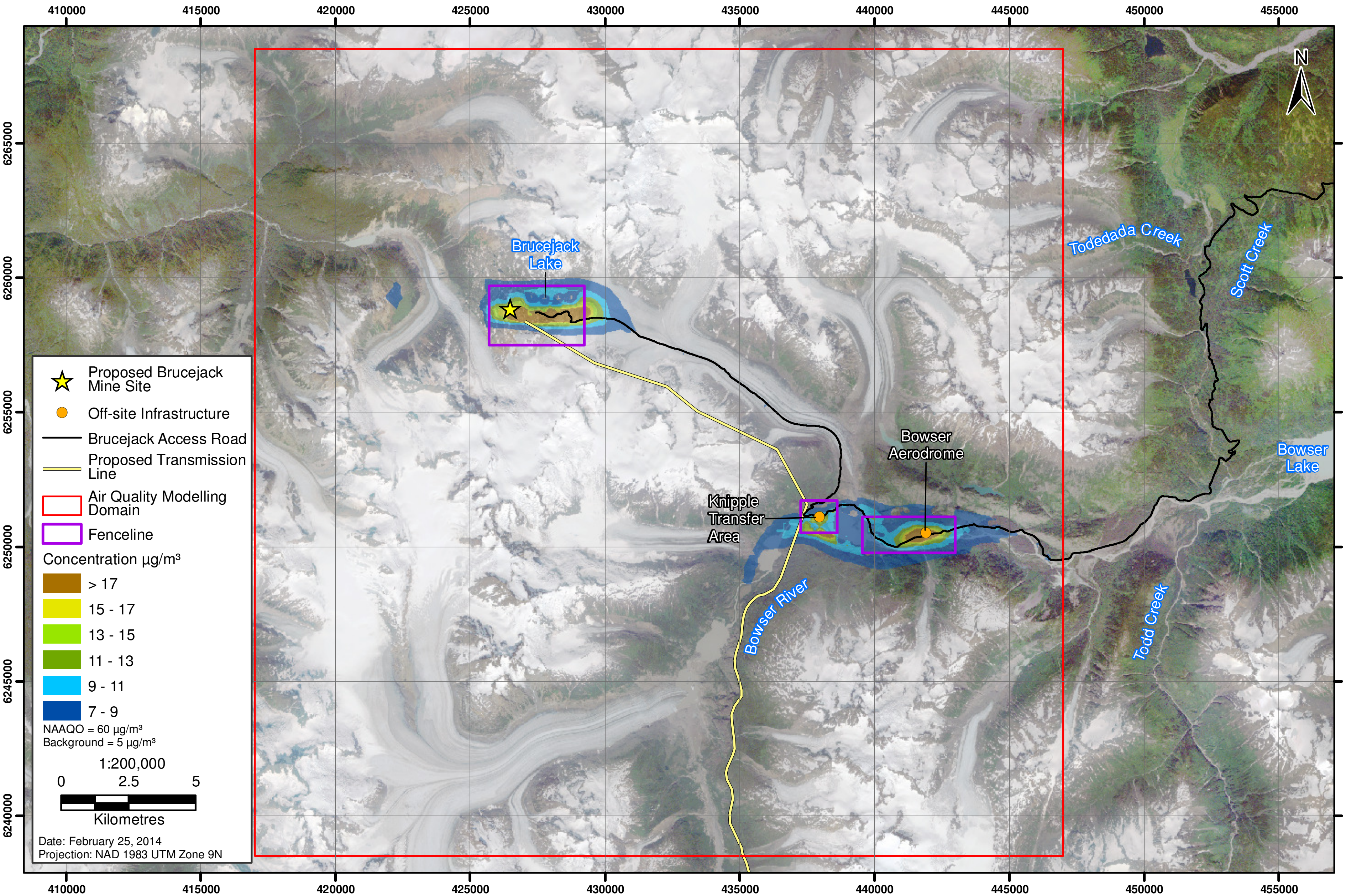


Figure 7.6-4
Maximum 1-hour SO_2 Concentration during Construction

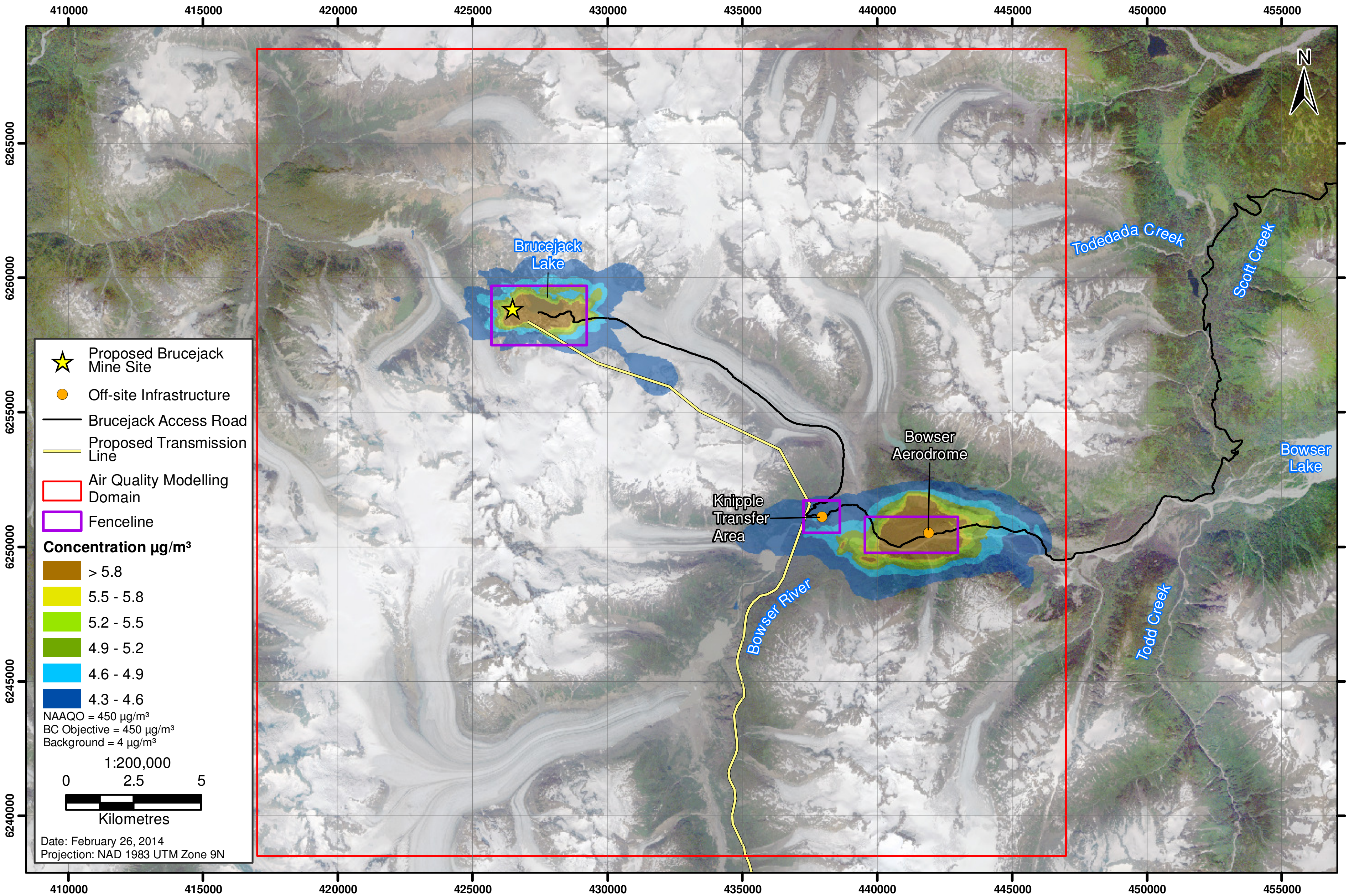


Figure 7.6-5
Maximum 24-hour SO_2 Concentration during Construction

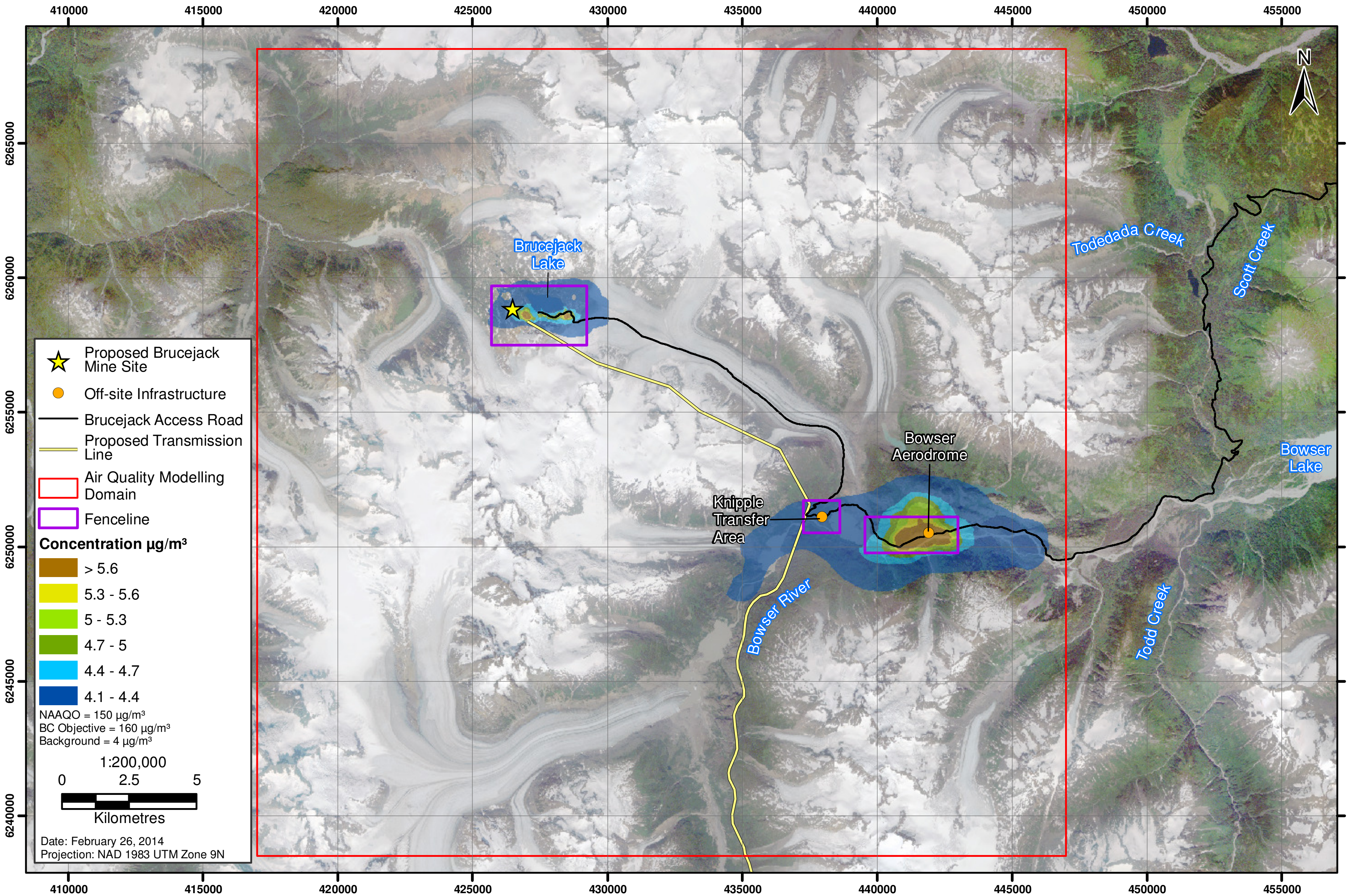


Figure 7.6-6
Annual SO_2 Concentration during Construction

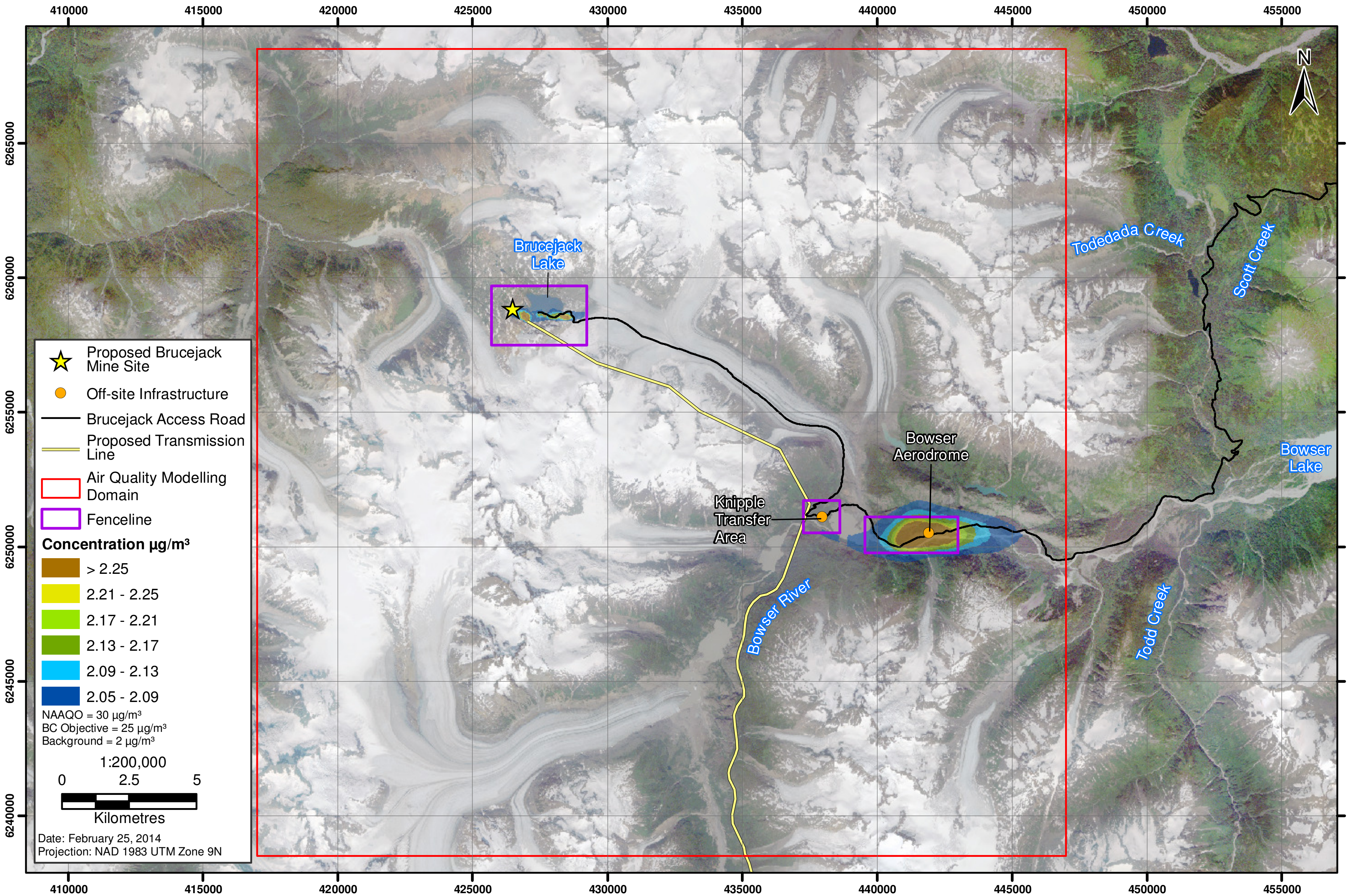


Figure 7.6-7
Maximum 1-hour CO Concentration during Construction

ERM

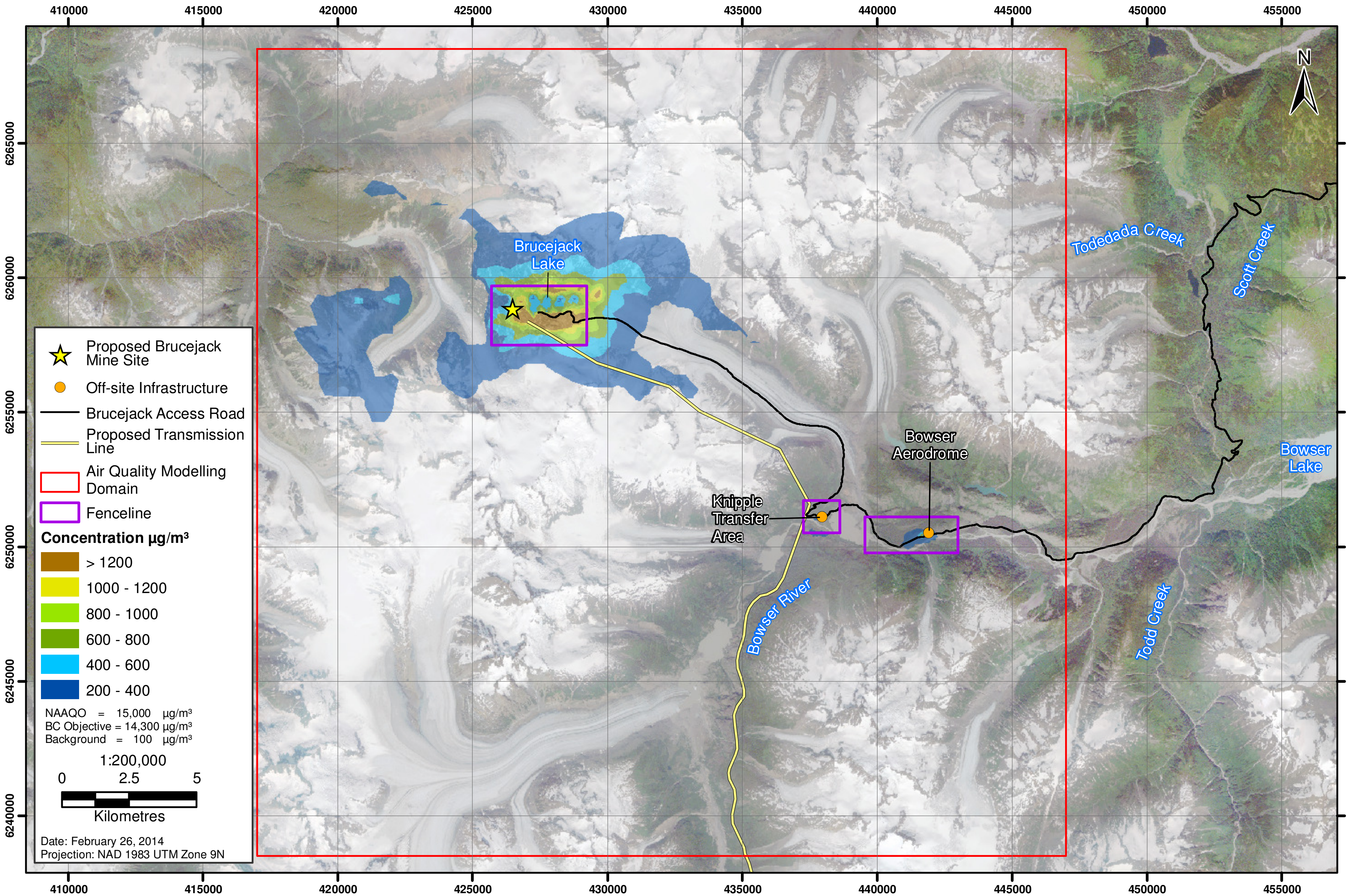


Figure 7.6-8
Maximum 8-hour CO Concentration during Construction

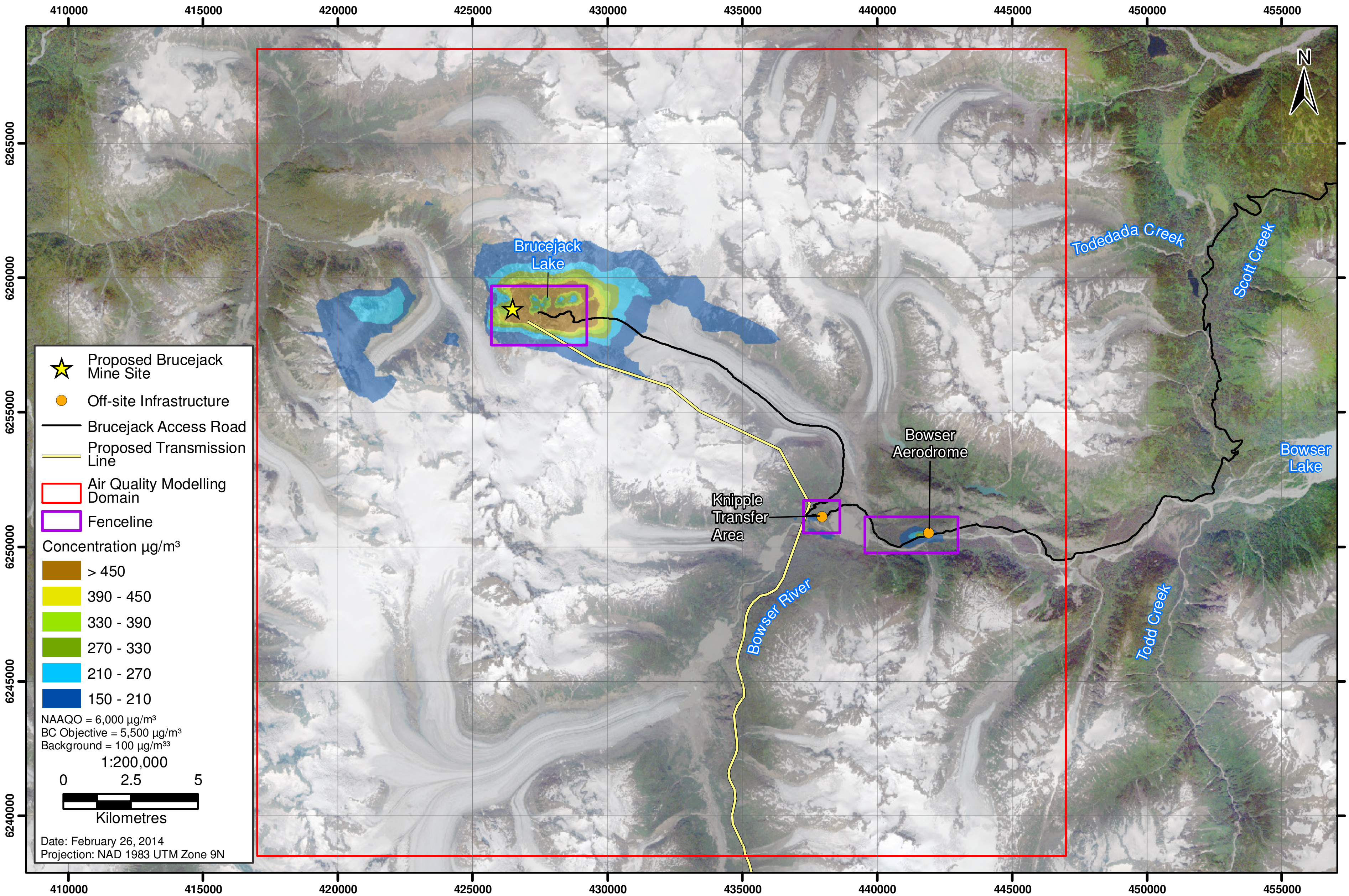


Figure 7.6-9
Maximum 24-hour TSP Concentration during Construction

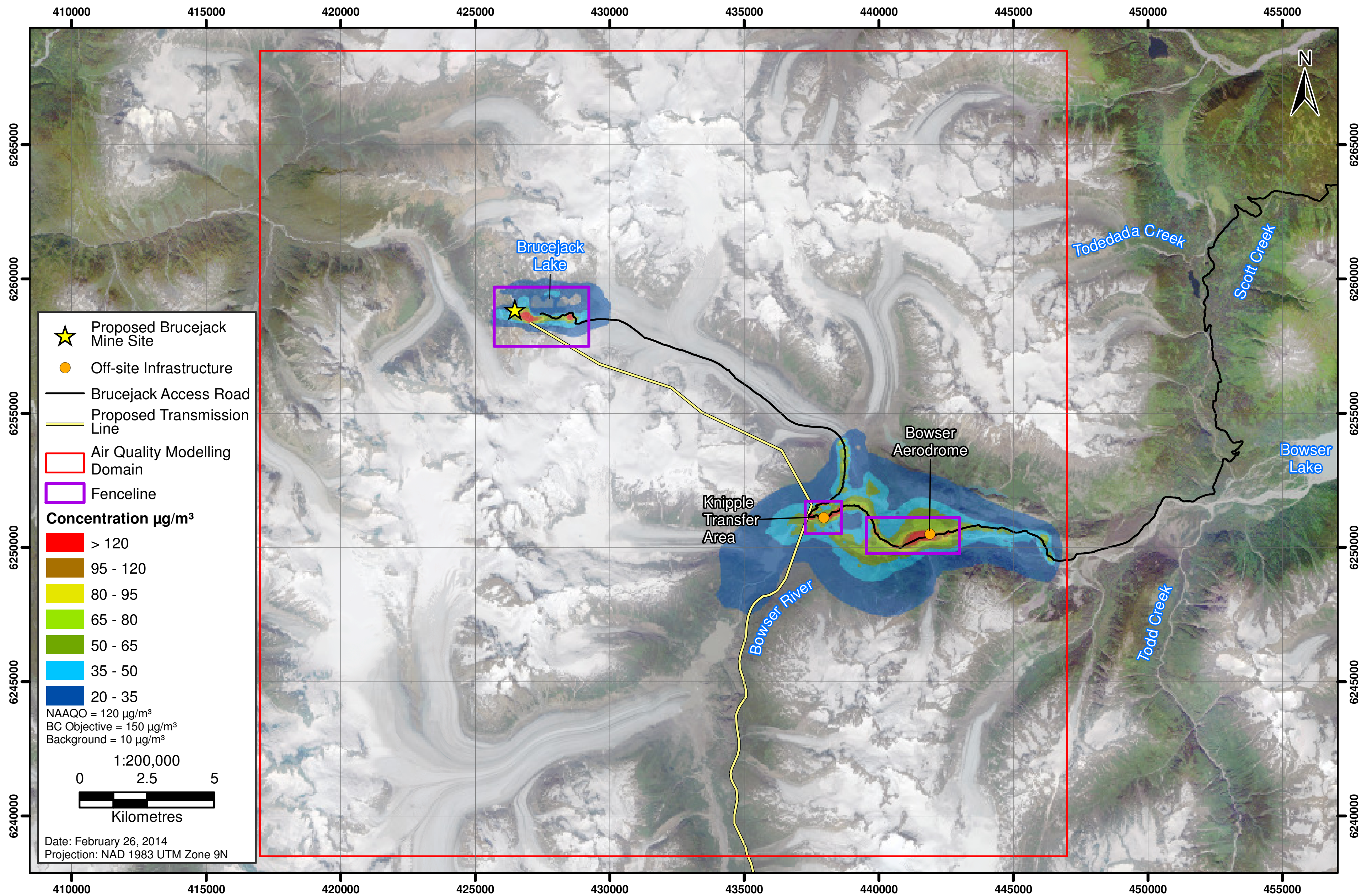


Figure 7.6-10
Annual TSP Concentration during Construction

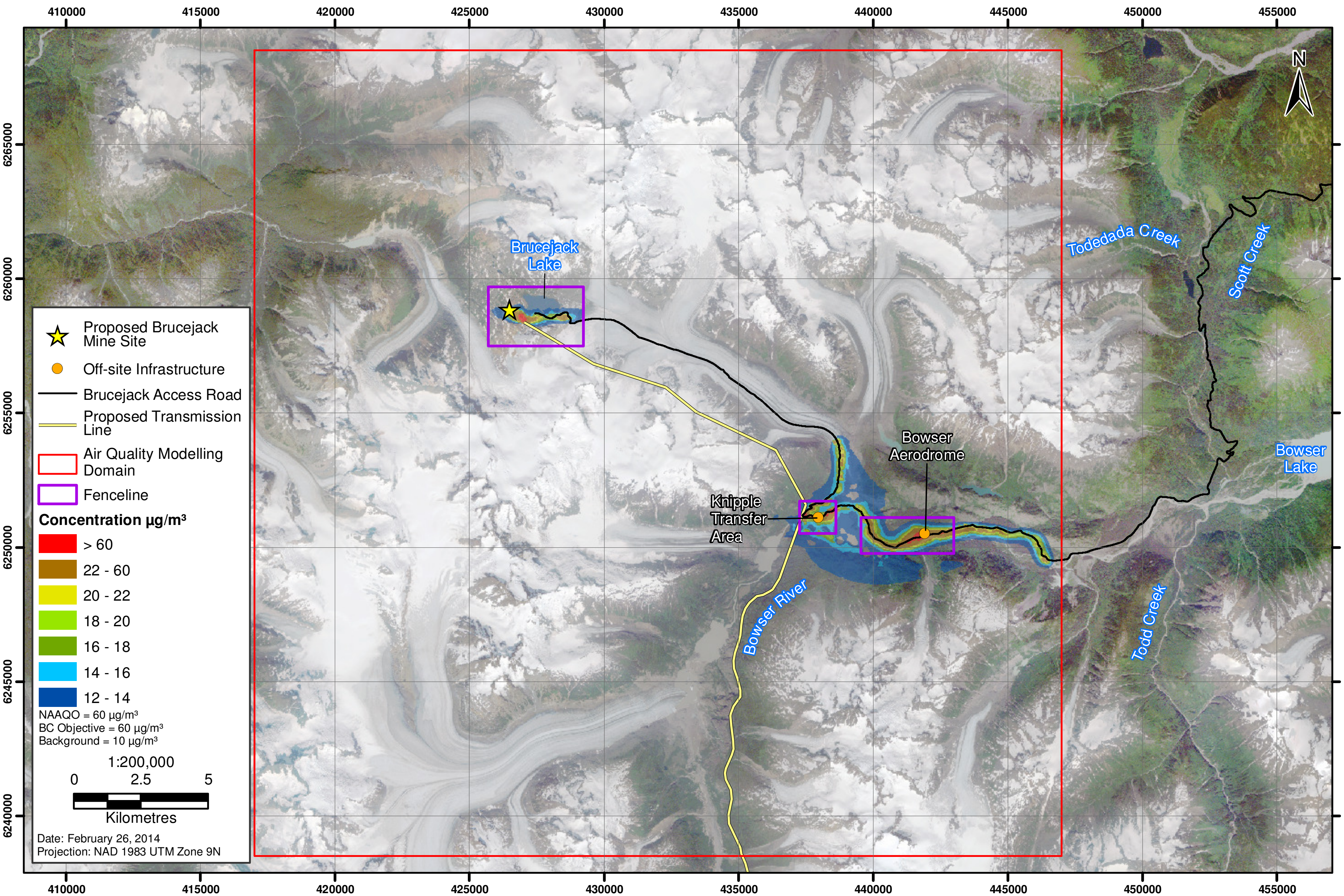
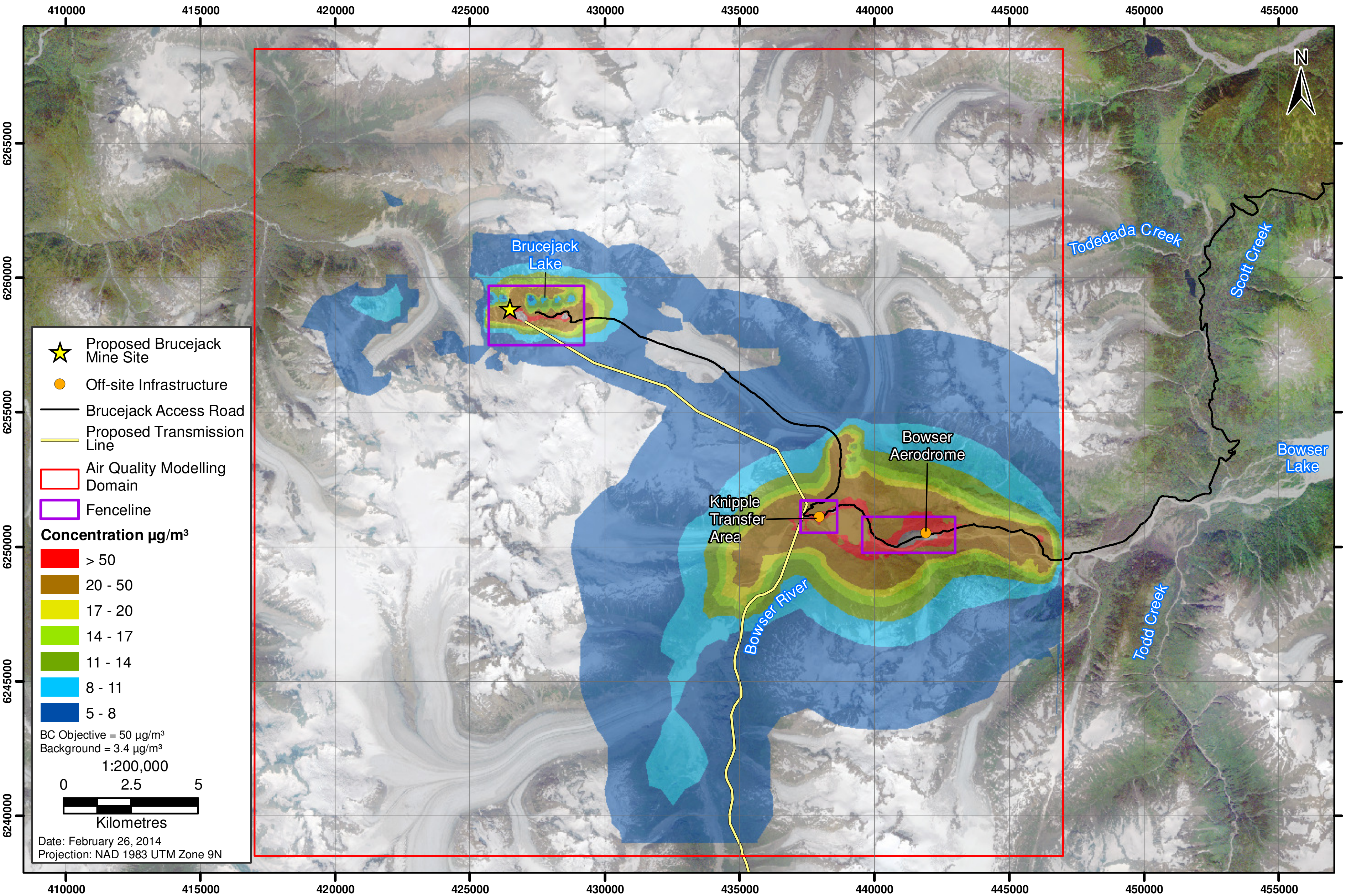


Figure 7.6-11
Maximum 24-hour PM_{10} Concentration during Construction

ERM



Exceedances were also predicted along the access road between the Knipple Transfer Area and the Bowser Aerodrome; however, the exceedances were predicted to extend less than 400 m from the centre line of the road. The most frequent exceedance occurred three times in a year, which is approximately 0.8% of the time. Additionally, exceedances were predicted to occur immediately south of Knipple Lake mostly due to the predominant wind from the east and the rapid increase of elevation around Knipple Lake. The most frequent exceedance occurs in this area, immediately south of the Knipple Transfer Area fence line, for a maximum of six days in a year (approximately 1.6% of the time).

Exceedances north and east of the Bowser Aerodrome were predicted to extend less than 400 m out from the fence line. Along the access road east of the Bowser Aerodrome, exceedances were predicted at four areas, each less than 300 m across. The highest frequency of exceedance in these areas occurred east of the Bowser Aerodrome for two days in a year (0.5% of the time).

7.6.2.6 $PM_{2.5}$

As mentioned earlier, the new CAAQs will supersede the NAAQOs in 2015 and 2020. However, the BC objectives for $PM_{2.5}$ are more stringent than the new CAAQs and will be used for comparative purposes in this study. The highest 98th percentile 24-hour $PM_{2.5}$ concentration predicted is 16.2 μg/m^3, which is approximately 65% of the BC objective of 25 μg/m^3, 54% of the NAAQO and 60% of the CAAQs of 27 μg/m^3 that will be in effect in 2020 (Table 7.6-15). The highest maximum concentration was predicted east of the Brucejack Mine Site fence line (Figure 7.6-12).

