AIR DISPERSION MODEL

KUDZ ZE KAYAH PROJECT

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Report prepared by: Catherine Henry — 12/12/2016

Catherine Henry, M.Sc.
Environmental Scientist

Report reviewed by: 12/12/2016

Kai Woloshyn, B.Sc.
Senior Environmental Manager

EXECUTIVE SUMMARY

Air quality has been identified as a valued component as part of the Kudz Ze Kayah Project's (the Project) environmental assessment. Subcomponents of the air quality VC are Criteria Air Contaminants (CACs) and Green House Gases (GHGs). Air dispersion modelling was conducted for the following CACs: sulphur dioxide (SO_2); total suspended particulate (TSP); carbon monoxide(CO); fine particulate matter ($PM_{2.5}$); coarse particulate matter (PM_{10}); and nitrous dioxide (NO_2). These CACs have been identified as measurable parameters for the air quality subcomponent. Due to the Project's remote location and the fact that there are no industrial or residential activities in the area, baseline air quality data were not collected. CACs are expected to be minimal and any existing baseline air contaminants likely originate from natural sources (e.g., fugitive dust) or long range transport, and likely consist mainly of fine particulate matter ($PM_{2.5}$) able to survive long range transport.

Air dispersion modelling was carried out using CALPUFF, a recognized and approved air dispersion model by the United States (US) Environmental Protection Agency (EPA) and the British Columbia Ministry of Environment (BCMOE). Surface meteorological data were taken from the Campbell Scientific weather station located at the Project site, for the 12-month period between September 1, 2015 and August 31, 2016. Meteorological parameters not observed at site (cloud ceiling height and cloud opacity) were obtained from Environment and Climate Change Canada (EC) Faro A and Watson Lake A meteorological stations. Upper air data were obtained from the Whitehorse airport upper air station.

Emission sources include gaseous and particle emissions from stationary and mobile sources as well as fugitive dust emissions. The main emission sources were identified for each Project phase, assuming a reasonable worst-case scenario, where for example, all equipment expected to be in operation on a non-continuous basis was assumed to operate at the same time. Emission rates were obtained from the US EPA AP-42: *Compilation of Air Emission Factors* (1995). Modelled scenarios include design mitigations (e.g. enclosures) and basic operational mitigations (e.g. road and exposed surface watering, and progressive reclamation).

Ambient concentrations were predicted at the camp in order to assess the potential exposure to off-shift receptors and results are also provided graphically as ambient concentration contours.

No exceedances of the Yukon Ambient Air Quality Standards (YAAQS) were predicted at the camp for $PM_{2.5}$, CO, NO_2 and SO_2, while TSP and PM_{10} are modelled to exceed YAAQS less than 1% and 1% of the time respectively. Higher ambient concentrations could occur in close proximity to the sources; however, these concentrations are not comparable to the YAAQS as they occur in an industrial area. Modelling results presented for each averaging period represent the maximum predicted value over the one-year period modelled (for each Project phase), except for the annual value which represents the single annual result for the modelling period. Therefore, ambient concentrations are predicted to be below the values reported the rest of the year. Additional mitigation measures presented in the Air Quality Management Plan, but not included in the model will likely contribute to a further reduction in ambient concentrations during all Project phases.

Greenhouse gases emissions were estimated for each Project phase based on anticipated equipment and vehicle use. Predicted Project greenhouse gas emissions are low compared to national total and mining sector emissions. During the operation phase, they could represent up to 22% of the total territorial emissions (assuming 2014 emission levels); however, Yukon emissions are overall very low. Predicted annual Project emission are well below the average annual GHG emissions of other mining facilities in Canada.

LIST OF ACRONYMS

BCMOE	British Columbia Ministry of Environment
CAC	Criteria Air Contaminant
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EC	Environment Canada
EPA	Environmental Protection Agency (US)
FS	Full Scale
g	gram
GHG	Greenhouse Gas
hp	horsepower
hr	hour
kW	kilowatt
lb	pound
IPCC	Intergovernmental Panel on Climate Change
LGO	Low Grade Ore
mb	millibar
Mg	Megagram
Mol	mole
N_2O	Nitrous Oxide
NAPS	National Air Pollution Surveillance Network
NO_2	Nitrogen Dioxide
NO_X	Nitrogen Oxides
$PM_{2.5}$	Fine Particulate Matter
PM_{10}	Coarse Particulate Matter
ppbv	Parts per Billion by Volume
PPE	Personal Protective Equipment
ppm	Parts per Million
ROM	Run of Mine
s	second
scf	Standard Cubic Foot
SO_2	Sulphur Dioxide
SO_X	Sulphur Oxides
SWE	Snow Water Equivalent
t	tonnes
TSP	Total Suspended Particulate
$\mu g/m^3$	Micrograms per Cubic Metre
US	United States
VC	Valued Component
VMS	Volcanogenic Massive Sulphide
VMT	Vehicle Mile Travelled
WSF	Waste Storage Facility
YAAQS	Yukon Ambient Air Quality Standards
YG	Yukon Government

Glossary

CALPUFF: Advanced, integrated Lagrangian puff modelling system for the simulation of atmospheric pollution dispersion. The CALPUFF model is designed to simulate the dispersion of buoyant, puff or continuous point and area pollution sources as well as the dispersion of buoyant, continuous line sources.

Criteria Air Contaminants (CACs): Set of air pollutants that cause smog, acid rain, and other health hazards. CACs are typically emitted from many sources in industry, mining, transportation, electricity generation and agriculture.

Diurnal: Pattern that recurs daily.

Emission Factor: Average emission rate of a given air contaminant or GHG for a given source, relative to units of activity.

Gaussian Puff Model: Model assuming that the air pollutant dispersion has a Gaussian distribution, meaning that the pollutant distribution has a normal probability distribution; can be used for predicting the dispersion of non-continuous air pollution plumes (puffs).

Global Warming Potential: Relative measure of how much heat a greenhouse gas traps in the atmosphere; it compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide.

Greenhouse Gas: Gas in the atmosphere that absorbs and emits radiation in the thermal infrared range. This process is the fundamental cause of the greenhouse effect.

Lagrangian Model: Dispersion model that mathematically follows pollution plume parcels as the parcels move in the atmosphere and that models the motion of the parcels as a random walk process. The Lagrangian model then calculates the air pollution dispersion by computing the statistics of the trajectories of a large number of the pollution plume parcels. A Lagrangian model uses a moving frame of reference as the parcels move from their initial location. It is said that an observer of a Lagrangian model follows along with the plume.

Mole: Unit of measurement in the International System of Units (SI) for amount of substance. It is defined as the amount of a chemical substance that contains as many elementary entities, (e.g. atoms, molecules, ions, electrons, or photons) as there are atoms in 12 grams of carbon-12.)

Passive Air Sampler: Passive (or diffusive) sampling relies on the unassisted molecular diffusion of gaseous agents (analytes) through a diffusive surface onto an adsorbent.

Radiosonde: Balloon-borne instrument platform used to measure and transmit simultaneously meteorological data while ascending through the atmosphere. The instrument consists of sensors for the measurement of pressure, temperature and relative humidity.

Tackifier: Adhesive product applied on slopes to manage erosion control by stabilizing soils (e.g. mulch, hydroseed and other non-toxic materials).

Upper Air: In synoptic meteorology and in weather observing, that portion of the atmosphere that is above the lower troposphere (the troposphere is the lowest part of the atmosphere, starting at the Earth's surface extending up to a height of 7 to 20 km).