The 6 μg/m^3 concentration contour, representing 24% of the BC objective, extends approximately 1 km east of the mine site area, approximately 1 km west of the Knipple Transfer Area, and approximately 1.5 km east of the Bowser Aerodrome area. A portion of the area between the Knipple Transfer Area and Bowser Aerodrome is also covered by this 6 μg/m^3 concentration isopleth, as well as a few small areas along the access road east of the Bowser Aerodrome.

The highest annual $PM_{2.5}$ of 6.2 μg/m^3 was predicted immediately east of the Bowser Aerodrome, representing 87% of the BC objective of 8 μg/m^3, 62% of the CAAQs of 10 μg/m^3 effective in 2015, and 70% of the CAAQs of 8.8 μg/m^3 effective in 2020. The 2.8 μg/m^3 concentration contour, representing 35% of the BC objective, extends approximately 700 m east of the Brucejack Mine Site fence line, approximately 500 m west of the Knipple Transfer Area fence line, and approximately 500 m north of the Bowser Aerodrome fence line (Figure 7.6-13). This concentration level also includes a portion of the area immediately south of the Knipple Lake and a few hundred metres on either side of the access road east of Bowser Aerodrome.

7.6.2.7 Dust Deposition

The Pollution Control Objectives for the Mining, Smelting, and Related Industries of British Columbia (BC MOE 1979) dustfall objectives from 1.7 to 2.9 mg/dm^2/day aim to protect the quality of BC's environment, mainly from a nuisance perspective. 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. For this Project, the 2.9 mg/dm^2/day dustfall objective is considered more applicable other than in areas with camps, cabins, and lodges on-site. The Project's highest 30-day dust deposition of 5.8 mg/dm^2/day (Table 7.6-15, Figure 7.6-14) was predicted immediately north of the Knipple Transfer Area on the fence line due to the close proximity to the access road. Since dustfall is mainly produced by fugitive dust, the portion of the access road on the glacier does not show exceedance along the road as road dust is not generated on the glacier.