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1 INTRODUCTION

Air dispersion modelling was conducted to assess potential Project related air quality effects of the Kudz Ze Kayah Project (the Project). Air quality was selected as a Valued Component (VC) because of its importance to both humans and wildlife. Elevated ambient concentration of criteria air contaminants (CACs) are associated with smog, acid rain and human health issues, while greenhouse gas (GHG) emissions are linked to climate change. This report presents the methodology and results for the air dispersion model prepared for the Project.

1.1 REGIONAL SETTING

The Project is located approximately 260 km northwest of Watson Lake and 115 km southeast of Ross River, Yukon. Access to the Project is via a 24 km long, all weather, single lane gravel Tote Road that connects the Project to the Robert Campbell Highway. The Project site is in the northern foothills of the Pelly Mountains of the Yukon Plateau and in the Finlayson Creek watershed, which includes the Geona Creek catchment.

1.2 PROJECT OVERVIEW

The Project comprises the ABM Deposit, of which there are two zones, the ABM Zone and the Krakatoa Zone. The ABM Deposit, is a polymetallic volcanogenic massive sulphide (VMS) deposit containing economic concentrations of copper, lead, zinc, gold and silver. Mining is planned to be conducted via both open pit and underground mining methods, with ore processed into separate copper, lead and zinc concentrates via sequential flotation through a nominal 2.0 million tonnes per year processing plant. Tailings will be deposited in a dry stack facility on the western slope of the Geona Creek valley, while waste rock will be stored according to acid generating and metal leaching potential. Strongly acid generating material will be co-disposed with the tailings or alternatively stored as paste backfill in the mined out underground workings. Other waste rock material will be placed on the surface.

1.3 OBJECTIVES

CACs were identified as a subcomponent for the air quality VC. Air dispersion modelling was conducted for the following CACs: sulphur dioxide (SO_2); total suspended particulate (TSP); carbon monoxide (CO); fine particulate matter ($PM_{2.5}$); coarse particulate matter (PM_{10}); and nitrous dioxide (NO_2) which are identified as measurable parameters. Theses measurable parameters were selected because they are CACs known to be associated with human health issues and because they are subject to ambient air quality standards in Yukon. Modelling results will inform effect characterization, evaluate the effectiveness of the mitigation measures and support the identification of residual effects. Note that even though ground level ozone is a CAC and has an associated ambient air quality standard, it was not modelled because it is a secondary pollutant (resulting from the transformation of primary pollutants).

Greenhouse gases (GHGs) were also identified as a subcomponent for the valued component air quality of the effect assessment, because of their known association with climate change. For GHGs the measurable parameters are: carbon dioxide (CO_2); methane (CH_4); and nitrous oxide (N_2O). For the GHGs an inventory was carried out to estimate average annual emissions for each Project phase.

2 YUKON AMBIENT AIR QUALITY STANDARDS (YAAQS)

Yukon Government (YG) implemented Ambient Air Quality Standards (YAAQS) for SO_2, TSP, CO, $PM_{2.5}$ and NO_2 in 2010, and more recently for PM_{10} (YG, 2014). PM_{10} and $PM_{2.5}$ represent the coarse and fine fractions of TSP, respectively. PM_{10} (aerodynamic diameter of less than 10 µm) is the fraction of TSP (total suspended particulate) that is inhalable, and therefore has the potential to cause adverse health effects. Fine particles (aerodynamic diameter of less than 2.5 µm) are able to penetrate deeper into the lungs and are generally considered a stronger risk factor than the coarse fraction of PM_{10} (particles in the 2.5-10 µm range) (WHO, 2013). The YAAQS and averaging periods are presented in Table 2-1.

Table 2-1: Yukon Ambient Air Quality Standards (YAAQS) [i]

Parameter	Standard (µg/m³)[ii]	Standard (ppm)[iii]	Standard (ppbv)[iv]
Sulphur Dioxide (SO_2) 1-hour average 24-hour average Annual arithmetic mean	—	—	172 57 11
Total Suspended Particulate (TSP) 24-hour average Annual geometric mean	120 60	—	—
Carbon Monoxide (CO) 1-hour average 8-hour average	—	13 5	—
Fine Particulate Matter ($PM_{2.5}$) 24-hour average (calendar day) Annual mean (calendar year)	28 10	—	—
Coarse Particulate Matter (PM_{10}) 24-hour average	50	—	—
Nitrogen Dioxide (NO_2) 1-hour average 24-hour average Annual arithmetic mean	—	—	213 106 32

[i] *All ambient air quality measurements will be referenced to standard conditions of 25 degrees Celsius and 101.3 kiloPascals.*
[ii] *µg/m³ – micrograms per cubic metre*
[iii] *ppm = parts per million*
[iv] *ppbv = parts per billion by volume*

3 EXISTING CONDITIONS

3.1 METEOROLOGY

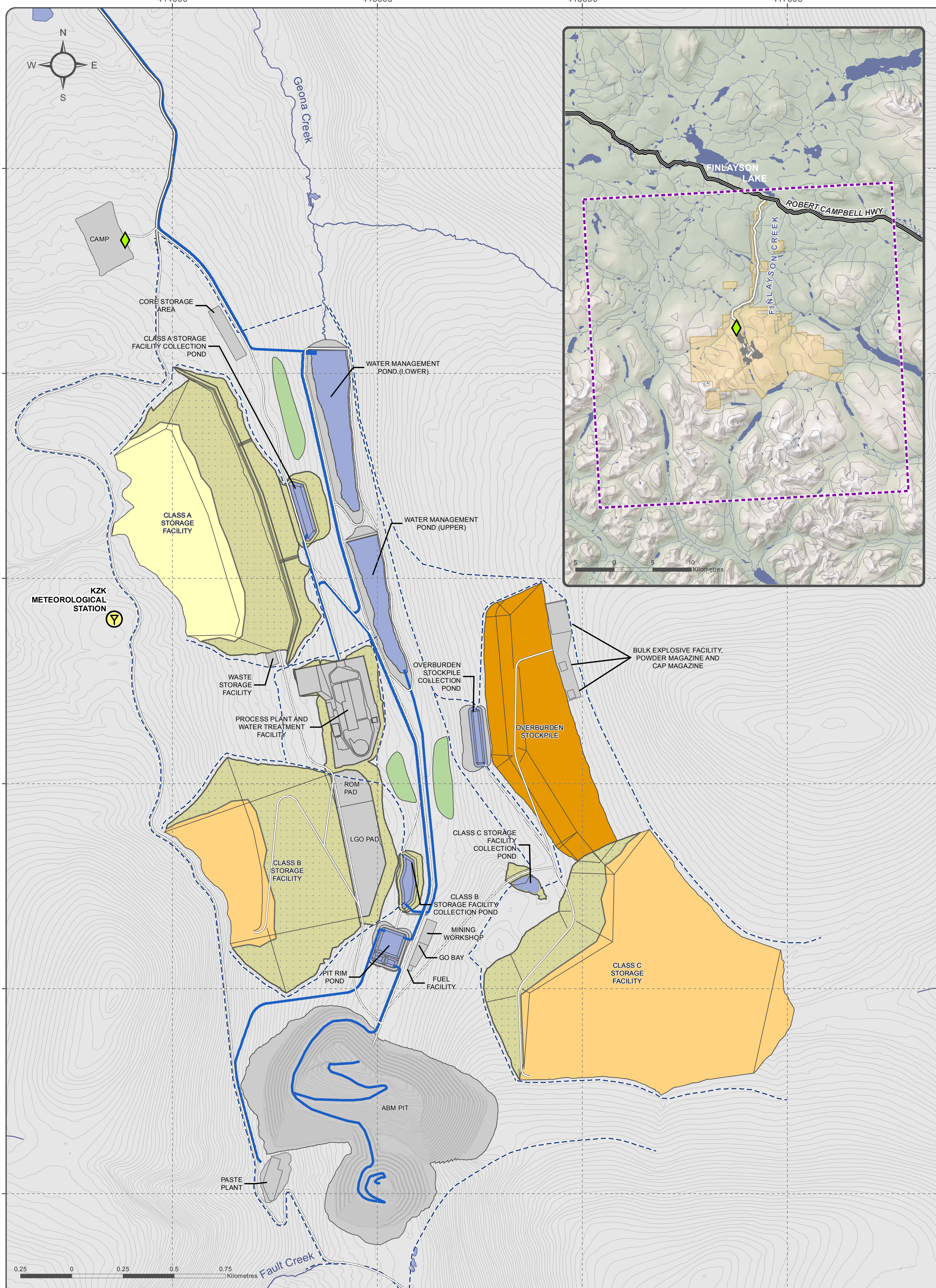
Climatic and meteorological conditions at site were characterized using regional data available through Environment and Climate Change Canada (EC) and Environment Yukon, as well as meteorological data collected on site in 1995 (in support of the Initial Environmental Evaluation and Type A Water Use Licence Application), and at the new site meteorological station commissioned in late August 2015. Details are provided in the *Hydrometeorology Baseline Report* (AEG, 2016), while a summary is presented below.

Monthly site results are summarized, for the period September 1, 2015 to August 31, 2016, in Table 3-1. The location of the meteorology station is presented in Figure 3-1.

3.1.1 TEMPERATURE

The mean annual temperatures at regional stations ranged from -4.7°C at Ross River to -2.2°C at Ketza River Mine for the period of record (ranging from 10 to 63 years depending on station), and extreme annual temperatures ranged from -59.4°C at Ross River in December to 35.4°C at Watson Lake in July. Long term records at the six regional stations studied indicate an increasing trend for average minimum, average maximum, and mean monthly temperatures.

The mean annual temperature recorded at the Project site for the period September 2015 to August 2016 was -0.47°C, with extremes ranging from -26.28°C to 19.89°C. When compared to both long term regional averages and to regional data for the same period, the 2015-2016 record at the Project site generally shows warmer winter temperatures (October to April), cooler summer temperatures (May to September), and reduced diurnal range.



Receptor

Meteorological Station

Pipeline

Diversion Ditch

Class A Storage Facility

Class B and C Storage Facility

Overburden Stockpile

Topsoil Stockpile

Progressive Reclamation

Pond/Water

Modeling Domain

Tote Road/Proposed Access Road

Proposed Mine Road

Datum: NAD 83; Projection: UTM Zone 9N

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FIGURE 3 - 1

MINE SITE LAYOUT, MODELLING DOMAIN AND RECEPTOR

NOVEMBER 2016

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(Last edited by: amatlashevska;11/30/2016/09:38 AM)

Table 3-1: Monthly Meteorological Data Summary, KZK, September 2015-August 2016

Month	Extreme Minimum Temperature (°C)	Average Minimum Temperature (°C)	Average Temperature (°C)	Average Maximum Temperature (°C)	Extreme Maximum Temperature (°C)	Average Relative Humidity (%)	Maximum Relative Humidity (%)	Minimum Relative Humidity (%)	Total Precipitation (mm)	Average Wind Speed (m/s)	Maximum Wind Speed (m/s)	Total Evapotranspiration (mm)	Average Solar Radiation (W/m^2)	Average Barometric Pressure (hPa) *	Total Pan Evaporation (mm)	Snow Water Equivalent (mm) **
Sep-15	-8.28	-0.66	1.42	3.65	8.94	76.4	96.6	57.7	23.25	5.78	25.42	34.0	105.85	1006.83	N/M	N/C
Oct-15	-11.05	-3.08	-1.12	0.89	6.01	73.0	96.1	39.9	7.18	4.71	19.17	14.1	50.31	1006.81	N/M	N/C
Nov-15	-26.28	-11.08	-8.57	-5.93	2.00	73.1	89.1	34.1	12.56	6.37	28.52	5.0	18.25	1000.62	N/M	N/C
Dec-15	-21.89	-13.28	-11.08	-9.23	0.23	78.8	88.6	49.0	6.30	3.47	23.62	-1.0	5.59	997.90	N/M	N/C
Jan-16	-17.04	-8.87	-6.97	-5.41	-0.94	72.4	88.3	31.7	2.88	4.91	25.99	2.2	12.82	1002.03	N/M	44.0
Feb-16	-21.58	-10.08	-8.02	-6.11	-0.75	75.5	90.1	53.1	3.84	4.97	20.93	7.4	44.84	1003.76	N/M	37.3
Mar-16	-16.21	-8.01	-6.14	-4.28	7.69	74.9	86.9	47.1	0.88	4.91	19.56	25.0	120.06	1003.95	N/M	49.3
Apr-16	-5.53	-2.61	-0.16	2.26	9.39	66.1	89.7	43.3	12.06	6.10	24.87	51.3	176.36	1008.63	N/M	N/C
May-16	-3.05	1.94	5.12	8.31	17.48	61.7	87.4	26.3	39.38	4.87	21.09	84.5	225.47	1014.41	N/M	N/C
Jun-16	1.45	6.39	9.81	13.29	19.42	57.2	78.2	36.1	18.26	4.84	16.9	106.2	256.27	1013.28	138.5	N/C
Jul-16	1.52	7.71	10.75	13.91	19.89	69.9	86.7	49.9	113.46	4.44	18.93	76.5	196.60	1014.69	111.5	N/C
Aug-16	0.33	6.71	9.29	12.31	18.93	71.0	93.2	45.6	103.22	4.70	17.29	59.52	153.18	1017.31	80.2	N/C
Year	-26.28	-2.91	-0.47	1.97	19.89	70.84	96.60	26.30	343.25	5.01	28.52	464.67	113.80	1007.52	N/A	N/A

** Corrected to sea-level equivalent*
*** Averaged across the 3 baseline snow survey stations for January and February and the 3 baseline and 4 peak snow survey stations for March*
N/A = Not Applicable
N/M = Not Measured
N/C = Not Calculated

3.1.2 PRECIPITATION

Mean annual precipitation at regional stations (calculated for a period of record ranging from 10 to 63 years depending on station) varied between 210 mm at Ross River and 710 mm at Ketza River Mine; the proportion of total annual precipitation falling as rain ranged from 39% at Ketza River Mine to 70% at Ross River and Faro. The greatest amount of precipitation generally fell between June and September for all regional stations. Long term records did not show clear trends when looking at total precipitation over time; however, the proportion of total precipitation falling as rain displayed an increasing trend at all stations, consistent with the rising trends observed in air temperature.

Total precipitation measured at the Project site for the period from September 1, 2015 to August 31, 2016 was 343 mm. When compared to long-term regional annual means, the 2015-2016 data collected at the Project generally showed lower total amounts than at most regional stations reviewed, except for Ross River and Faro, which have lower long-term averages. When compared to regional data for the same period, the Project had a higher annual precipitation level than both Faro and Watson Lake, but the difference doesn't account for the expected amount associated to the elevation difference between the stations. However, regional data are sparse and do not cover a wide range of elevations. The data suggest that the site receives less precipitation than would be expected based on the elevation. Other factors such as the geographic position on the northeast side of the Pelly Mountains likely play a greater role in determining the precipitation received on site.