Figure 7.6-12
Maximum 24-hour Total $PM_{2.5}$ Concentration during Construction

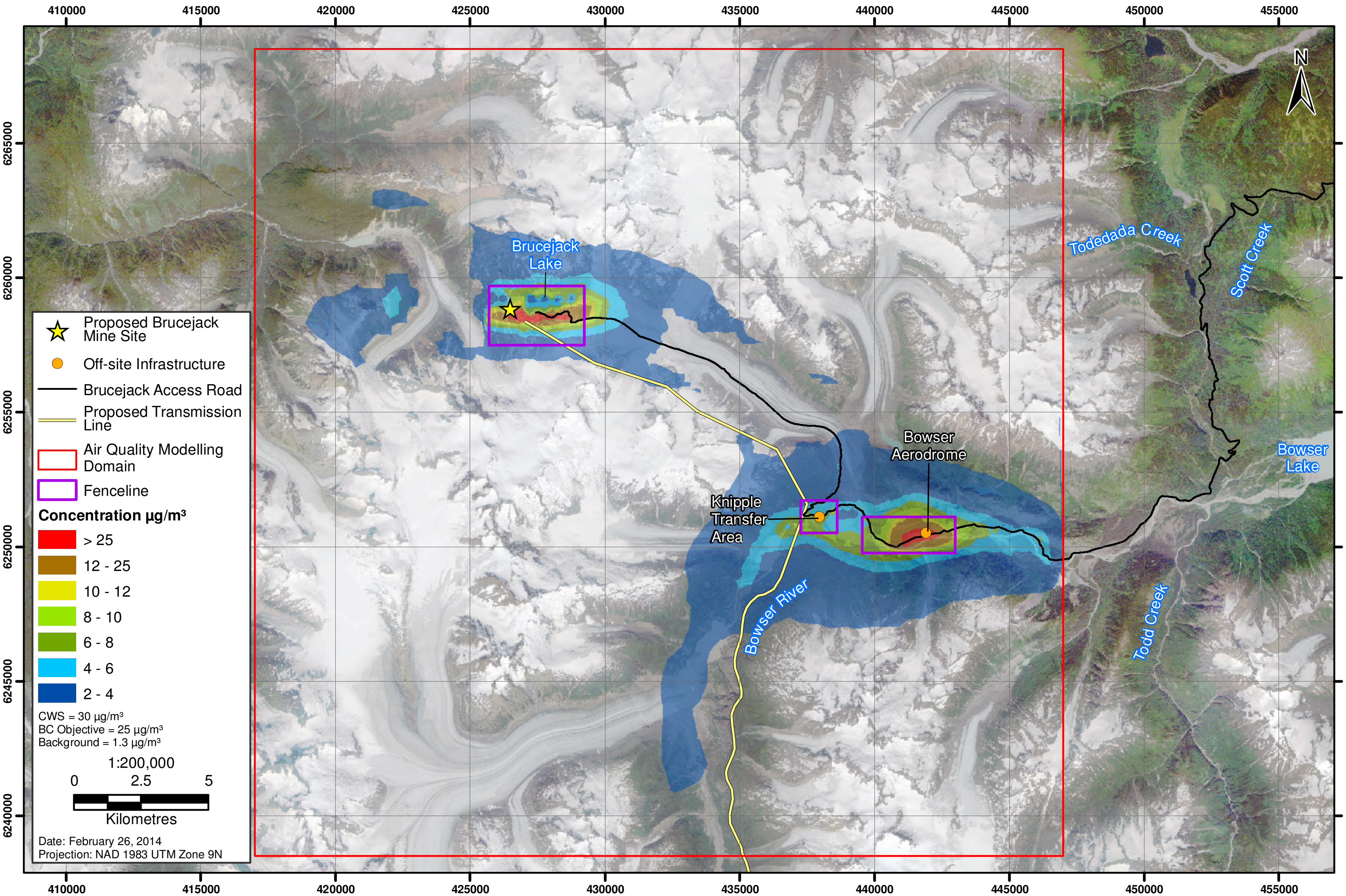


Figure 7.6-13

Annual $PM_{2.5}$ Concentration during Construction

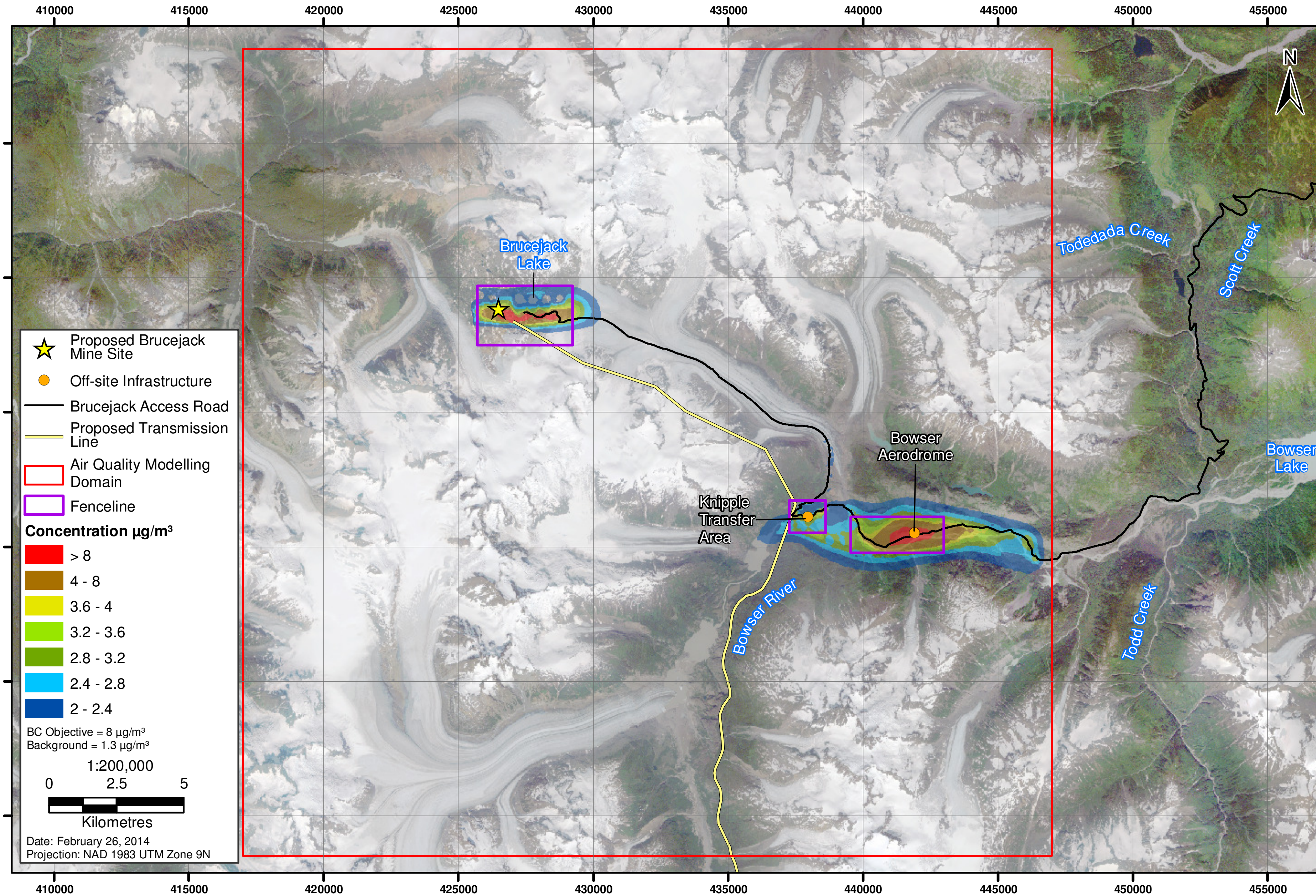
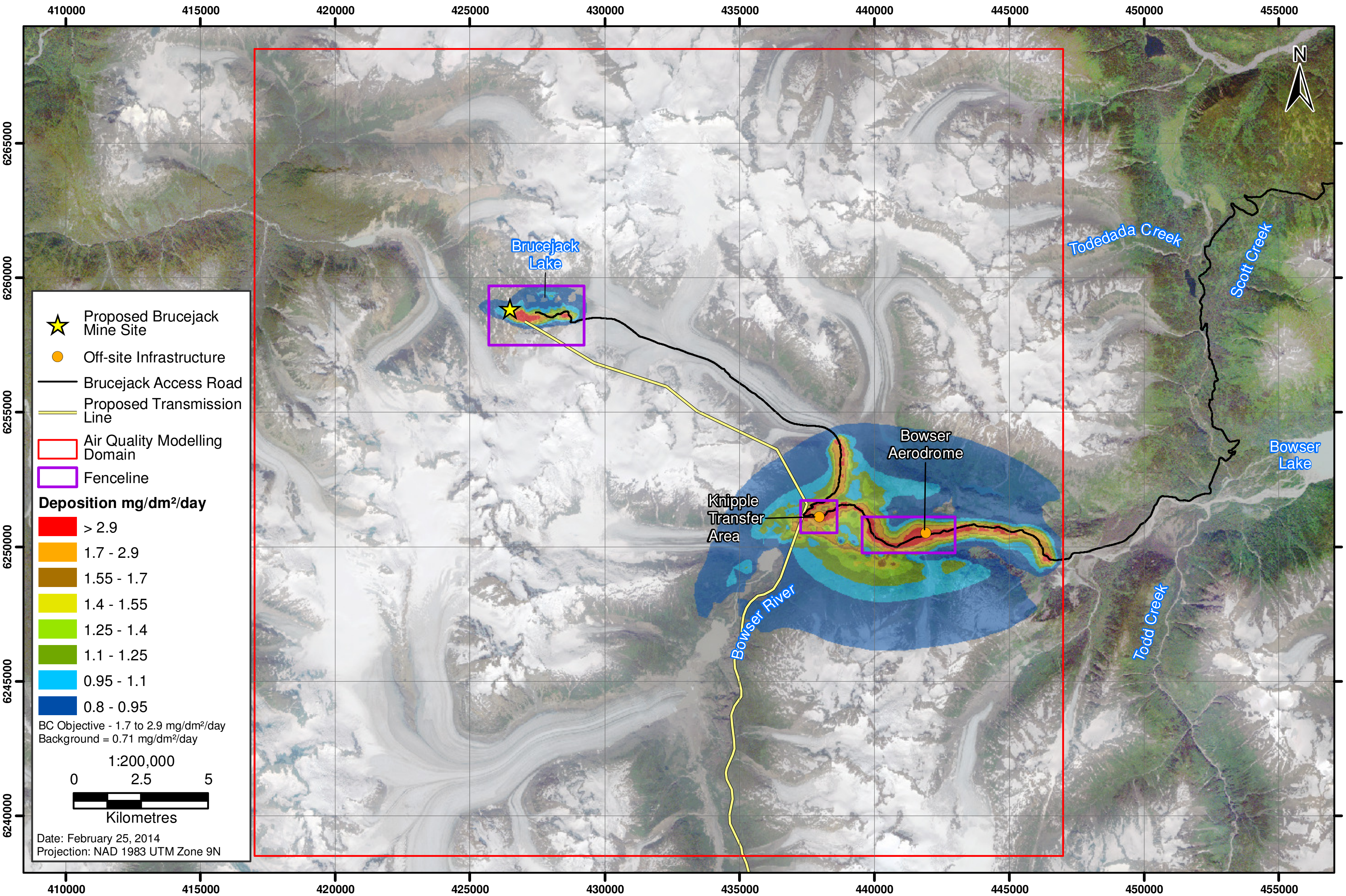


Figure 7.6-14

Maximum 30-day Dust Deposition during Construction



The maximum 30-day dust deposition rate is higher than the BC objective of 2.9 $mg/dm^2/day$; however, exceedance over the objective of 2.9 $mg/dm^2/day$ is predicted to extend less than 100 m on either side of the access road. The 1.7 $mg/dm^2/day$ objective is predicted to exceed approximately 300 m on either side of the access road. Other than the access road, exceedances over the 1.7 $mg/dm^2/day$ objective extend approximately 300 m west of the Knipple Transfer Area and immediately south of Knipple Lake. Although exceedances over the BC objectives were predicted, the extent of these exceedances is limited to a short distance beyond the road. Due to the fast settling nature of large particles, increase in dustfall deposition is expected around unpaved access roads but with limited extent.

Furthermore, the dustfall monitoring results for the baseline varied from 0.14 to 2.67 $mg/dm^2/day$, indicating that dust deposition varies with seasons and activities, but will decrease once the activity ceases operation. It should also be noted that the background dustfall monitoring was conducted during the summer when dustfall deposition is typically higher than that during the winter.

7.6.2.8 Acid Deposition

Acid deposition levels, calculated from nitrogen- and sulphur-containing pollutants based on acidity, are presented in Figure 7.6-15 and Table 7.6-15. The highest acid deposition level outside the Project fence line was predicted to be 256 eq/ha/year and occurred on the west side of the Bowser Aerodrome fence line.

7.6.3 Predicted Dispersion Model Results for Operation Phase

Predicted maximum concentrations for the Operation phase are summarized in Table 7.6-16.

7.6.3.1 Nitrogen Dioxide

The dispersion model results for NO_2 for all averaging periods are shown in Table 7.6-16. As mentioned earlier in Section 7.6.1.1, the NO_2 concentrations were estimated using OLM. The highest 1-hour NO_2 concentration (Figure 7.6-16) was predicted to be 104 $\mu g/m^3$ on the fence line south of the Knipple Transfer Area, representing 26% of the NAAQO. The 50 $\mu g/m^3$ concentration contour (12.5% of the NAAQO) extends approximately 2 km north of the Brucejack Mine Site fence line, and an area approximately 4 km west of the mine site area less than 1.5 km across. Along the access road, the 50 $\mu g/m^3$ concentration extends approximately 2 km on either side of the road. Additionally, the 50 $\mu g/m^3$ concentration also extends approximately 5 km west of the Knipple Transfer Area and 5 km east of Bowser Aerodrome.

The highest 24-hour NO_2 concentration of 89 $\mu g/m^3$ represents about 45% of the NAAQO and was predicted around the same area as the highest 1-hour NO_2 concentration on the fence line south of the Knipple Transfer Area (Figure 7.6-17). The 30 $\mu g/m^3$ concentration contour, representing 15% of the NAAQO, extends to approximately the same areas as the 1-hour NO_2 50 $\mu g/m^3$ level.

The highest annual NO_2 concentration was predicted to be 24 $\mu g/m^3$, which is approximately 40% of the annual NAAQO. The highest values were predicted immediately east of the Bowser Aerodrome area (Figure 7.6-18). No exceedance of the NAAQOs were predicted for any averaging periods.

7.6.3.2 Sulphur Dioxide

The dispersion model results for SO_2 outside the mining fence line are summarized in Table 7.6-16, and indicate no exceedances over the criteria for any averaging period. The highest 1-hour SO_2 concentration of 10.1 $\mu g/m^3$ (Figure 7.6-19) and the highest 24-hour SO_2 concentration of 5.6 $\mu g/m^3$ (Figure 7.6-20) were predicted north of the Bowser Aerodrome on the fence line, representing approximately 3% of the provincial and federal criteria. The highest annual concentration of 2.27 $\mu g/m^3$ (Figure 7.6-21), predicted to occur east of the Bowser Aerodrome, represents less than 8% of the BC objective and is an increase of 12.5% from the baseline condition.

Figure 7.6-15
Annual Acid Deposition during Construction

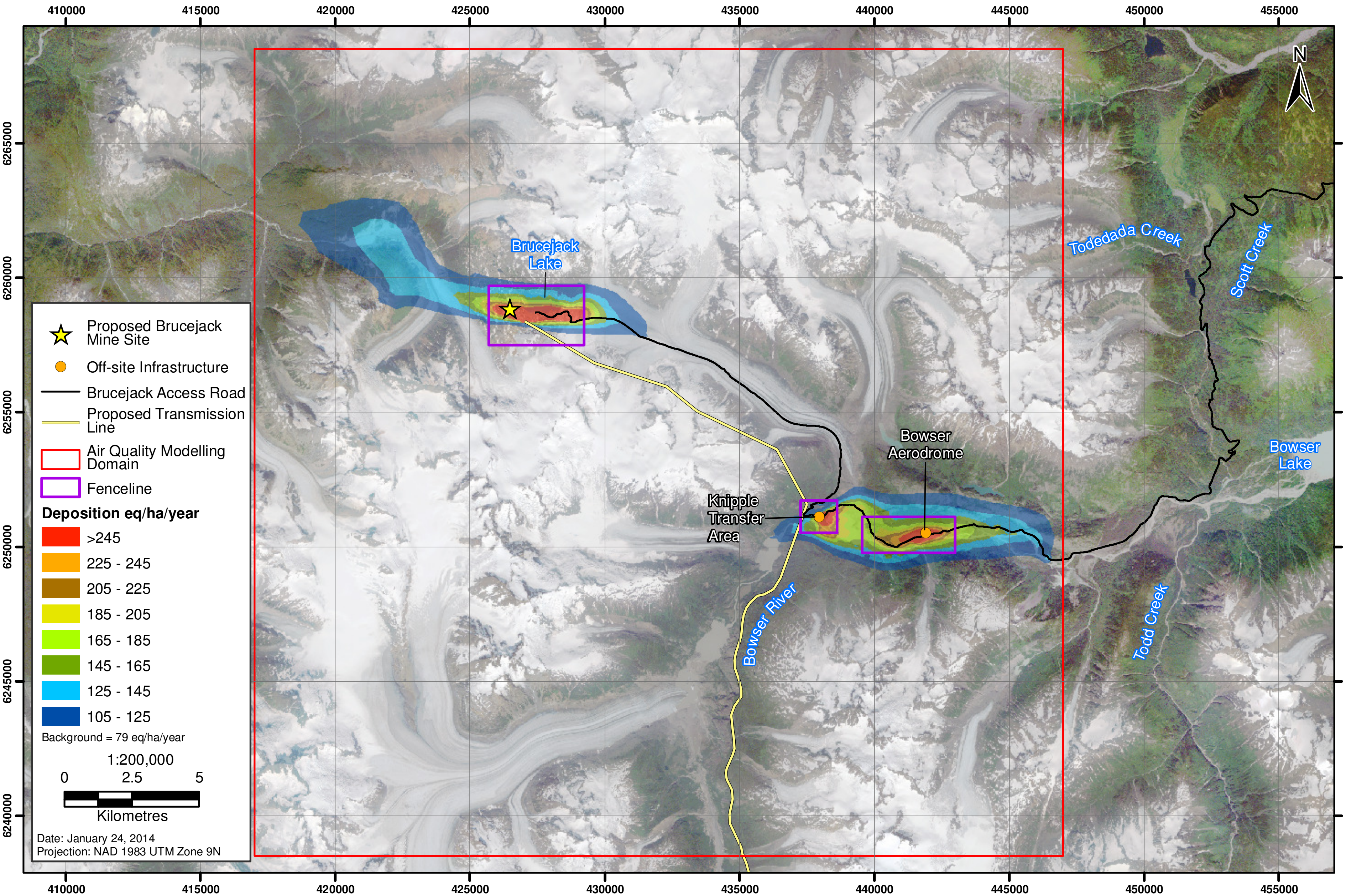


Table 7.6-16. Maximum Concentration and Deposition Rate during Operation

Pollutant	Averaging Period	Concentrations ($\mu g/m^3$), Dust Deposition ($mg/dm^2/day$) or Acid Deposition (eq/ha/year)					Number of Exceedances	Frequency of Exceedance
		Criteria			Maximum Predicted Concentrations			
		NAAQOs	BC Objective	Background	Project	Project + Background		
NO_2	1-hour	400	-	21	83	104	-	-
	24-hour	200	-	21	68	89	-	-
	Annual	60	-	5	19	24	-	-
SO_2	1-hour	450	450	4	6.1	10.1	-	-
	24-hour	150	160	4	1.6	5.6	-	-
	Annual	30	25	2	0.27	2.27	-	-
CO	1-hour	15,000	14,300	100	115	215	-	-
	8-hour	6,000	5,500	100	48	148	-	-
TSP	24-hour	120	150	10	69	79	-	-
	Annual	60	60	10	19	29	-	-
PM_{10}	24-hour	-	50	3.4	**55**	**58**	1	0.3%
$PM_{2.5}$	24-hour	30[a] , 28[d] (2015) and 27 [d](2020)	25[b]	1.3	5.6	6.9	-	-
	Annual	10[d] (2015) and 8.8[d] (2020)	8[c]	1.3	2.9	4.2	-	-
Dust deposition	30-day	-	1.7 to 2.9	0.71	**3.0**	**3.7**	9	75%
Acid deposition	Annual	-	-	79	287	366	-	-

Notes:
Dash (-) indicates information not available or applicable. Bold indicates exceedance over criteria.
[a] Annual 98th percentile value, averaged over three consecutive years. Canada-wide standard published by CCME.
[b] Based on annual 98th percentile value.
[c] BC objective of 8 $\mu g/m^3$ and planning goal of 6 $\mu g/m^3$ was established in 2009.
[d] CAAQS adopted in 2013 and will be in effective in 2015 and 2020.

Figure 7.6-16

Maximum 1-hour NO_2 Concentration during Operation

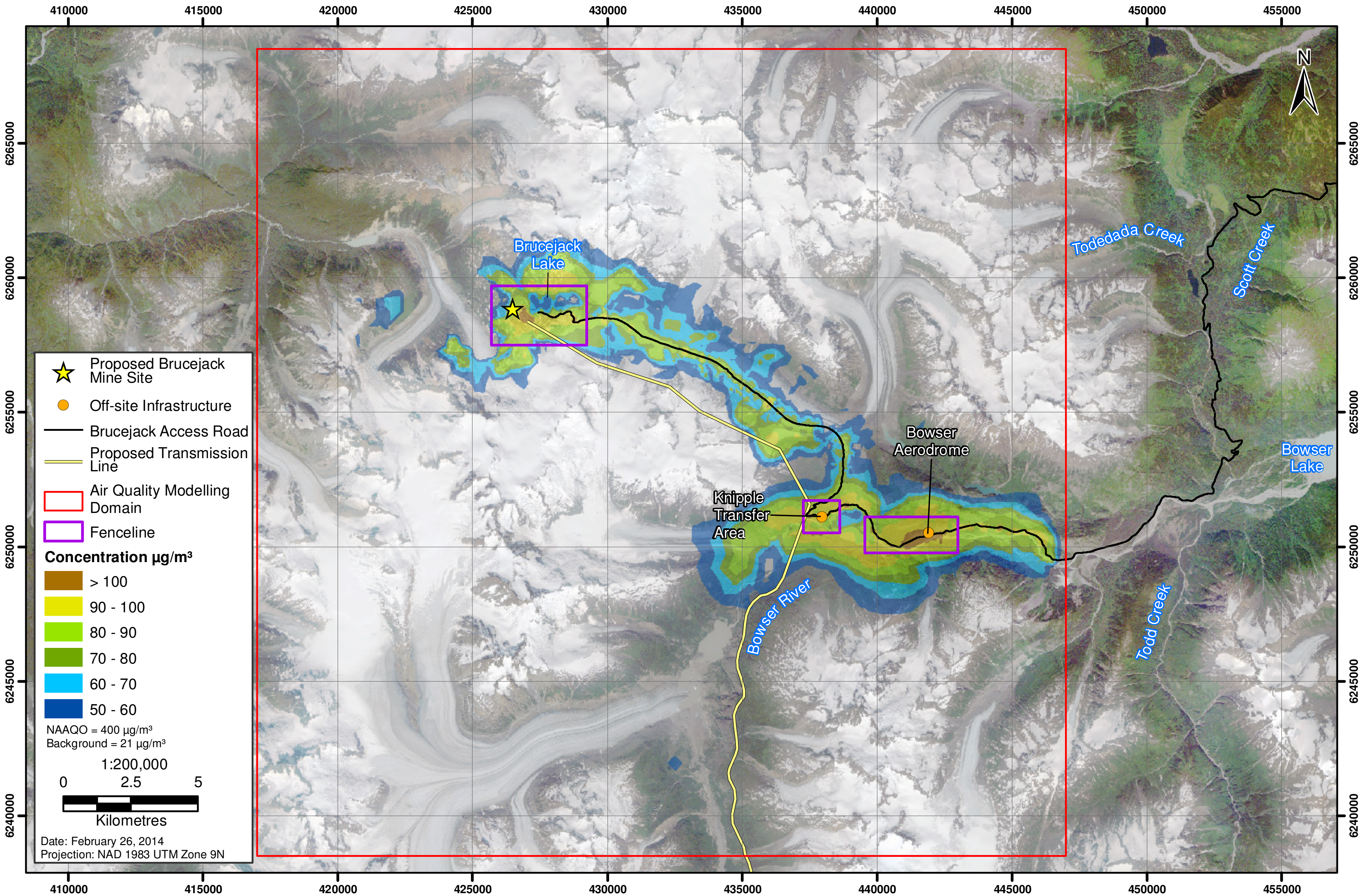


Figure 7.6-17

Maximum 24-hour NO_2 Concentration during Operation

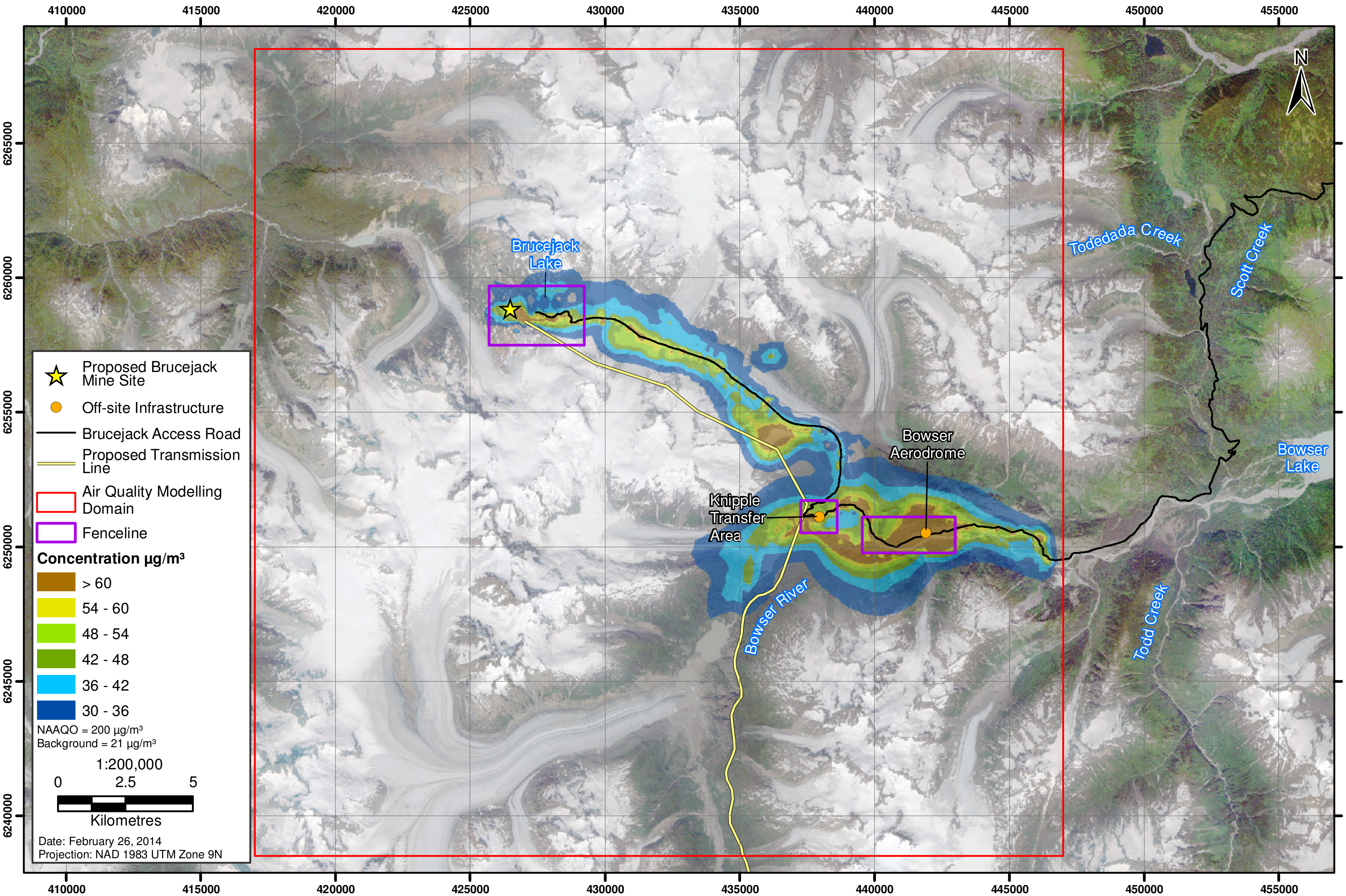


Figure 7.6-18
Annual NO_2 Concentration during Operation

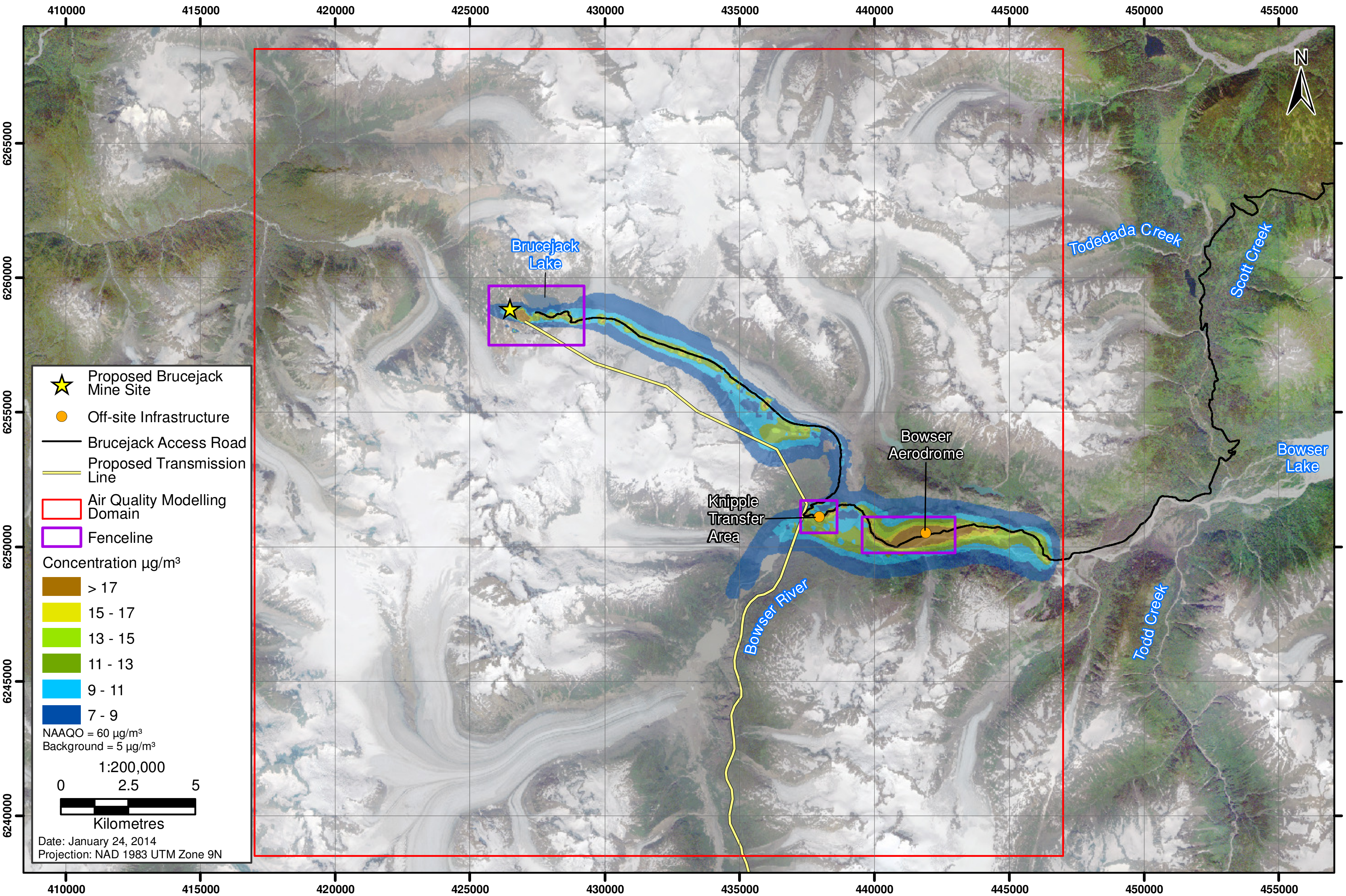


Figure 7.6-19
Maximum 1-hour SO_2 Concentration during Operation

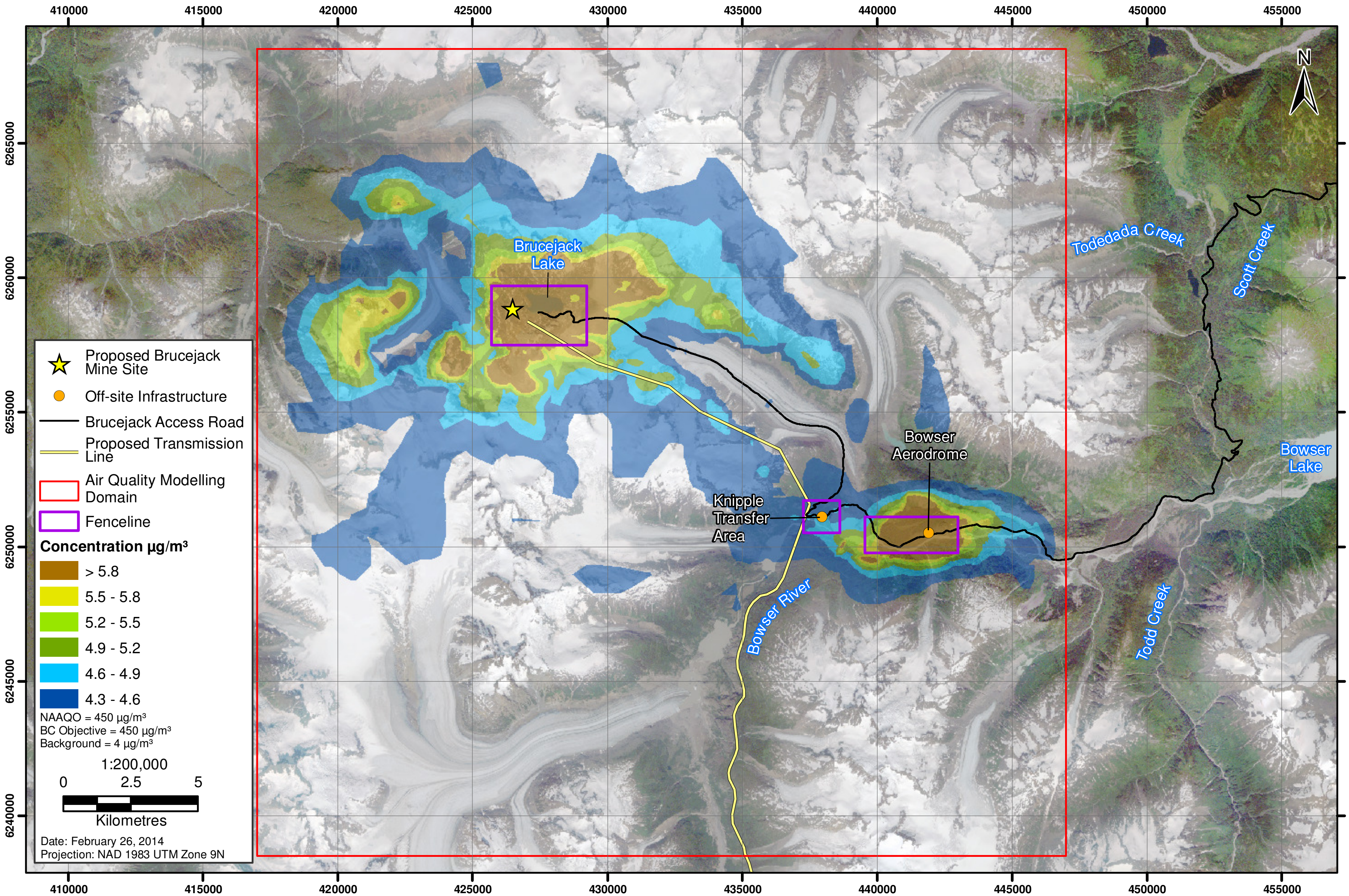


Figure 7.6-20

Maximum 24-hour SO_2 Concentration during Operation

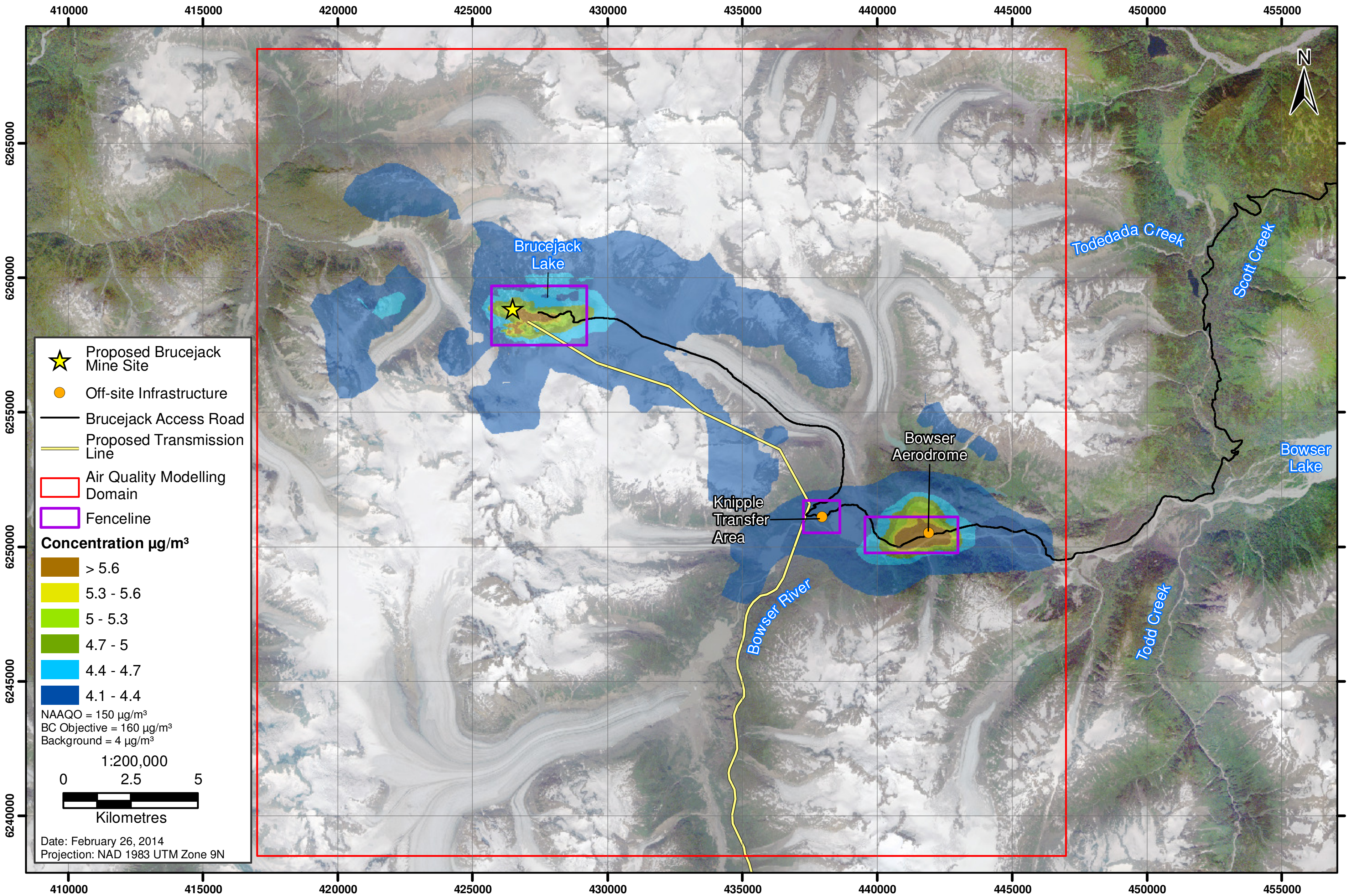
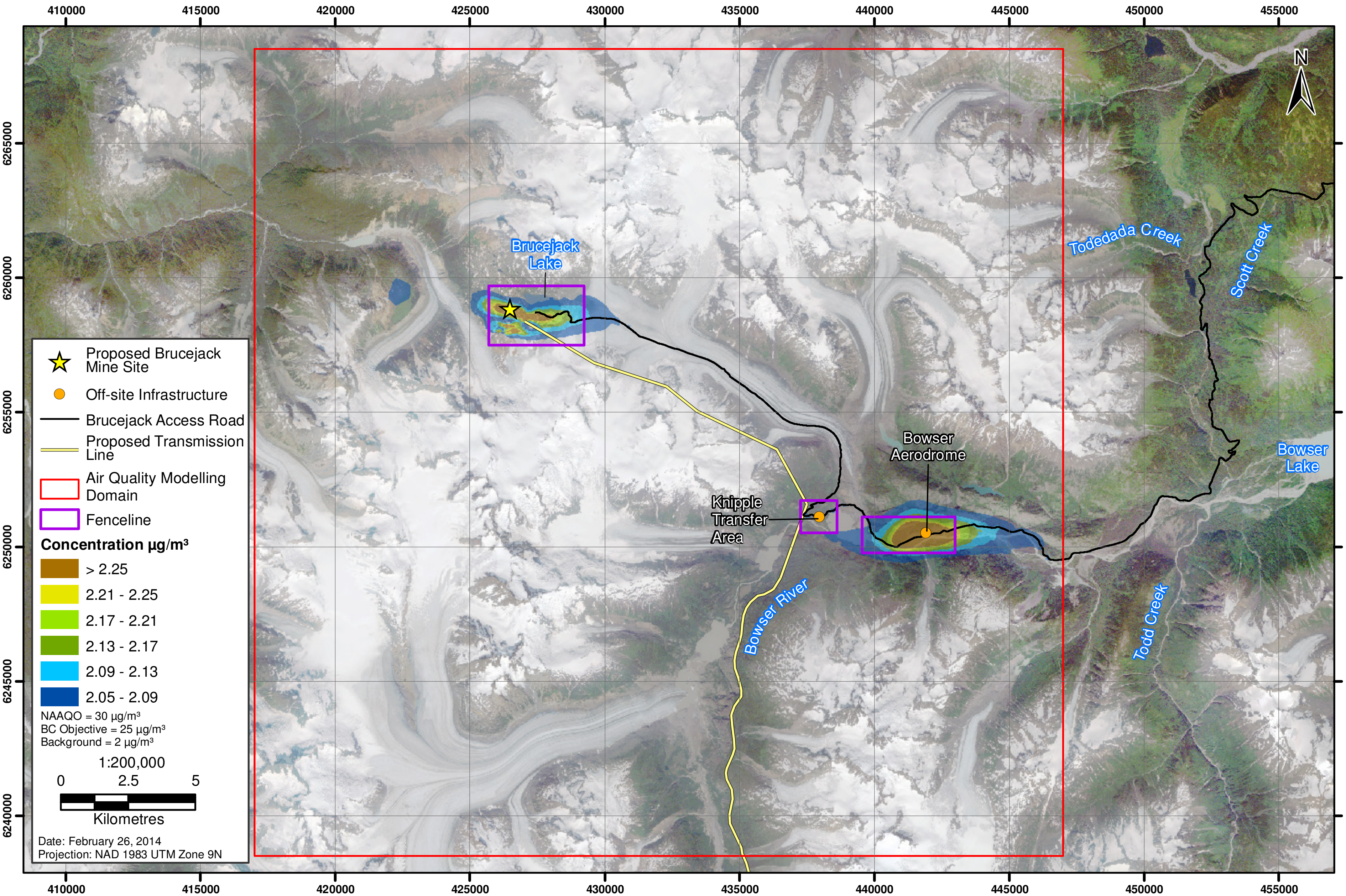


Figure 7.6-21
Annual SO_2 Concentration during Operation



7.6.3.3 Carbon Monoxide

The highest maximum 1-hour and 8-hour CO concentrations are summarized in Table 7.6-16 and are predicted to be 215 µg/m^3 and 148 µg/m^3, respectively, representing less than 3% of BC objectives, shown in Figures 7.6-22 and 7.6-23.

7.6.3.4 Total Suspended Particulate

The dispersion model results for TSP outside the mining fence line, summarized in Table 7.6-16, indicates no exceedances over the criteria for both averaging periods. The highest 24-hour TSP concentration of 79 µg/m^3, predicted to occur by the access road between Knipple Transfer Area and Bowser Aerodrome, represents approximately 66% of the NAAQO and 53% of the BC objective. The 50 µg/m^3 concentration contour (42% of NAAQO) does not extend beyond the fence line at the mine site area and extends less than 500 m on either side of the access road (Figure 7.6-24).

The highest annual TSP concentration of 29 µg/m^3 was predicted to occur in close proximity to the access road east of the Bowser Aerodrome area and represents approximately 50% of the relevant criteria (Figure 7.6-25). The 18 µg/m^3 concentration level representing 30% of the criteria extends to less than 500 m on either side of the access road.

7.6.3.5 PM_{10}

The predicted 24-hour PM_{10} concentration of 58 µg/m^3, presented in Table 7.6-16, exceeds the BC objective of 50 µg/m^3, however, this exceedance is predicted to occur only one day per year. The exceedances were predicted to occur by the access road between the Knipple Transfer Area and Bowser Aerodrome when the road turns towards the south. However, the exceedances do not extent beyond 600 m from the centre line of the access road (Figure 7.6-26). The frequency of exceedance at this location of one day in a year is approximately 0.3% of the time. Although an exceedance is predicted, the extent and frequency of the exceedance predicted is limited.

7.6.3.6 $PM_{2.5}$

The maximum $PM_{2.5}$ concentrations predicted for the Operation phase are summarized in Table 7.6-16 with no exceedance over the BC objectives, current NAAQOs, or CAAQs that will come in effect in 2015 and 2020. The highest 24-hour $PM_{2.5}$ concentration of 6.9 µg/m^3, representing 28% of the BC objective and 20% of the current NAAQO, was predicted to occur close to the access road east of the Bowser Aerodrome area where the access road bends (Figure 7.6-27). The predicted concentration of 6 µg/m^3, which represents 24% of the BC objective, does not extend beyond the fence line at the Brucejack Mine Site, but extends approximately 200 m south of the Knipple Transfer Area and covers an area with a diameter of less than 250 m between the Knipple Transfer Area and Bowser Aerodrome. The 6 µg/m^3 isopleth also extends less than 500 m on either side of the access road at a few locations.

The highest annual $PM_{2.5}$ concentration was predicted to occur on the fence line east of the Knipple Transfer Area by the access road (Figure 7.6-28). The highest value of 4.2 µg/m^3 represents 53% of the BC objective and 42% of the CAAQS of 10 µg/m^3, which will be in effective in 2015. The 2 µg/m^3 concentration contour level, representing 25% of the BC objective, extends less than 2 km from the sources.