3.1.3 SNOWPACK

The 2016 snow survey data at five regional stations indicated that 2016 was a below average snow year. Snow Water Equivalent (SWE) values in April 2016 ranged from 62% to 93% of long-term average with a mean of 78%, whereas the May 2016 SWE values ranged 0% to 91% of normal with a mean of 44%.

Snow surveys conducted at the Project in January, February and March 2016 indicate lower SWE values than at regional stations, although sampling was not carried out at the same time of year. The 2016 snow survey data at the Project also indicated a lower snow year when compared to the 1995 site snow survey results.

3.1.4 WIND SPEED AND DIRECTION

Wind speed and direction are measured at a height of 10 m at the site Campbell Scientific meteorological station. Wind data collected between September 1, 2015 and August 31, 2016 are presented in Figure 3-2. The prevailing winds blew from the northwest to northeast and the highest average wind speeds originated from the northeast. Wind Rose summary statistics are presented in Table 3-2. The strongest winds were observed during the month of November for the period of record (Table 3-1).

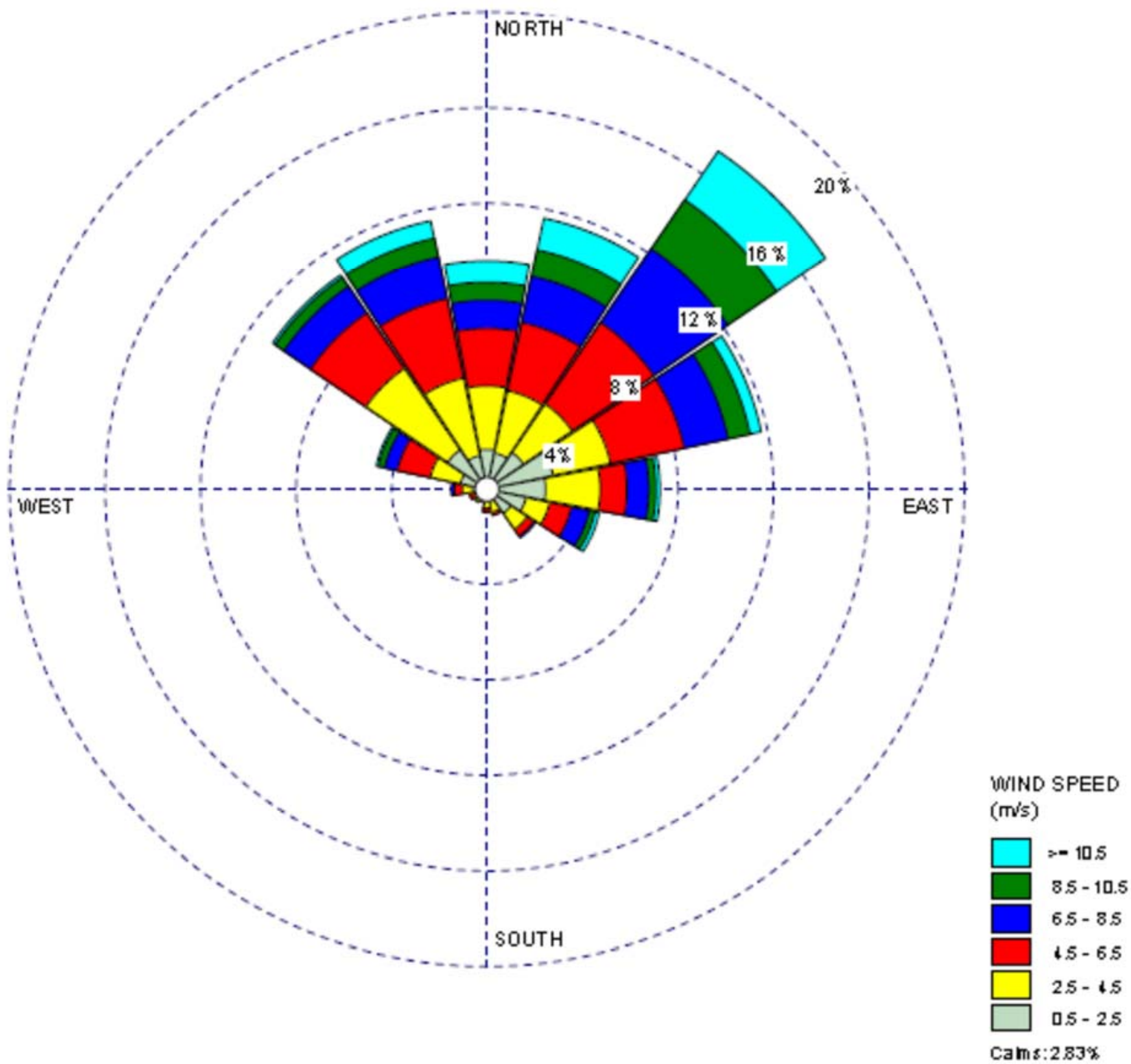


Figure 3-2: Wind Rose, KZK, September 2015 to August 2016

Table 3-2: Wind Rose Summary Statistics

Total Number of Hours	8,784
Average Wind Speed	5.01 m/s
Calm Records	249
Calm Winds Frequency	2.83%
Data Availability	99.52%
Incomplete/Missing Records	42
Total Records Used	8,742

3.1.5 OTHER METEOROLOGICAL PARAMETERS

For the period of record (September 1, 2015 to August 31, 2016), relative humidity and barometric pressure at the Project meteorological station were generally consistent with regional patterns. Solar radiation peaked in June and was at a minimum in December. Pan evaporation measurements and evapotranspiration calculations at the Project for the 2015-2016 period were generally consistent with 1995 measurements and estimates.

3.2 AIR QUALITY

3.2.1 AIR CONTAMINANTS

Due to the Project's remote location and the fact that there are no industrial or residential activities in the area, baseline air quality data were not collected. Gaseous air contaminants are expected to be minimal and any existing baseline air contaminants likely originate from natural sources (e.g., fugitive dust) or long range transport, and likely consist mainly of fine particulate matter ($PM_{2.5}$) able to survive long range transport.

The nearest air quality monitoring station for which data are available is operated by Environment and Climate Change Canada as part of the National Air Pollution Surveillance Network (NAPS) and is located in Whitehorse, a distance of about 255 km away. Because of the urban setting, ambient concentrations measured in Whitehorse are influenced by anthropogenic sources and are not deemed representative of ambient conditions at the Project site. For context, Table 3-3 below presents Whitehorse air quality data over the past four years, and shows that even in a location where a lot more anthropogenic sources exist in comparison to the Project site, ambient levels of gaseous contaminants are well below their respective YAAQS. The only pollutant for which exceedances occasionally occur is $PM_{2.5}$, and elevated levels are generally associated in part with residential wood smoke in the winter time (EC, 2015a). A 2006 emission inventory for Whitehorse (Senes, 2008), estimated that, *"…on an annual basis, heating contributes 84% to $PM_{2.5}$ emissions, followed by fugitive dust (~9%), mobile (both on and off road) sources (~4%) and industrial point sources (~3%)"* (EC, 2015a).