Figure 7.6-22
Maximum 1-hour CO Concentration during Operation

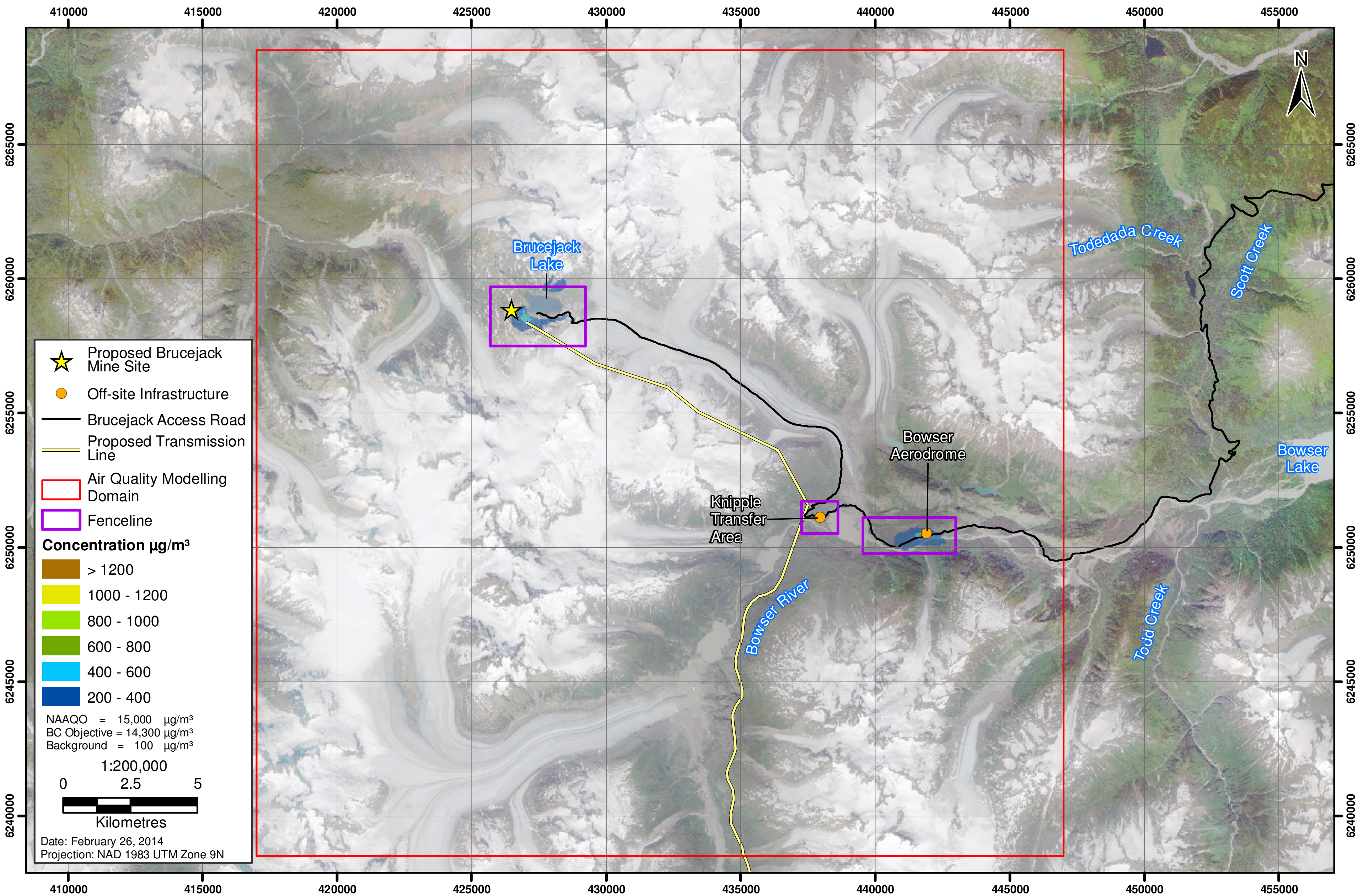


Figure 7.6-23
Maximum 8-hour CO Concentration during Operation

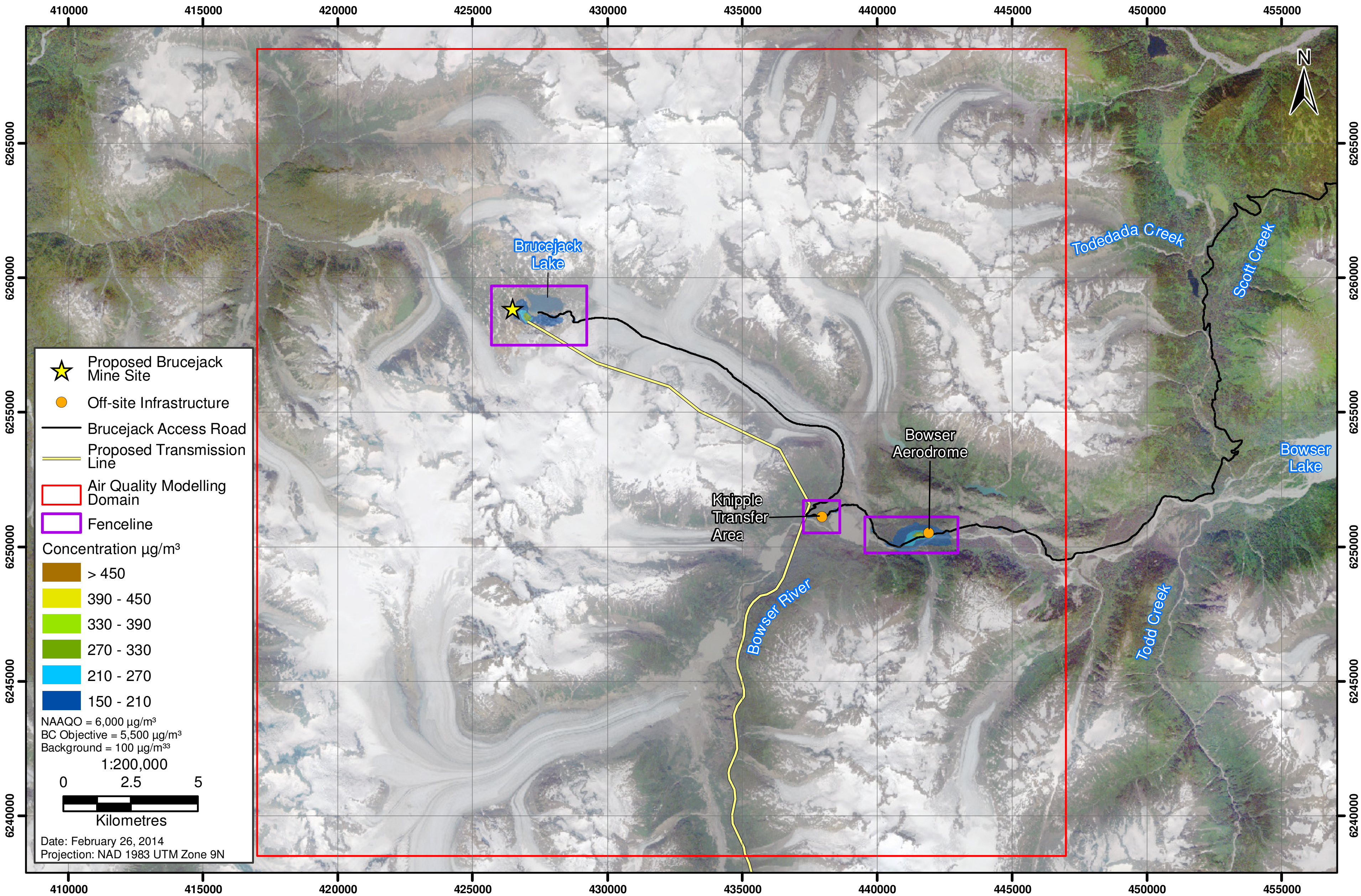


Figure 7.6-24
Maximum 24-hour TSP Concentration during Operation

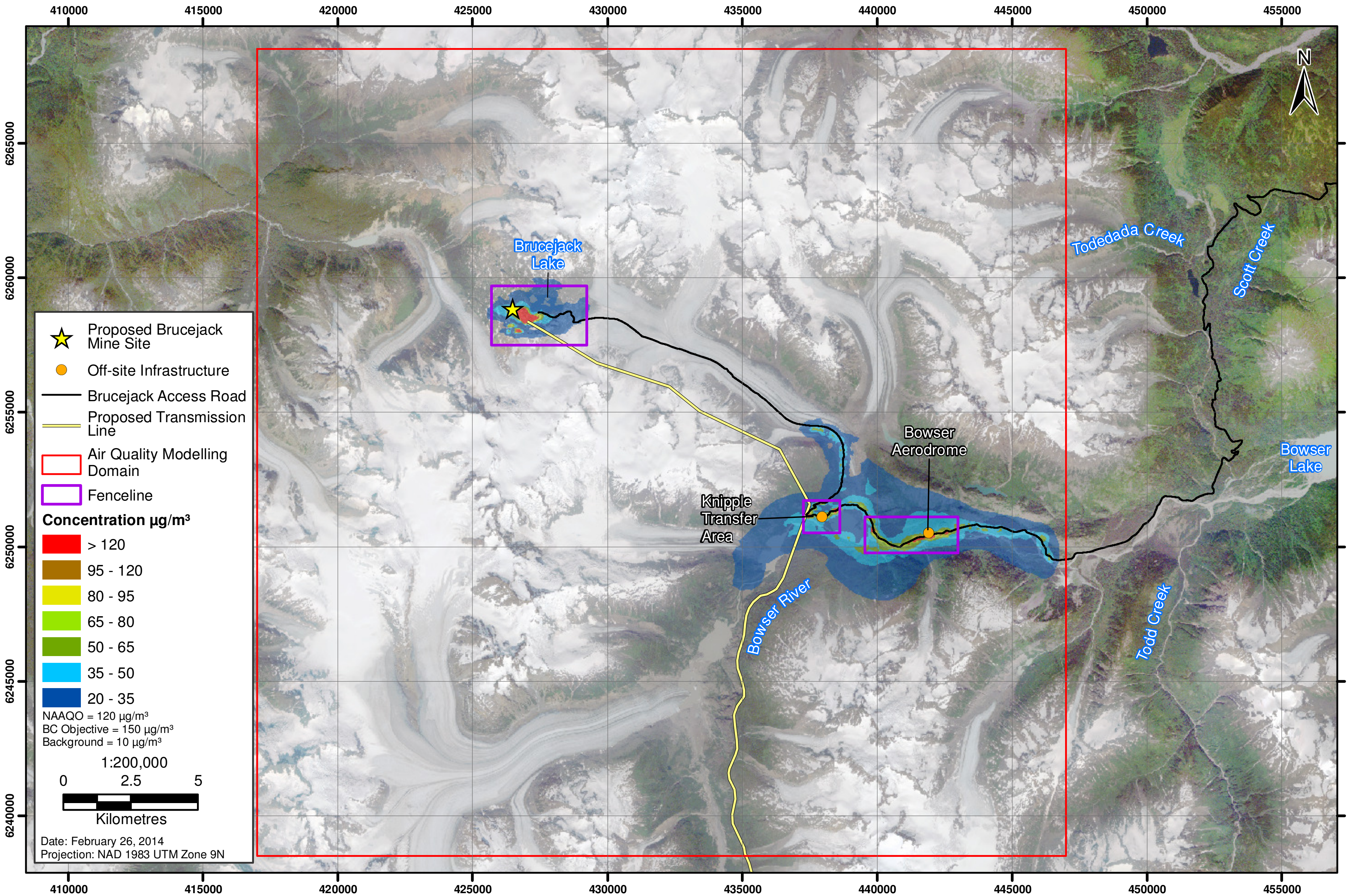


Figure 7.6-25

Annual TSP Concentration during Operation

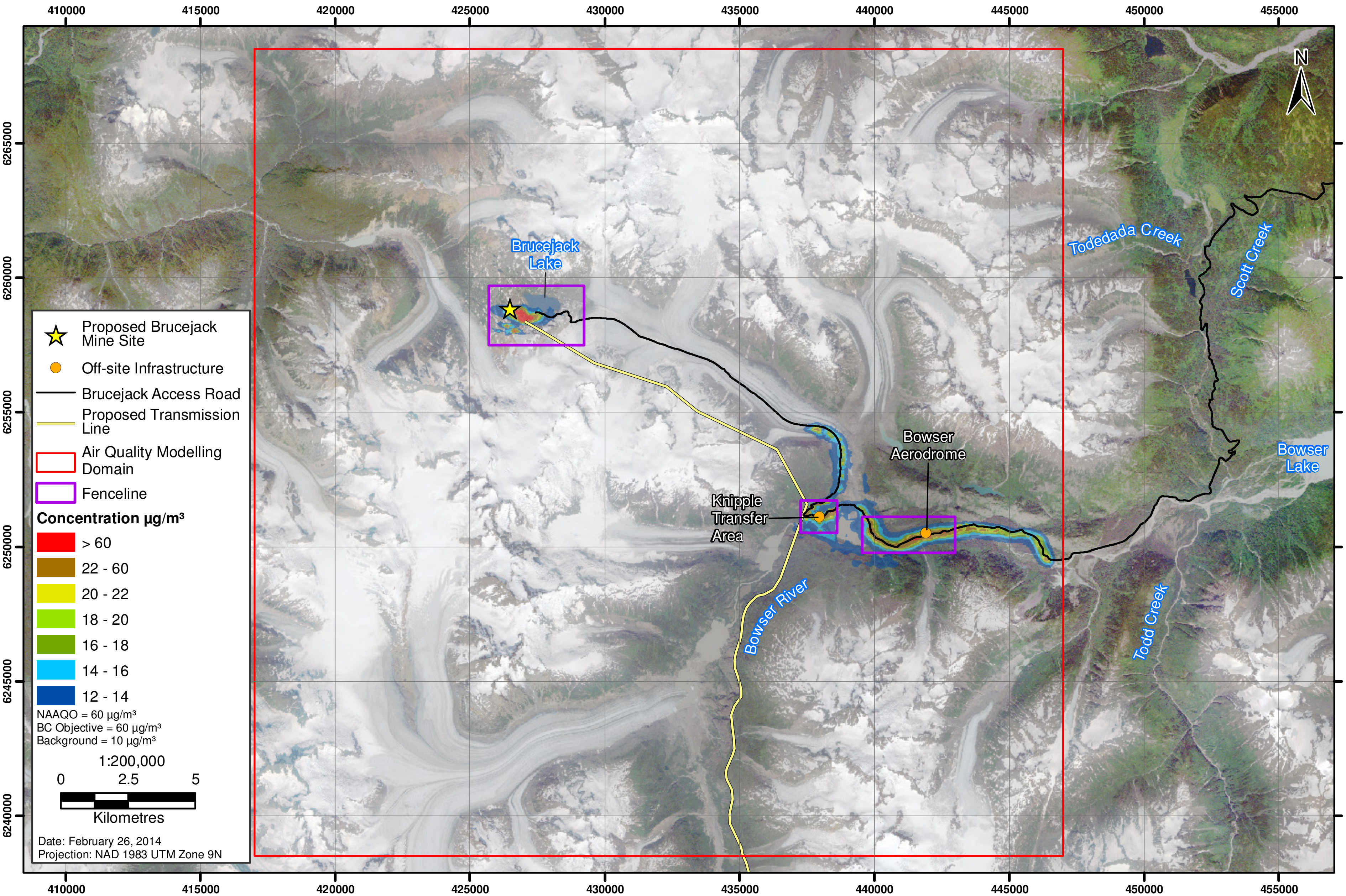


Figure 7.6-26

Maximum 24-hour PM_{10} Concentration during Operation

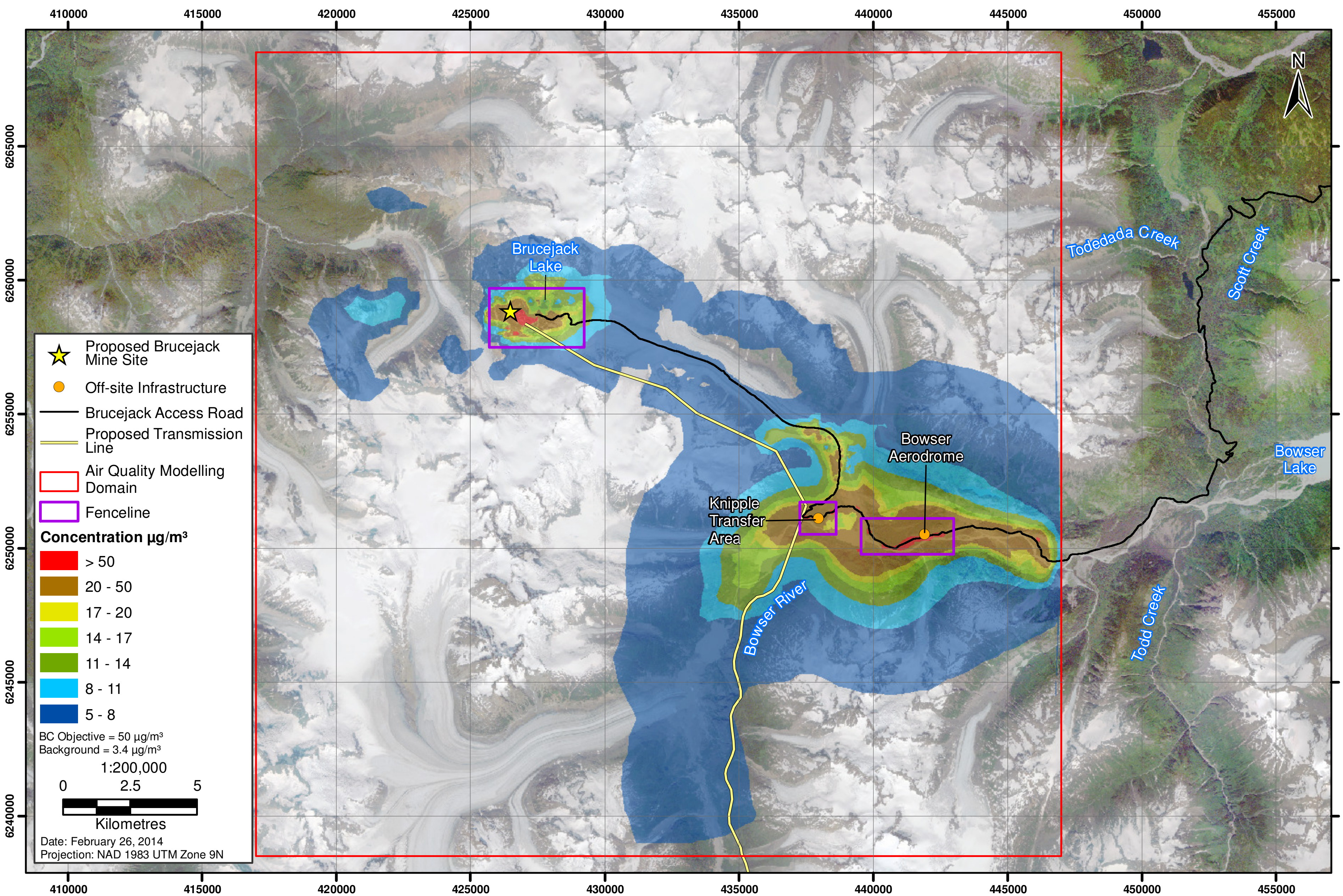


Figure 7.6-27
Maximum 24-hour $PM_{2.5}$ Concentration during Operation

ERM

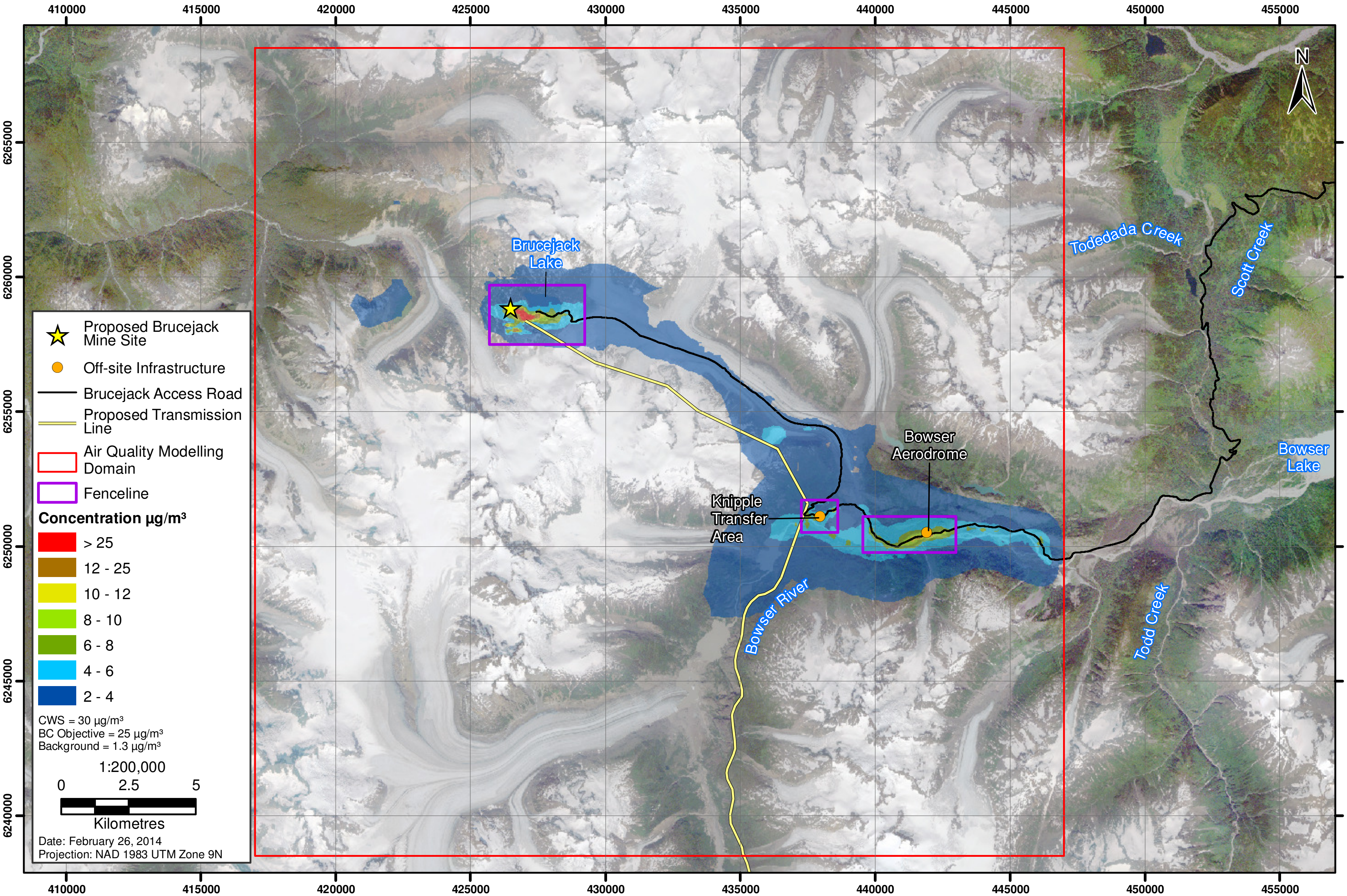
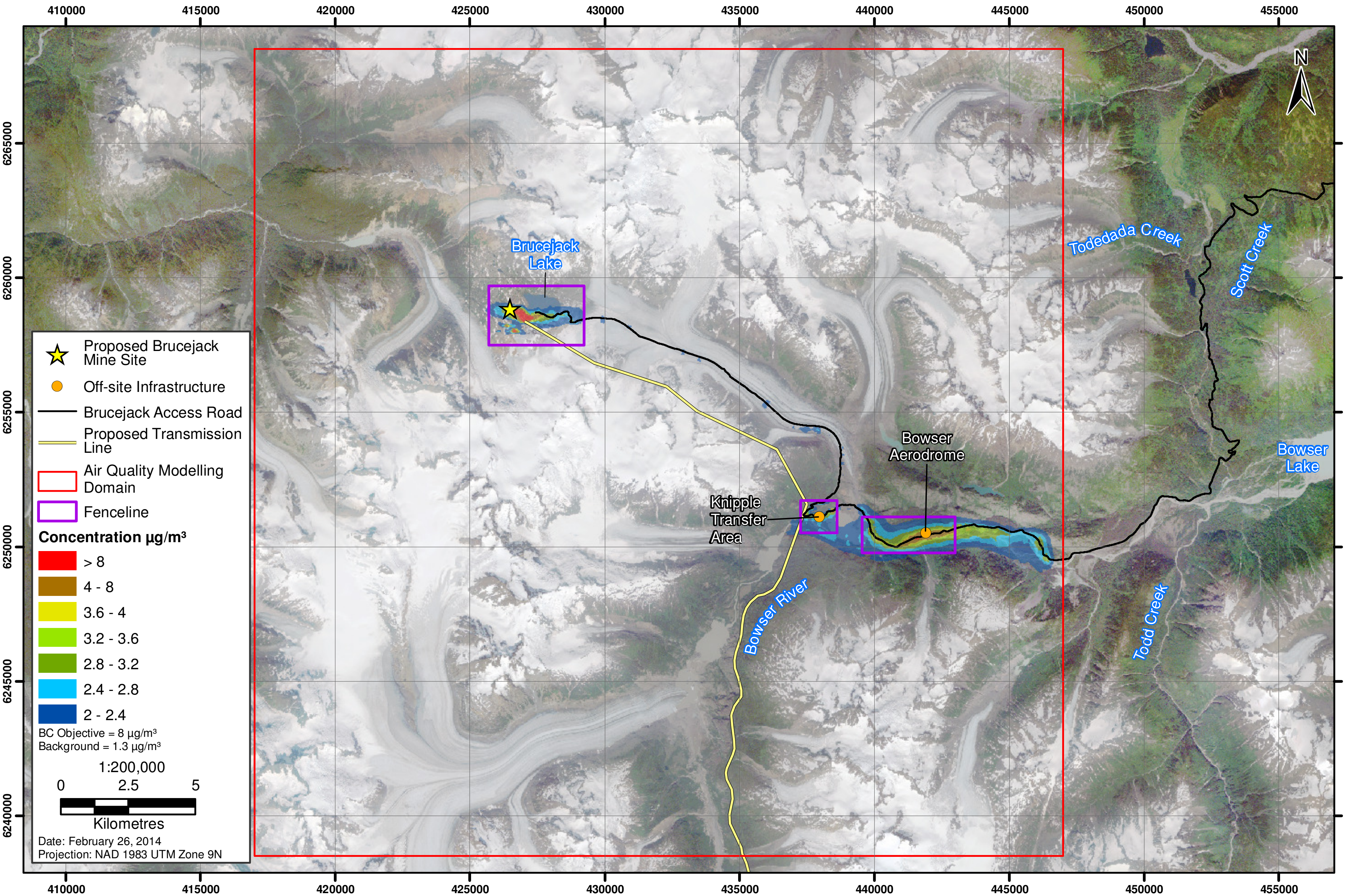


Figure 7.6-28

Annual $PM_{2.5}$ Concentration during Operation



7.6.3.7 Dust Deposition

The Project's highest 30-day dust deposition rate of 3.7 mg/dm^2/day (Table 7.6-15) was predicted on the south side of the access road from the Brucejack Mine Site to the Knipple Transfer Area where the road bends south; however, the most frequent exceedance of nine times in a year was predicted on the access road immediately east of the Bowser Aerodrome, representing 75%[2] of the time in a year. Since dustfall is mainly contributed to by fugitive dust, the portion of the access road on the glacier does not show exceedance since road dust is not expected on glaciers. Also note that dust deposition model did not account for snow cover in the winter which is approximately six to seven months a year; therefore, actual frequency of exceedance would be limited to the summer months only.

The exceedances over the BC objective of 2.9 mg/dm^2/day were only predicted within 170 m on either side of the road (Figure 7.6-29). Due to road dust caused by vehicle traffic on unpaved roads, elevated dust deposition in close vicinity to the access road is expected. In this Project, dustfall reaches 0.8 mg/dm^2/day (12.5% increase from baseline) within 2.5 km from the Project fence line. From the access road alone, the 0.8 mg/dm^2/day increase does not extend beyond 1.3 km on either side of the road.