Table 3-3: Air Pollutants Ambient Concentrations, Whitehorse NAPS station 2012-2015

		CO		$PM_{2.5}$	NO_2	
	YAAQS	**13 ppbv**	**5 ppbv**	**28 µg/m³**	**213 ppbv**	**106 ppbv**
	Averaging Period	**1 hr**	**8 hrs**	**24 hrs**	**1 hr**	**24 hrs**
2012	Mean	0.3	0.3	6	6	6
	95th percentile	0.6	0.5	14	23	18
	Max	3.5	1.9	**31**	49	33
2013	Mean	n/a	n/a	6	5	5
	95th percentile	0.6	0.5	17	20	16

		CO		$PM_{2.5}$	NO_2	
	Maximum	2	1.3	**41**	45	26
2014	Mean	n/a	n/a	n/a	n/a	n/a
	95th percentile	0.7	0.7	17	21	17
	Maximum	2.7	1.4	**39**	40	26
2015	Mean	n/a	n/a	n/a	5	5
	95th percentile	n/a	n/a	13	21	16
	Maximum	n/a	n/a	27	81	34

Source: National Air Pollution Surveillance Program (NAPS), 2016a
Notes: µg/m³ = micrograms per cubic metre; ppbv = parts per billion by volume
Values in red exceed the YAAQS

Very limited ambient air quality data are available for remote Yukon locations; however, monitoring of SO_2, NO_2 and particulate matter was conducted at the Casino Mine Project in 2013. SO_2 and NO_2 were sampled via passive samplers; however, the exposure period was not specified. Two samples were collected for each pollutant and all results were found to be below the detection limit of 0.1 ppb, except for one NO_2 sample that had a measured value of 0.2 ppb (Casino Mining Corporation, 2014a). Results for particulate matter are summarized in Table 3-4.

Table 3-4: Hourly Particulate Matter Baseline Ambient Concentration, Casino Mine Project

		Test 1	Test 2
	Date	**23-May-2013**	**13-Jun-2013**
	Duration (D:H:M)	**20:00:51**	**12:00:50**
$PM_{2.5}$	Average (µg/m³)	4	4
	Maximum (µg/m³)	11	13
PM_{10}	Average (µg/m³)	6	7
	Maximum (µg/m³)	11	13
TSP	Average (µg/m³)	6	7
	Maximum (µg/m³)	1	13

** Source: Casino Mining Corporation, 2014*

PM_{10} sampling was also conducted by Yukon Government in 2013 in the Keno City area. One station was established to represent background levels and was located 8 km outside of Keno City, away from roads or other anthropogenic influences. Five-minute data averaged over the different sampling periods (ranging from 14 to 53 hours) were reported. Results at this station indicated average levels of 2.8 µg/m³, 10.2 µg/m³ and 3.8 µg/m³ in June, July and August respectively (Yukon Government, 2014).

Table 3-5 below summarizes the baseline levels assumed for this model, CACs were assumed to be minimal under baseline conditions, as supported by results of the passive sampling for SO_2 and NO_2 for the Casino Mine Project. Ambient baseline particulate levels for a 24-hr averaging period were taken to be the average of the Casino data above and the Keno results for PM_{10}. Note that the particulate data are representative of summer concentrations and that winter ambient concentrations are expected to be lower. Because no relevant data are available for longer averaging periods, a conversion factor was used to estimate annual averages, as recommended by the US EPA (EPA, 1992) and shown in Table 3-6.

Table 3-5 Air Contaminants Baseline Concentrations used in Model

Contaminant	Unit	Background Concentration	
		24-hour	Annual
TSP	µg/m³	7	1
PM_{10}	µg/m³	6	1
$PM_{2.5}$	µg/m³	4	1
CO	ppm	0	0
SO_2	ppbv	0	0
NO_2	ppbv	0	0

Table 3-6: Averaging Time Conversion Factors (EPA, 1992)

Averaging Time	**Multiplying Factor (1 hour average x the multiplying factor)**
3 hours	0.9 (±0.1)
8 hours	0.7 (±0.2)
24 hours	0.4 (±0.2)
Annual	0.08 (±0.02)

3.2.2 GREENHOUSE GASES

Information on total Yukon and Canadian GHG emissions from 1990 to 2014 was obtained from the National Inventory Report (EC, 2016b), and is presented in Table 3-7.

Table 3-7: National and Territorial GHG Emissions (in kilotonnes of CO_2 equivalent/year)

Year	Canada Total Emissions	Canada Emissions - Mining Sector	Yukon Total Emissions
1990	613,000	6,000	531
2000	747,000	6,000	505
2005	696,000	7,000	459
2010	706,000	7,000	344
2011	710,000	8,000	384
2012	718,000	8,000	393
2013	731,000	8,000	351
2014	732,000	8,000	268

Source: National Inventory Report (EC, 2016b)

Emissions from the mining sector (excluding smelting and refining) represent an average of 1% of the total Canadian GHG emissions. Yukon emissions represent less than 0.1% of total Canadian emissions. In 2014, total GHG emissions in Canada had increased by 19.5% compared to 1990 emissions, while in Yukon, they had decreased by 49.5% relative to 1990 emissions.

4 AIR DISPERSION MODELLING

"CALPUFF" is a Gaussian puff model that can account for time- and space-varying meteorological conditions, different source configurations and contaminants, and chemical transformations. *It can be applied to model near field effects (in the order of tens of metres) to transport distances of hundreds of kilometres* (BCMOE, 2008). The modelling system consists of three main components and a set of preprocessing and postprocessing programs. The main components of the modelling system are CALMET (a diagnostic 3-dimensional meteorological model), CALPUFF (an air quality dispersion model), and CALPOST (a postprocessing package).

CALPUFF is recommended in the Guidelines for Air Quality Dispersion Modelling in British Columbia (BCMOE, 2008) and by the United States Environmental Protection Agency (EPA, 2014a). More specifically, the EPA approves CALPUFF version 5.8.5, CALMET version 5.8.5 and CALPOST Version 6.221. As such, those versions were selected in the present study, while Lakes Environmental CALPUFF View Version 8.3.0 was used for graphical interface.

4.1 INPUT DATA

4.1.1 METEOROLOGICAL DATA

4.1.1.1 Surface Data

Surface meteorological data were taken from the Campbell Scientific weather station located at the Project site, for the 12-month period between September 1, 2015 and August 31, 2016. Meteorological parameters not observed at site (cloud ceiling height and cloud opacity) were obtained from Environment and Climate Change Canada Faro A (Climate ID: 2100519) and Watson Lake A (climate ID: 2101201) meteorological stations, located approximately 165 km and 180 km away from the Project area, respectively. Cloud opacity was estimated from total cloud amount as opacity was not available, and missing hourly values were estimated by interpolation.

4.1.1.2 Upper Air Data

Twice daily upper air radiosonde data for the modelling period (September 1, 2015 to August 31, 2016) were obtained from the Whitehorse airport upper air station (WMO Station ID: 71964) through the

NOAA/ESRL Radiosonde Database. The Whitehorse airport is the only upper station in Yukon and therefore, considered the best data available for the Project site.

4.1.2 EMISSION SOURCES

Emission sources include gaseous and particle emissions from stationary and mobile sources as well as fugitive dust emissions. The main emission sources were identified for each Project phase according to the following schedule:

- Construction Phase: Year -2 to 0;
- Operation Phase: Year 1 to 10; and
- Closure Phase: Year 11 to 13.

For each Project phase, a reasonable worst-case scenario was modelled, where for example, all equipment expected to be in operation on an as needed or non-continuous basis was assumed to operate at the same time.

For input into the model, sources were characterized as point, volume or line-area/area sources, and are further described in the following Sections. Emission factors were obtained from the US EPA AP-42: *Compilation of Air Emission Factors* (1995). Since the fifth edition of AP-42 was published in 1995, EPA has published supplements and updates to the fifteen chapters available in *Volume I, Stationary Point and Area Sources,* and the latest available information was used in the model for each source type.

4.1.2.1 Point Sources

Emission rates for the sources (listed in Table 4-1) were obtained from US EPA AP-42 *Section 3.4 Large Stationary Diesel and all Stationary Dual-fuel Engine*, Section 1.4 *Natural Gas Combustion,* and Section 2.1 *Refuse Combustion* (EPA, 1995). Emission rates provided in lb/hp-hr, lb/10^6 standard cubic foot (scf) or kg/Mg were converted to g/s based on the equipment power output or energy input.

Emission rates for nitrogen oxides assume the use of control technologies in diesel engines. Controlled emission rates for other pollutants were not available and as such, uncontrolled emission rates were used, and provide conservative estimates. To provide a conservative estimate, all sources that are anticipated to operate only during part of a Project phase (e.g. 6 months) were assumed to operate simultaneously. Table 4-1 summarizes the point source information for all three Project phases.

Table 4-1: Point Sources and Emission Rates

Source	Location	Power output (kW) or Rate	Usage			Emission Rates (g/s)					
			Construction Phase	Operation Phase	Closure Phase	SO_x [1]	TSP	PM_{10}	$PM_{2.5}$	CO	NO_x
Diesel Generator	Camp	250	24hr/day	-	12hr/day	0.0005126	0.02957	0.02431	0.02032	0.2323	0.5491
Diesel Generator (x6)	Process Plant Facility	18	14hr/day	-	12hr/day 6 months	0.00003691	0.002129	0.00175	0.001463	0.01673	0.03954
Diesel Generator (x2)	Process Plant Facility	60	14hr/day	-	-	0.000123	0.007097	0.005834	0.004877	0.05576	0.1318
Diesel Generator	Process Plant Facility	80	14hr/day	-	-	0.000164	0.009462	0.007779	0.006503	0.07434	0.1757
Diesel Generator	Water Treatment Plant	200	-	-	As required	0.0004101	0.02366	0.01945	0.01626	0.1859	0.4393
Dual fuel Generator (x6 in N+2 configuration)	Process Plant Facility	3800	-	24hr/day	-	0.0003944	3.351E-14	3.351E-14	3.351E-14	4.8155	0.02818
Boiler	Camp	3400000 Btu/hr [2]	24hr/day	24hr/day	24hr/day	1.5529E-09	1.967E-08	1.967E-08	1.967E-08	2.1741E-07	3.6234E-07
Incinerator	Immediately south of Class A Waste Storage Facility (WSF)	100 kg/hr [3]	As required	As required	As required	0.00003472	0.00009722	0.00009722	0.00009722	0.0001389	0.00004167
Pump	Open pit – overburden sump	40	24hr/day	24hr/day	-	0.00008202	0.004731	0.003889	0.003251	0.03717	0.08786
Pump (x3)	Open pit well	4	24hr/day	24hr/day	-	8.2016E-06	0.0004731	0.0003889	0.0003251	0.003717	0.008786
Drill (x2)	Open pit	202	24hr/day	24hr/day	-	0.0004142	0.02389	0.01964	0.01642	0.1877	0.4437
Drill	Open pit	403	-	24hr/day	-	0.0008263	0.04767	0.03919	0.03276	0.3745	0.8852
Bulldozer	Open pit	330	4hr/day 6 months	4hr/day	-	0.0006773	0.03907	0.03212	0.02685	0.307	0.7256
Excavator	Open pit	1140	14hr/day 6 months	20hr/day	-	0.002339	0.1349	0.1109	0.09274	1.0603	2.5061
Crane (x2)	Process Plant Facility	298	4hr/day	-	12hr/day 6 months	0.000611	0.03525	0.02898	0.02422	0.2769	0.6546
Crane (x3)	Process Plant Facility	172	4hr/day	-	12hr/day 6 months	0.0003517	0.02029	0.01668	0.01394	0.1594	0.3767
Crane	Process Plant Facility	201	2hr/day	-	12hr/day 6 months	0.0004121	0.02377	0.01954	0.01634	0.1868	0.4415
Excavator	Process Plant Facility	352	12hr/day 1 month	-	-	0.0007217	0.04163	0.03422	0.02861	0.3271	0.7731
Elevated Work Platform (x6)	Process Plant Facility	55	8hr/day	-	8hr/day 6 months	0.0001128	0.006505	0.005348	0.004471	0.05111	0.1208

Source	Location	Power output (kW) or Rate	Usage			Emission Rates (g/s)					
			Construction Phase	Operation Phase	Closure Phase	SO_x [1]	TSP	PM_{10}	$PM_{2.5}$	CO	NO_x
Loader (crusher)	Process Plant Facility	603	-	24hr/day	-	0.001235	0.07126	0.05859	0.04898	0.5599	1.3235
Loader (tailings)	Process Plant Facility	223	-	24hr/day	-	0.0004572	0.02637	0.02168	0.01812	0.2072	0.4898
Loader (concentrate)	Process Plant Facility	223	-	24hr/day	-	0.0004572	0.02637	0.02168	0.01812	0.2072	0.4898
Bulldozer	Class A Storage Facility	330	2hr/day 6 months	2hr/day	4hr/day	0.0006773	0.03907	0.03212	0.02685	0.307	0.7256
Grader	Class A Storage Facility	216	1hr/day 6 months	1hr/day	1hr/day	0.0004434	0.02558	0.02103	0.01758	0.201	0.475
Bulldozer	Class B Storage Facility	330	6hr/day 6 months	8hr/day	4hr/day	0.0006773	0.03907	0.03212	0.02685	0.307	0.7256
Grader	Class B Storage Facility	216	1hr/day 6 months	1hr/day	1hr/day	0.0004434	0.02558	0.02103	0.01758	0.201	0.475
Bulldozer	Class C Storage Facility	330	-	14hr/day	3hr/day	0.0006773	0.03907	0.03212	0.02685	0.307	0.7256
Grader	Class C Storage Facility	216	-	2hr/day	1hr/day	0.0004434	0.02558	0.02103	0.01758	0.201	0.475
Bulldozer	Overburden Stockpile	330	12hr/day 6 months	2hr/day	-	0.0006773	0.03907	0.03212	0.02685	0.307	0.7256
Grader	Overburden Stockpile	216	1hr/day 6 months	1hr/day	-	0.0004434	0.02558	0.02103	0.01758	0.201	0.475
Loader	Overburden Stockpile	352	-	-	8hr/day	0.0007217	0.04163	0.03422	0.02861	0.3271	0.7731
Excavator	Mine workshop	352	12hr/day 1 month	-	-	0.0007217	0.04163	0.03422	0.02861	0.3271	0.7731
Excavator	Explosive Facility	352	12hr/day 1 month	-	-	0.0007217	0.04163	0.03422	0.02861	0.3271	0.7731
Crane	Mine workshop	298	4hr/day 3 months	-	4hr/day 2 months	0.000611	0.03525	0.02898	0.02422	0.2769	0.6546
Crane	Explosive Facility	298	4hr/day 3 months	-	4hr/day 2 months	0.000611	0.03525	0.02898	0.02422	0.2769	0.6546
Loader	Paste Fill Plant	223	-	5hr/day	-	0.0004572	0.02637	0.02168	0.01812	0.2072	0.4898
Bulldozer	Explosive Facility	330	-	-	6hr/day 1 month	0.0006773	0.03907	0.03212	0.02685	0.307	0.7256
Loader	Topsoil Stockpile	352	-	-	8hr/day	0.0007217	0.04163	0.03422	0.02861	0.3271	0.7731
Loader	Diversion ditches	352	-	-	8hr/day 4 months	0.0007217	0.04163	0.03422	0.02861	0.3271	0.7731
Loader	Open pit Spillway	352	-	-	8hr/day 2 weeks	0.0007217	0.04163	0.03422	0.02861	0.3271	0.7731