7.6.3.8 Acid Deposition

The highest acid deposition outside the Project fence line during the Operation phase was predicted to be 366 eq/ha/year and occurred along the access road east of the Bowser Aerodrome. The acid levels are presented in Figure 7.6-30 and Table 7.6-15.

Table 7.6-16 summarizes the predicted maximum concentrations and deposition rates during Operation.

7.7 MITIGATION MEASURES FOR AIR QUALITY

The goal of mitigating emissions starts with avoiding the emission sources followed by controlling the sources. Various mitigation measures have already been incorporated into the Project during the design stage. The assessment of the emissions discussed in Section 7.5.1 and the potential changes to air quality in Section 7.6 have already included these mitigation measures. The specific mitigating changes are discussed in the following sections and more detail can be found in the Air Quality Management Plan (Section 29.2).

7.7.1 Underground Mining Process

Underground mining processes typically have less effect on the environment compared to open-pit mining processes. For this Project, blasting and part of the material handling and ore processing will occur underground, limiting the changes to air quality. Due to the large particle sizes, fugitive dust sources do not typically travel upward toward the air raises, to be eventually transported to the ambient air.

In the underground mine, the air quality is expected to meet the standards set in the Health, Safety and Reclamation Code for Mines in British Columbia by BC Ministry of Energy and Mines (BC MEMPR 2008). By limiting the pollutant concentrations underground, the emission rate from the underground mines through the air raises would also be controlled.

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[2] Dust deposition model did not account for snow cover in the winter which is approximately six to seven months a year; therefore, actual frequency of exceedance would be limited to the summer months only.

Figure 7.6-29

Maximum 30-day Dust Deposition during Operation

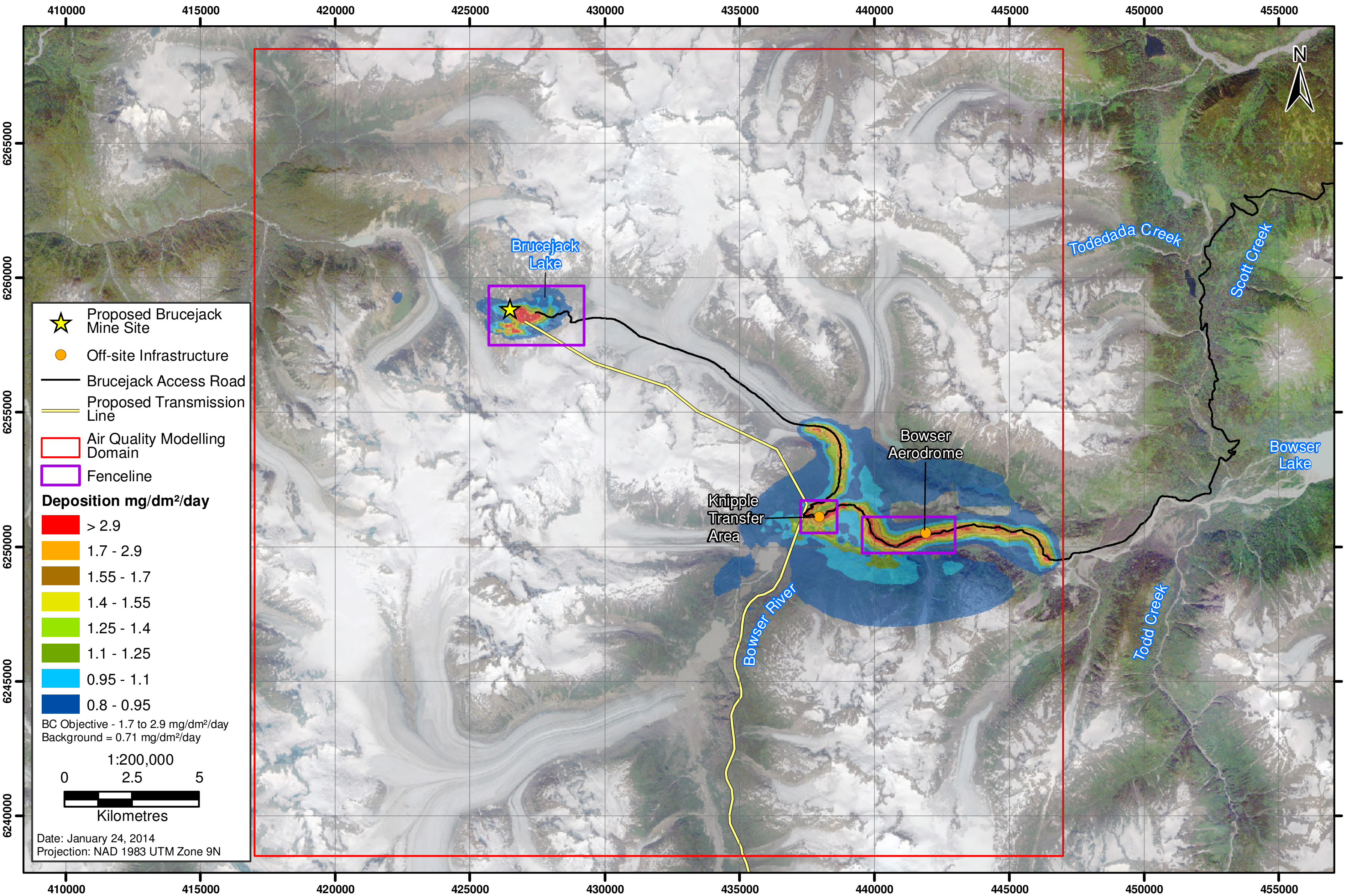
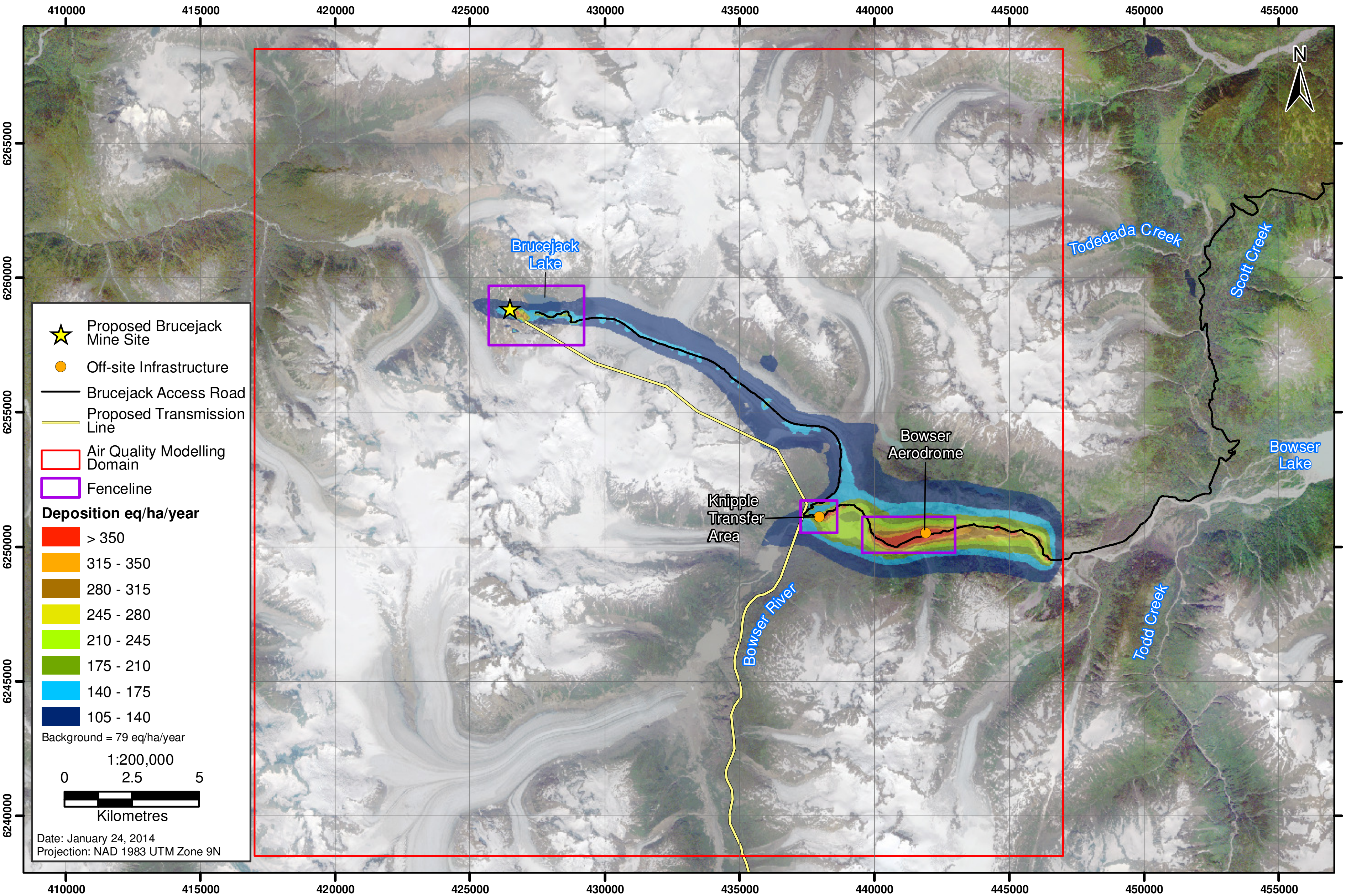


Figure 7.6-30
Annual Acid Deposition during Operation



7.7.2 Equipment and Vehicles

Equipment and vehicles used for this Project will be maintained on a regular basis to ensure their effectiveness. Regular inspections will be conducted and parts showing signs of excessive wear or damage will be replaced promptly. Poorly maintained engines can use up to 50% more fuel (D. Cope Enterprises 2004). Studies indicate 1995 model-year and older vehicles produce smog up to 19 times greater than a new vehicle (Summerhill 2013). Moreover, the Project is planning to connect to a transmission line in order to eliminate the use of diesel generators during the Operation phase, therefore reducing emissions.

7.7.3 Unpaved Access Road

When a vehicle travels on an unpaved road, the force of the wheels on the road surface causes pulverization of surface material, with the quantity of resultant dust emissions dependant on the fraction of silt and road surface material. Various mitigation measures can be applied to reduce unpaved road dust such as paving the road, changing the road surface material, or applying surface treatments. Paving the road is typically costly and not generally necessary for private roads. The silt content of the material usually varies with location and is difficult to change. The most frequently used method is to apply surface treatments. There are two main categories of surface treatments, wet suppression and chemical stabilization. Wet suppression, or watering the road, increases the moisture content, which conglomerates particles and reduces the likelihood of them becoming re-suspended when vehicles pass over the surface. Chemical stabilization or chemical suppressants are more effective than watering, but may also introduce other environmental issues by introducing chemicals in the soil and eventually into the water stream. Unpaved access roads will be watered to mitigate road dust. With at least 2% moisture ratio, fugitive dust emissions can be reduced by 75% (US EPA 2006a).

7.7.4 Baghouse and Scrubber

Crushing can be a significant source of dust emissions if not mitigated. Crushing of low- and high-moisture ore produces significantly different amounts of particulate matter. Primary crushing of ore will take place underground to control fugitive dust emissions to the environment. The crushed ore will be transported to the mill through the conveyor decline where ore will be further processed. It is important to consider the air speed in the conveyor decline, to determine that it is not high enough to cause re-suspension of dust. Since the drift air will be flowing into the conveyor decline while the ore conveyor will be moving out of the conveyor, the differential air velocity is the factor to be considered. The design conveyor speed is 0.5 m/s and the design drift velocity of air flowing into the conveyor decline will have a maximum velocity of 5 m/s. Therefore, the resulting air flow in the conveyor decline should not exceed approximately 4.5 m/s (Brucejack Feasibility Study, Appendix 5-A).

Other than increasing the moisture content of the ore, installation of baghouses is the most common mitigation method. Fabric filters generally collect particles with sizes ranging from submicron to several hundred microns in diameter at efficiencies in excess of 99% (US EPA 2002). Two baghouses, one underground and one on surface, will be installed with multiple dust pickup points along the crushing circuit to reduce fugitive dust emissions.

Sulphur exists in the gold gravity concentrate (about 15 to 20%). In order to reduce SO_2 emissions from the gold refinery process, a scrubber will be installed in the gold room. Although the scrubber will be installed mainly to reduce SO_2 emissions, the scrubber will also reduce particulate emissions; however, to be conservative, the reduction in particulate emissions was not included in the assessment. Control efficiencies of scrubbers vary with scrubber type. For example, wet limestone systems are mostly designed for 90% removal but some may show up to 98% removal. The lime spray drying process has a median reduction efficiency of 90%, while spray dryers often achieve greater than 90% SO_2 removal (US EPA 2000).

7.7.5 Best Practices

Other than the mitigation measures mentioned above, other best practices will also be adopted where possible. Below are some of the suggested practices that may be adopted by the Project:

- using add-ons such as cabin heaters to reduce idling;
- optimizing driving speed to reduce fuel usage and fugitive road dust;
- minimize drop distance of material into the surge bin, stockpiles, or between conveyor belts.

7.8 PREDICTED CHANGES ON AIR QUALITY

According to the dispersion model results presented in Section 7.6, the Project will result in a change in air quality conditions. The changes in indicators are described in Table 7.8-1.

Table 7.8-1. Summary of Predicted Changes after Mitigation for Air Quality

Indicators	Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[a]	Description of Mitigation Measure(s)	Description of Predicted Change(s)
NO_2, SO_2, CO, TSP and $PM_{2.5}$	Construction and Operation	Construction and Operation activities	Project emissions that lead to increased concentrations of CACs	Maintaining equipment, installing scrubber, installing baghouses and watering the road	Increase in concentration but no exceedance was predicted
PM_{10}	Construction and Operation	Construction and Operation activities	Project emissions that lead to increased concentrations of CACs	Maintaining equipment, installing scrubber, installing baghouses and watering the road	Increase in concentration with infrequent exceedance and limited extent
Dustfall	Construction and Operation	Construction activities	Project emissions that lead to increased deposition of dust	Maintaining equipment, installing scrubber, installing baghouses and watering the road	Increase in deposition rate with but limited extent

[a] *"Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the intermediate component, and the actual change or effect that results.*

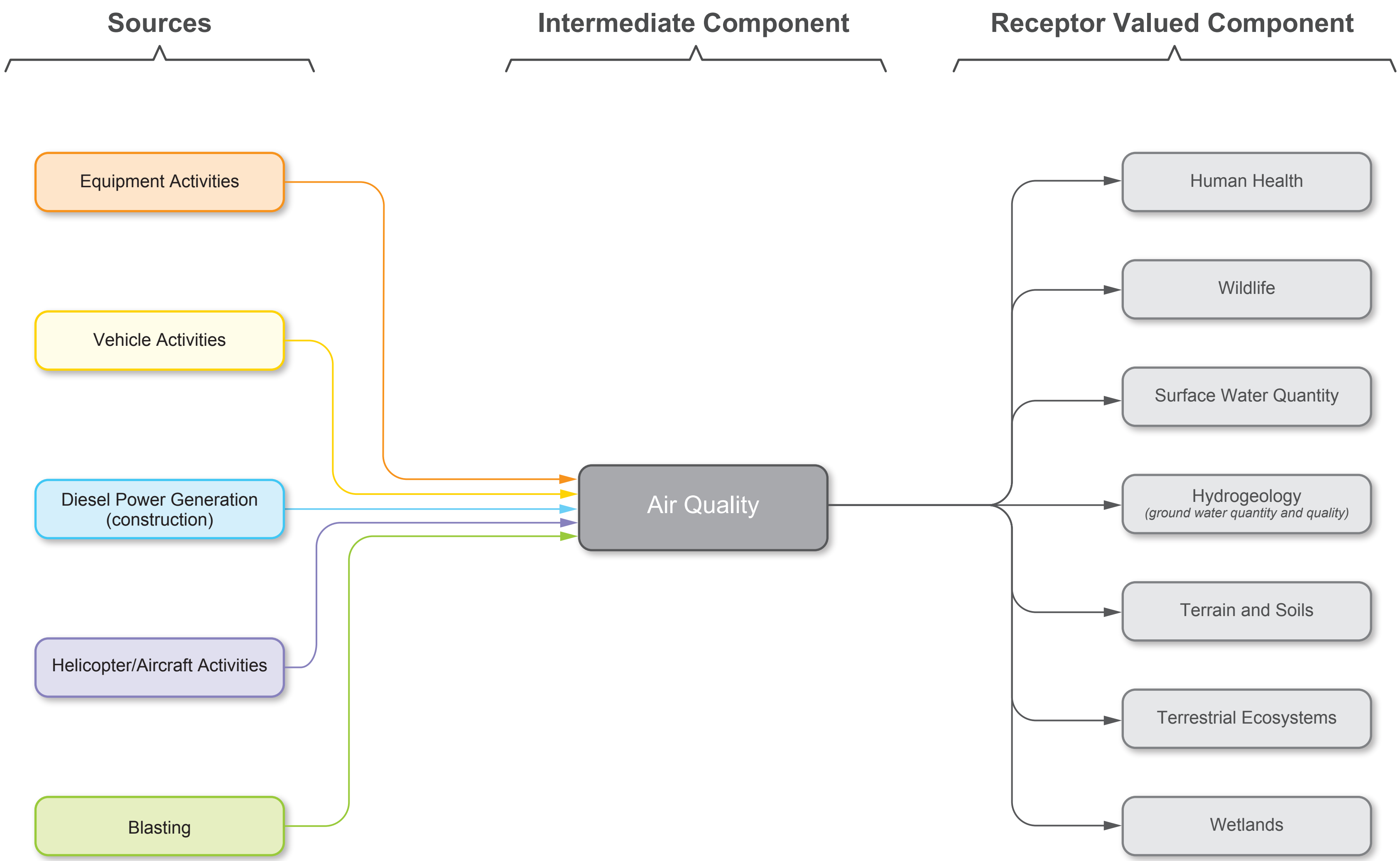
The change to air quality during the Construction and Operation phases increases in concentrations and deposition of several CACs. Although exceedances were predicted for PM_{10} and dustfall, the frequency of exceedance for PM_{10} was small and the extent of exceedance for both was limited. The source of emissions will be continuous but the change in levels varies throughout the year and throughout the mine life; therefore, the frequency of the change to air quality is considered regular. The change in ambient air quality is expected to be limited to up to 10 km for CACs and within 1 km for fugitive dust. The resilience of the area for change in air quality is considered medium. Although the change in ambient air quality is regular in frequency during the Construction and Operation phases, ambient air quality will return to baseline conditions once the activities cease so the changes are reversible.

7.9 AIR QUALITY AS A PATHWAY TO RECEPTOR VALUED COMPONENTS

As mentioned previously, air quality is an important environmental factor in ensuring the conservation of local vegetation, wildlife, and human health. Poor air quality can adversely affect human health and dustfall may affect the conservation of soil and vegetation. The CACs included in this study have the potential to affect the environment and human health. The linkage between air quality and receptor VCs are presented in Figure 7.9-1.

Figure 7.9-1

Linkage between Air Quality and Receptor Valued Components



Air quality may directly result in change in soil and vegetation quality and terrestrial ecology. Change in vegetation may affect wildlife and also consequently may change the quality of country foods. Dust deposition may alter water quality and wetlands. Degradation of air quality may also directly affect human health through inhalation.

The potential impacts of air quality on receptor VCs are described in:

- Chapter 10, Surface Water Hydrology Predictive Study;
- Chapter 11, Terrain and Soils Predictive Study;
- Chapter 13, Assessment of Potential Surface Water Quality Effects;
- Chapter 16, Assessment of Potential Terrestrial Ecology Effects;
- Chapter 17, Assessment of Potential Wetlands Effects;
- Chapter 18, Assessment of Potential Wildlife Effects; and
- Chapter 21, Assessment of Potential Health Effects.

7.10 CUMULATIVE CHANGE FOR AIR QUALITY

Cumulative changes relate to changes "*which are likely to result from the designated project in combination with other projects and activities that have been or will be carried out*". This definition follows that for cumulative effects in Section 19(1) of the *Canadian Environmental Assessment Act,* 2012 (2012) and is consistent with the IFC Good Practice Note on Cumulative Impact Assessment (ESSA Technologies Ltd. and IFC 2012), which refers to consideration of other existing, planned, and/or reasonably foreseeable future projects and developments. This cumulative change assessment provides information to supplement the Cumulative Effects Assessment (CEA) for the receptor VCs, which is a requirement of the AIR and the EIS Guidelines and is necessary for the proponent to comply with the *Canadian Environmental Assessment Act, 2012* (2012) and the BC *Environmental Assessment Act (2002)*.

The assessment method adopted here complies with the Canadian Environmental Assessment Agency (CEA Agency) *Operational Policy Statement Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012* (CEA Agency 2013) and the *Guideline for the Selection of Valued Components and the Assessment of Potential Effects* (BC EAO 2013). The method involves the following key steps, which are further discussed in the proceeding sub-sections:

- scoping;
- analysis;
- identification of mitigation measures;
- identification of residual cumulative changes; and
- characterization of residual cumulative changes.

7.10.1 Establishing the Scope of the Cumulative Change Assessment

The scoping process involves identification of the intermediate components for which residual changes are predicted, definition of the spatiotemporal boundaries of the assessment, and an examination of the relationship between the residual changes of the Project and those of other projects and activities.

7.10.1.1 Identifying Intermediate Components for the Cumulative Change Assessment

Air quality as an intermediate component in this assessment was selected using four criteria following BC EAO (2013):

- there must be a residual change as a result of the Project being proposed;

- that predicted change in the condition of the intermediate component must be demonstrated to interact cumulatively with residual environmental effects from other projects or activities;
- it must be known that the other projects or activities have been or will be carried out and are not hypothetical; and
- the cumulative environmental effect must be likely to occur.