Source	Location	Power output (kW) or Rate	Usage			Emission Rates (g/s)					
			Construction Phase	Operation Phase	Closure Phase	SO_x [1]	TSP	PM_{10}	$PM_{2.5}$	CO	NO_x
Crane	Paste Fill Plant	298	-	-	4hr/day 2 months	0.000611	0.03525	0.02898	0.02422	0.2769	0.6546
Bulldozer	Paste Fill Plant	330	-	-	6hr/day 1 month	0.0006773	0.03907	0.03212	0.02685	0.307	0.7256

[1] *Assumed ultra low sulphur diesel (15 ppm) as per Sulphur in Diesel Fuel Regulations (SOR/2002-254)*

[2] *Input in Btu/hr. Converted to scf/hr using average heat content of 1,032 Btu per scf (US Energy Information Administration, 2016)*

[3] *Maximum input rate*

4.1.2.2 Line-Area Sources

Project roads were modelled as line-area sources and emissions consist of fugitive dust from unpaved road surfaces and of vehicle emissions. Emission factors for fugitive dust were taken from EPA AP-42 Section 13.2.2 *Unpaved Roads*, vehicle emissions for light vehicles were obtained from Cai et al. (2013) and heavy vehicle emissions from EPA's *Average In-Use Emissions from Heavy-Duty Trucks* (2008).

Emissions factors for fugitive dust from traffic on unpaved roads were calculated using the equation provided in US EPA's AP-42 Section 13.2.2.2, *Industrial Roads*:

$$E = k \left(\frac{s}{12}\right)^{a} \left(\frac{W}{3}\right)^{b} \qquad (1)$$

where:

k, a and b are size-specific empirical constants and

E = size-specific emission factor (lb/Vehicle Mile Travelled (VMT))

s = surface material silt content (%)

W = mean vehicle weight (tons)

Results assume a silt content of 8.0% (Countess Environmental, 2006). The mean vehicle weight was calculated for each road segment and Project phase based on estimated daily traffic volume.

Natural mitigation under the form of rain or other precipitation can be accounted for according to the equation below (Countess Environmental, 2006):

$$Eext = E\left[\frac{(365-P)}{365}\right] \qquad (2)$$

where:

Eext = annual size-specific emission factor extrapolated for natural mitigation

E = emission factor

P = number of days in a year with at least 0.254 mm of precipitation

Also, minimal fugitive dust emissions by wind erosion are expected to occur during winter, when the ground is frozen. The equation above was therefore adapted to account for that, by defining P as the number of days with average temperature below 0°C (ground assumed to be frozen) plus the number of days with at least 0.254 mm of precipitation when the average daily temperature is above 0°C. Using meteorological data collected at site between September 1, 2015 and August 31, 2016, the value for P was found to be 279, yielding a natural control rate of 76% (i.e. Eext = 0.24*E).

To further reduce fugitive dust, BMC will water roads and use a tackifier on exposed surfaces, as required during the summer months. The control efficiency of such measures varies with the rate and frequency of application, traffic volume, and prevailing meteorological conditions. For PM_{10}, the estimated control efficiency of road watering ranges between 10 and 74% (Countess Environmental, 2006). The average value of 42% was used in the model. It should be noted that:

> *Midwest Research Institute found no significant differences in the measured control efficiencies for the $PM_{2.5}$ and PM_{10} size fractions of unpaved road emissions based on repeated field measurements of uncontrolled and controlled emissions. Thus, without actual published $PM_{2.5}$ control efficiencies, the user may wish to utilize the published PM_{10} values for both size fractions.* (Countess Environmental, 2006)

It is expected that control efficiency would be higher for TSP, but to ensure a conservative estimate, the same value of 42% was used in the model for all particle sizes.

Fugitive dust and vehicle emissions rates for light and heavy trucks in grams per vehicle mile travelled (VMT) were converted to grams per metre squared per second (g/m^2*s) based on individual road segment length, average road width and daily traffic volume for each segment. Emission rates for roads (line-area sources) presented in Table 4-2 represent the sum of controlled fugitive dust emissions and vehicle emissions.

Table 4-2: Line-Area Sources and Emission Rates

Road Segment	Segment Length (km)	# Light Trucks per day	# Heavy Trucks per day	TSP (g/m^2*s)	PM_{10} (g/m^2*s)	$PM_{2.5}$ (g/m^2*s)	NOx (g/m^2*s)	CO (g/m^2*s)	SOx (g/m^2*s)
Construction Phase									
Fuel facility to open pit	0.556	0	6	5.669E-07	1.602E-07	1.619E-08	6.662E-09	1.81E-09	1.424E-11
Open pit to Explosive Facility	2.611	10	6	1.388E-06	3.921E-07	3.939E-08	1.331E-08	7.07E-09	3.042E-11
Open pit to Class A WSF	2.115	10	18	9.945E-06	2.808E-06	2.823E-07	7.463E-08	2.463E-08	5.89E-11
Open pit to Class B WSF	1.402	10	55	2.611E-05	7.373E-06	7.416E-07	2.209E-07	6.599E-08	1.467E-10
Open pit to Overburden Stockpile	1.922	10	153	6.934E-05	1.958E-05	1.970E-06	6.200E-07	1.789E-07	3.864E-10
Laydown Area (within the Class A Facility) to Process Plant Facility	0.832	0	24	1.008E-05	2.847E-06	2.865E-07	9.485E-08	2.683E-08	5.696E-11
Class B WSF to Process Plant Facility	0.807	0	40	1.283E-05	3.624E-06	3.655E-07	1.581E-07	4.472E-08	9.493E-11
Camp to Process Plant Facility	2.402	8	0	2.964E-07	8.369E-08	8.399E-09	2.8E-09	3.604E-09	1.295E-11
Workshop to Class A WSF	2.269	0	20	6.415E-06	1.812E-06	1.827E-07	7.904E-08	2.236E-08	4.747E-11
Workshop to Class B WSF	1.417	0	20	6.415E-06	1.812E-06	1.827E-07	7.904E-08	2.236E-08	4.747E-11
Explosives to Class A WSF	4.984	0	20	6.415E-06	1.812E-06	1.827E-07	7.904E-08	2.236E-08	4.747E-11
Explosive to Class B WSF	3.483	0	20	6.415E-06	1.812E-06	1.827E-07	7.904E-08	2.236E-08	4.747E-11
Open pit to Process Plant Facility	1.878	10	0	3.705E-07	1.046E-07	1.05E-08	3.501E-09	4.505E-09	1.618E-11
Open pit to Run of Mine (ROM) Pad	1.143	0	131	5.671E-05	1.602E-05	1.612E-06	5.177E-07	1.465E-07	3.109E-10
Highway to Process Plant Facility	21.897	0	8	7.558E-07	2.136E-07	2.159E-08	8.883E-09	2.414E-09	1.899E-11
Operation Phase									
Open pit to Explosive Facility	2.611	0	6	7.743E-07	2.187E-07	2.202E-08	9.812E-09	2.565E-09	1.424E-11
Process Plant Facility to Paste Fill Plant	2.935	0	106	3.400E-05	9.604E-06	9.685E-07	4.189E-07	1.185E-07	2.516E-10
Open pit to Class A WSF	2.115	10	21	1.127E-05	3.183E-06	3.199E-07	8.649E-08	2.798E-08	6.602E-11
Open pit to Class B WSF	1.402	10	103	4.692E-05	1.325E-05	1.333E-06	4.105E-07	1.197E-07	2.606E-10
Open pit to Class C WSF	2.05	10	236	0.0001045	2.952E-05	2.97E-06	9.361E-07	2.683E-07	5.763E-10