7.10.1.2 Potential Interaction of Projects and Activities with the Brucejack Gold Mine Project for Air Quality

A review of the interaction between predicted changes on intermediate components from the Project and effects of other projects and activities on air quality was undertaken. The review assessed the projects and activities identified in Section 6.8.2 of the Assessment Methodology, including:

- regional projects and activities that are likely to affect the intermediate component, even if they are located outside the direct zone of influence of the project;
- effects of past and present projects and activities that are expected to continue into the future (i.e., beyond the effects reflected in the existing conditions of the intermediate component);
- activities not limited to other reviewable projects, if those activities are likely to affect the intermediate component cumulatively (e.g., forestry, mineral exploration, commercial recreational activities).

Ambient air quality returns to baseline levels after the sources are removed. Therefore, for a cumulative change to exist there would need to be both spatial and temporal overlap simultaneously. A matrix identifying the potential cumulative interactions for air quality is provided in Table 7.10-1.

Table 7.10-1. Potential Cumulative Change Interactions for Air Quality

Projects and Activities	Air Quality
Historical	
Eskay Creek Mine	
Goldwedge Mine	
Granduc Mine (Past Producer)	
Johnny Mountain Mine	
Kitsault Mine (Past Producer)	
Silbak Premier Mine	
Snip Mine	
Sulphurets Project	
Swamp Point Aggregate Mine	
Present	
Brucejack Exploration	
Forrest Kerr Hydroelectric Power	
Long Lake Hydroelectric	
McLymont Creek Hydroelectric Project	
Northwest Transmission Line	
Red Chris Mine	

(continued)

Table 7.10-1. Potential Cumulative Change Interactions for Air Quality (completed)

Projects and Activities	**Air Quality**
Reasonably Foreseeable Future	
Arctos Anthracite Coal Mine	
Bear River Gravel	
Bronson Slope Mine	
Coastal GasLink Pipeline Project	
Galore Creek Mine	
Granduc Copper Mine	
KSM Project	
Kinskuch Hydroelectric Project	
Kitsault Mine	
Kutcho Mine	
LNG Canada Export Terminal Project	
Northern Gateway Pipeline Project	
Prince Rupert Gas Transmission Project	
Prince Rupert LNG Project	
Schaft Creek Mine Project	
Spectra Energy Transmission Line Project	
Storie Moly Mine	
Treaty Creek Hydroelectric Project	
Turnagain Mine	
Volcano Hydroelectric Project	

Black = likely interaction between Brucejack Gold Mine Project and other project or activity
Grey = possible interaction between Brucejack Gold Mine Project and other project or activity
White = unlikely interaction between Brucejack Gold Mine Project and other project or activity

7.10.1.3 Spatio-temporal Boundaries of the Cumulative Change Assessment

The assessment boundaries define the maximum limit within which the assessment is conducted. They encompass the areas within, and times during which, the Project is expected to interact with the intermediate component and with other projects and activities, as well as the constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part of the air quality cumulative change assessment, and encompasses possible direct, indirect, and induced changes of the Project on air quality.

Spatial Boundaries

The spatial linkages between the Project and other projects are shown in Figure 7.10-1. For air quality, spatial linkage is defined as any projects that have sources that may change air quality inside the Brucejack air quality RSA. Projects that have spatial interaction with the Brucejack Gold Mine Project are:

- Goldwedge Mine;
- Sulphurets Project;
- KSM Project; and
- Treaty Creek Hydroelectric Project.

Temporal Boundaries

The Construction phase of the Project is expected to start in 2015 and an Operation phase lasting approximately 22 years will follow immediately after construction ends. Production is expected to start in the third quarter of 2016. The Project timeline is expected to overlap spatially and temporally with the following past, present, and reasonably foreseeable future projects:

- Brucejack Exploration;
- KSM Project; and
- Treaty Creek Hydroelectric Project.

As previously mentioned, cumulative change exist only if there is both spatial and temporal overlap. In this case, Goldwedge Mine, Sulphurets Project, and Brucejack Exploration will not have a cumulative interaction with the Brucejack Gold Mine Project; therefore, these projects are not carried further into consideration.

7.10.1.4 Potential for Cumulative Changes

The mine area of the KSM Project will be located approximately 5 km northwest of the Brucejack Gold Mine Project area and the processing plant will be located approximately 15 km northeast of the Brucejack Gold Mine Project area; therefore, there will be spatial interaction between the KSM Project and the Brucejack Gold Mine Project. The KSM Project's construction phase is expected to start in 2014 and operation in 2019. The timeline is similar to the Brucejack Gold Mine's proposed timeline of operation in 2016; therefore, each of the projects will have both spatial and temporal interactions. Potential cumulative changes to air quality from Brucejack Gold Mine Project, and other projects and activities are summarized in Table 7.10-2.

Table 7.10-2. Potential Cumulative Changes between the Brucejack Gold Mine Project Air Quality and Other Projects and Activities

	Brucejack Gold Mine Project	**Past Project or Activity**	**Existing Project or Activity**	**Reasonably Foreseeable Future Project or Activity**	**Type of Potential Cumulative Effect** *(physical-chemical transport, nibbling loss, spatial crowding, temporal crowding, synergistic, additive, growth inducing)*
Air Quality	X	-	Brucejack Exploration	KSM Project	additive

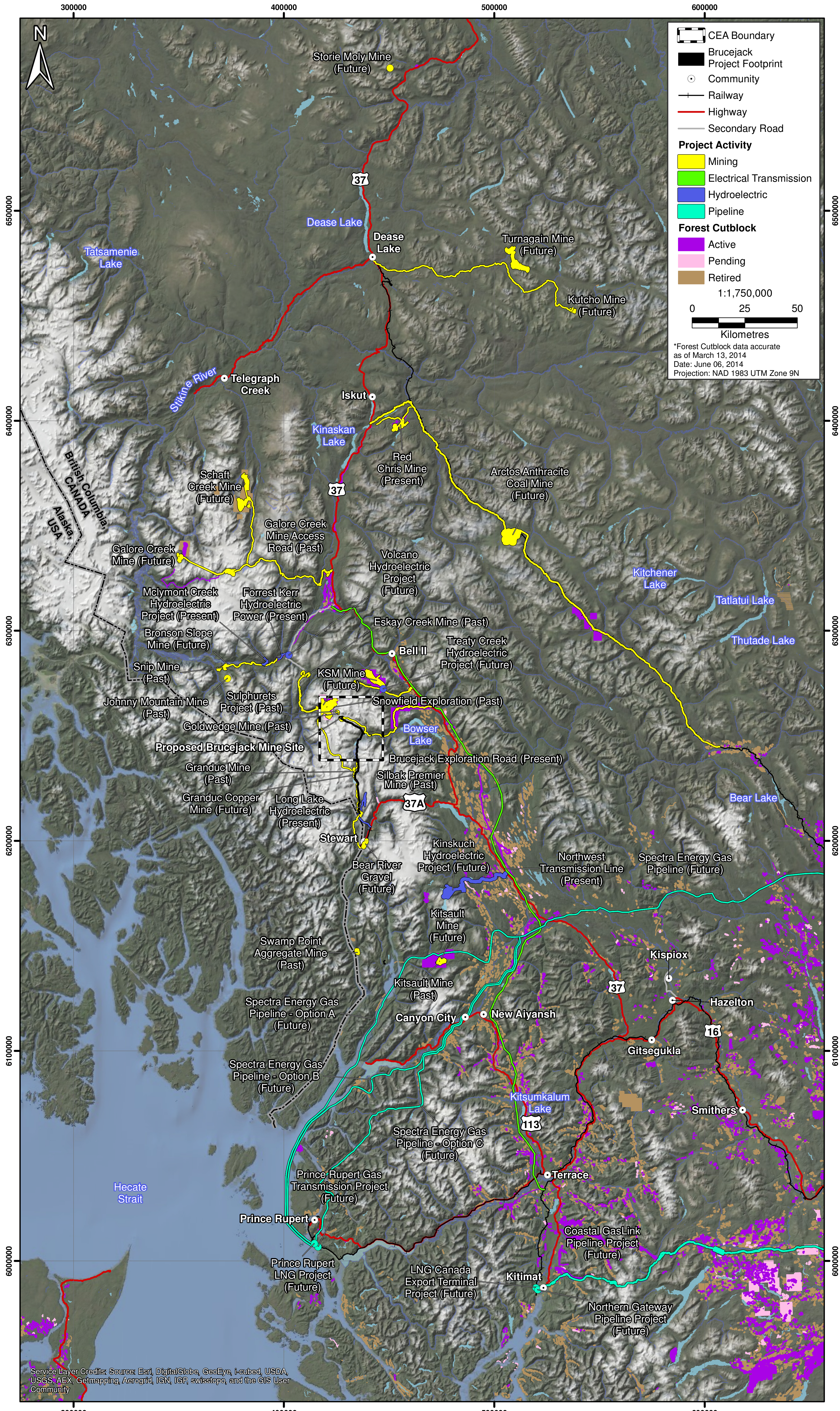
7.10.2 Analysis of Cumulative Changes

The KSM Project has the potential to interact spatially and temporally with the Brucejack Gold Mine Project. The change in air quality condition caused by the KSM Project needs to be considered in relation to the Brucejack Gold Mine Project. The decrease in air quality due to the project activities was assessed for the KSM Project. The increase in pollutant concentrations or dust deposition levels predicted in the KSM effects assessment at the Brucejack Mine Site was obtained from the KSM Project dispersion model results (Rescan 2013b). The incremental increases were applied to the maximum predicted concentrations or deposition predicted for the Brucejack Gold Mine Project, together with the background levels, in order to determine the future predicted level when both the Brucejack Gold Mine Project and KSM Project are in operation.

Figure 7.10-1

Air Quality CEA Boundary Showing all other Projects and Activities Relevant to Air Quality in the Vicinity of the Brucejack Mine Project

ERM



The calculation is shown as follows:

Future concentration = Background + Increment from Brucejack Gold Mine Project + Increment from KSM Project

The predicted increment from the KSM Project was obtained for the Brucejack Mine Site because the Mine Site is the closest facility to the KSM Project operation area and where the maximum cumulative change is expected.

7.10.3 Mitigation Measures to Address Cumulative Predicted Changes

Mitigation measures have been integrated into the design of the Project such as the use of baghouses and wetting of the access roads, and certain mitigation measures have been proposed by both the KSM Project and Brucejack Gold Mine Project.

7.10.4 Predicted Cumulative Changes for Air Quality

The increase in pollutant concentrations or dust deposition levels during operation due to the KSM Project at the Brucejack Gold Mine Project area, based on the combined dispersion model results, is summarized in Table 7.10-3.

The predicted NO_2 concentrations for 1-hour maximum are 144 $\mu g/m^3$, which is approximately 36% of the NAAQO. The 24-hour and annual concentrations of 97 $\mu g/m^3$ and 24 $\mu g/m^3$, respectively, are approximately half of the NAAQO. The predicted 1-hour (12 $\mu g/m^3$), 24-hour (6 $\mu g/m^3$), and annual (2.3 $\mu g/m^3$) SO_2 concentrations are less than 10% of the most stringent criteria. The maximum predicted 1-hour and 8-hour CO concentrations are less than 4% of the BC objectives.

The highest 24-hour TSP maximum concentration of 92 $\mu g/m^3$ represents 77% of the NAAQO and 61% of the BC objective. The maximum TSP annual concentration of 30 $\mu g/m^3$ represents 50% of the federal and provincial criteria. The highest 24-hour PM_{10} maximum concentration was predicted to be 65 $\mu g/m^3$, which exceeds the BC objective of 50 $\mu g/m^3$; however, the exceedances were only predicted within a short distance along certain sections of the access roads close to the Knipple Transfer Area. Exceedance by the Brucejack Mine Site is not expected. As mentioned earlier, the CAAQs for 24-hour and annual $PM_{2.5}$ will be in effect in 2015 and 2020; however, the BC objectives for 24-hour and annual $PM_{2.5}$ are more stringent than the CAAQs. The BC objectives are used here as thresholds. The highest 24-hour $PM_{2.5}$ maximum concentration was predicted to be 7.5 $\mu g/m^3$, which is 30% of the BC objective of 25 $\mu g/m^3$. The predicted highest annual concentration is 4.3 $\mu g/m^3$ represents 54% of the BC objective of 8 $\mu g/m^3$. Additionally, the highest annual concentration is also lower than the BC planning goal of 6 $\mu g/m^3$, established in 2009. The highest 30-day dust deposition at the Project is predicted to be 3.7 $mg/dm^2/day$ with or without the presence of the KSM Project and therefore, there is no cumulative change for dust depositions between the Brucejack Gold Mine Project and KSM Project. The highest dust deposition of 3.7 $mg/dm^2/day$ exceeds the BC objective of 1.7 to 2.9 $mg/dm^2/day$; however, the extent of exceedance over the more stringent objective was only predicted within 170 m on either sides of the road and exceedance over the less stringent objective was predicted within 200 m on either side of the road and a small area approximately 350 m south of the Knipple Transfer Area.

Predicted cumulative changes are those changes remaining after the implementation of all mitigation measures and are summarized in Table 7.10-4.

Table 7.10-3. Predicted Pollutant Increment from KSM Project at Brucejack Gold Mine Project Area

Pollutant	Averaging Period	Concentrations ($\mu g/m^3$) or Deposition rate ($mg/dm^2/day$)					
		Criteria		Background	KSM Project Increment at Brucejack Gold Mine Project	Maximum at Brucejack Gold Mine Project	Cumulative Concentration
		NAAQOs	BC Objective				
NO_2	1-hour	400	-	21	40	83	144
	24-hour	200	-	21	8	68	97
	Annual	60	-	5	0.4	19	24
SO_2	1-hour	450	450	4	2.0	6.1	12
	24-hour	150	160	4	0.4	1.6	6
	Annual	30	25	2	0.03	0.27	2.3
CO	1-hour	15,000	14,300	100	87	115	302
	8-hour	6,000	5,500	100	34	48	182
TSP	24-hour	120	150	10	13	69	92
	Annual	60	60	10	0.8	19	30
PM_{10}	24-hour	-	50	3.4	6.2	**55**	**65**
$PM_{2.5}$	24-hour	30[a] , 28[d] (2015) and 27[d] (2020)	25[b]	1.3	0.6	5.6	7.5
	Annual	10[d] (2015) and 8.8[d] (2020)	8[c]	1.3	0.06	2.9	4.3
Dust deposition	30-day	-	1.7 to 2.9	0.71	0.00017	**3**	**3.7**

Notes:
Dash (-) indicates information not available or applicable. Bold indicates exceedance over criteria. Numbers may not add up due to rounding.
[a] Annual 98th percentile value, averaged over three consecutive years. Canada-wide standard published by CCME.
[b] Based on annual 98th percentile value.
[c] BC objective of 8 $\mu g/m^3$ and planning goal of 6 $\mu g/m^3$ was established in 2009.
[d] CAAQS adopted in 2013 and will be in effective in 2015 and 2020.

Table 7.10-4. Summary of Predicted Cumulative Changes on Air Quality

Intermediate Component	Timing of Predicted Cumulative Change[a]	Description of Cause-Effect	Description of Additional Mitigation (if any)	Description of Predicted Cumulative Change
Air Quality	Operation	Project emissions that lead to increased concentrations of CACs and deposition of dust	Mitigation measures being implemented for both projects	Increase in CACs as summarized in Table 7.10-3

[a] *Refers to the Project phase or other timeframe during which the effect will be experienced by the intermediate component.*

7.10.5 Characterizing Predicted Cumulative Changes for Air Quality

The predicted cumulative changes for each intermediate component were characterized by considering the Project's incremental contribution to the predicted cumulative change under two scenarios:

- Future case without the Project: a consideration of residual effects from all other past, existing, and future projects and activities on a sub-component without the Brucejack Gold Mine Project (scenario 1).
- Future case with the Project: a consideration of all residual effects from past, existing, and future projects and activities on a sub-component with the Brucejack Gold Mine Project (scenario 2).

This approach helps predict the relative influence of the Brucejack Gold Mine Project on the residual cumulative change for each intermediate component, while also considering the role of other projects and activities in causing that change.

For scenario 1, which is the future case without the Brucejack Gold Mine Project, the future predicted air quality condition at the Brucejack Mine Site would be affected by the KSM Project only. The predicted condition would be the values presented in Table 7.10-3 from column "KSM Project Increment at Brucejack Gold Mine Project" plus background concentrations; for scenario 2, the future condition represented by the maximum concentrations at the Brucejack Gold Mine Project area are presented in Table 7.10-3 from the column "Cumulative Concentration."

7.10.6 Air Quality as a Pathway for Interaction with Receptor Valued Components

7.10.6.1 Air Quality Pathway for Interaction with Human Health

The air quality pathway for interaction with human health is outlined in Section 7.9. The residual cumulative changes from air quality outlined in Section 7.10.4 may be used to assess cumulative changes on:

- Chapter 10, Surface Water Hydrology Predictive Study;
- Chapter 11, Terrain and Soils Predictive Study;
- Chapter 13, Assessment of Potential Surface Water Quality Effects;
- Chapter 16, Assessment of Potential Terrestrial Ecology Effects;
- Chapter 17, Assessment of Potential Wetlands Effects;
- Chapter 18, Assessment of Potential Wildlife Effects; and
- Chapter 21, Assessment of Potential Health Effects.

7.11 SUMMARY AND CONCLUSIONS FOR AIR QUALITY

The Project-related emissions within the RSA originating from Project components and activities were estimated and the dispersion of Project-related emissions through the atmosphere was predicted. The predicted incremental concentration and deposition rates were added to baseline levels to determine predicted air quality concentrations with the Project in place. The predicted results showed increase in concentrations and depositions. Infrequent exceedance with limited extent was predicted for PM_{10} concentration during the Construction (six days in a year or 1.6% of the time) and Operation (one day in a year or 0.3% of the time) phases. Dust deposition also exceeded the BC objective with limited extent from the sources.

Cumulative change was assessed assuming both Brucejack Gold Mine Project and KSM Project will be operating at the same time. Increased CAC concentrations and dust deposition was predicted for the cumulative change; however only exceedances for PM_{10} and dust deposition were predicted, which is consistent with the Project-only changes. Table 7.11-1 summarizes the predicted changes to air quality.

Table 7.11-1. Predicted Changes to Air Quality

Predicted Changes	Project Phase(s)	Mitigation Measures	Residual Change	Cumulative Residual Change	Receptor VCs Affected
Increase in concentrations of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ and increase in dust deposition level. Exceedances predicted for 24-hour PM_{10} (1.6% of the time). Exceedances predicted for dust deposition within hundreds of metres from the road.	Construction	Maintaining equipment and watering the road.	Project emissions that lead to increased concentrations of CACs.	Project emissions that lead to increased concentrations of CACs.	Human health
Increase in dust and acid deposition levels.	Construction	Maintaining equipment and watering the road.	Project emissions that lead to increased dust and acid deposition.	Project emissions that lead to increased dust and acid deposition.	Surface water hydrology, terrain and soil, surface water quality, terrestrial ecology, wetlands, wildlife, and human health
Increase in concentrations of NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ and increase in dust deposition level. Exceedances predicted for 24-hour PM_{10} (0.3% of the time). Exceedances predicted for dust deposition within hundreds of metres from the road.	Operation	Maintaining equipment, installing a scrubber, installing baghouses, and watering the road.	Project emissions that lead to increased concentrations of CACs.	Project emissions that lead to increased concentrations of CACs.	Human health
Increase in dust and acid deposition levels.	Operation	Maintaining equipment, installing a scrubber, installing baghouses, and watering the road.	Project emissions that lead to increased dust and acid deposition.	Project emissions that lead to increased dust and acid deposition.	Surface water hydrology, terrain and soil, surface water quality, terrestrial ecology, wetlands, wildlife, and human health

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