Road Segment	Segment Length (km)	# Light Trucks per day	# Heavy Trucks per day	TSP (g/m^2*s)	PM_{10} (g/m^2*s)	$PM_{2.5}$ (g/m^2*s)	NOx (g/m^2*s)	CO (g/m^2*s)	SOx (g/m^2*s)
Open pit to Overburden Stockpile	1.922	10	38	1.810E-05	5.113E-06	5.142E-07	1.537E-07	4.699E-08	1.064E-10
Class A WSF to Process Plant Facility	0.832	3	79	2.587E-05	7.307E-06	7.367E-07	3.132E-07	8.967E-08	1.923E-10
Camp to Process Plant Facility	2.402	12	0	4.446E-07	1.255E-07	1.26E-08	4.201E-09	5.405E-09	1.942E-11
Open pit to Process Plant Facility	1.878	10	0	3.705E-07	1.046E-07	1.05E-08	3.501E-09	4.505E-09	1.618E-11
Open pit to ROM Pad	1.143	0	63	2.727E-05	7.702E-06	7.75E-07	2.49E-07	7.043E-08	1.495E-10
Process Plant Facility to Highway	21.897	0	27	6.730E-06	1.902E-06	1.922E-07	1.067E-07	3.019E-08	6.408E-11
Closure Phase									
Class A WSF to Process Plant Facility	0.832	8	4	1.549E-06	4.374E-07	4.404E-08	1.602E-08	7.049E-09	2.244E-11
Camp to Process Plant Facility	2.402	12	0	4.446E-07	1.255E-07	1.26E-08	4.201E-09	5.405E-09	1.942E-11
Open pit to camp	4.444	6	0	2.223E-07	6.277E-08	6.299E-09	2.1E-09	2.703E-09	9.709E-12
Open pit to Class C WSF	1.974	0	8	2.566E-06	7.249E-07	7.31E-08	3.162E-08	8.944E-09	1.899E-11
Camp to Class A WSF	1.549	6	0	2.223E-07	6.277E-08	6.299E-09	2.1E-09	2.703E-09	9.709E-12
Overburden to Class A WSF	4.363	0	13	4.17E-06	1.178E-06	1.188E-07	5.137E-08	1.453E-08	3.085E-11
Topsoil to Class A WSF	1.556	0	13	4.17E-06	1.178E-06	1.188E-07	5.137E-08	1.453E-08	3.085E-11
Camp to Class B WSF	4.268	6	0	2.223E-07	6.277E-08	6.299E-09	2.1E-09	2.703E-09	9.709E-12
Overburden to Class B WSF	2.776	0	17	5.453E-06	1.54E-06	1.553E-07	6.718E-08	1.901E-08	4.035E-11
Topsoil to Class B WSF	2.191	0	16	5.132E-06	1.45E-06	1.462E-07	6.323E-08	1.789E-08	3.797E-11
Camp to Class C WSF	6.027	6	0	2.223E-07	6.277E-08	6.299E-09	2.1E-09	2.703E-09	9.709E-12
Overburden to Class C WSF	1.31	0	11	3.528E-06	9.967E-07	1.005E-07	4.347E-08	1.23E-08	2.611E-11
Topsoil to Class C WSF	2.94	0	10	3.207E-06	9.061E-07	9.137E-08	3.952E-08	1.118E-08	2.373E-11
Camp to Overburden Stockpile	5.958	6	0	2.223E-07	6.277E-08	6.299E-09	2.1E-09	2.703E-09	9.709E-12
Camp to Topsoil Stockpile	3.168	6	0	2.223E-07	6.277E-08	6.299E-09	2.1E-09	2.703E-09	9.709E-12

4.1.2.3 Area Sources

Area sources were used in CALPUFF to model fugitive dust emissions resulting from wind erosion of exposed areas. Emission factors were taken from US EPA AP-42 Section 11.9 *Western Surface Coal Mining,* which provides information for wind erosion of exposed areas such as seeded land, stripped overburden, and graded overburden. Particle size multipliers provided in AP-42 Section 13.2.5 *Industrial Wind Erosion* were used where appropriate (EPA, 1995). The same natural control and dust management measures (surface watering) as for unpaved roads were assumed. In addition, the area sources modelled for each Project phase assumed progressive reclamation. Table 4-3 presents controlled emission rates for area sources.

For the open pit fugitive dust emissions from blasting, the emission factor for TSP was calculated according to the following equation (EPA, 1995):

$$E = 0.000014(A)^{1.5}$$

where:

E = emission factor in lb/blast

A = horizontal area (ft^2), with blasting depth ≤ 70 ft (21.3 m)

Scaling factors specific to blasting for PM_{10} and $PM_{2.5}$ are provided along with the above equation in US EPA AP-42 Section 11.9. The inclusion of blasting emissions ensures a very conservative scenario as blasting is expected to occur only three to four times a week. Also, as the pit development progresses in a series of benches, the benches and rock face will act as a wind break and resulting dust dispersion outside the pit will be considerably attenuated. Therefore, the maximum fugitive dust will occur during the initial pit development, when blasts are located close to the original ground elevation, and this is the scenario that was modelled.

Table 4-3: Area Sources and Emission Rates

Source	Exposed Area (m^2)			Emission Rates (g/m^2*s)		
	Construction Phase	Operation Phase	Closure Phase	TSP	PM_{10}	$PM_{2.5}$
Open pit	300,854	804,213	481,116	3.716E-07	1.858E-07	2.798E-08
Class A WSF	132,855	321,408	-			
Class B WSF	165,716	162,984	-			
Class C WSF	-	1,018,469	-			
Overburden Stockpile	218,192	491,199	-			
Topsoil Stockpiles	167,408	69,244	-			
ROM and Low Grade Ore (LGO) pads	80,338	80,338	-			
Open pit blasting	1,500 *	-	-	5.823E-05	1.754E-05	1.012E-06

Source	Exposed Area (m^2)			Emission Rates (g/m^2*s)		
	Construction Phase	Operation Phase	Closure Phase	TSP	PM_{10}	$PM_{2.5}$
	-	2,500 *	-	7.517E-05	3.909E-05	2.255E-06

** Area per blast*

4.1.2.4 Volume Sources

Volume sources were used in CALPUFF to model fugitive dust emissions resulting from material handling and transfer and mineral processing activities. Emission factors were taken from US EPA AP-42 Section 11.19.2 *Crushed Stone Processing and Mineral Processing* and Section 11.24 *Metallic Minerals Processing.* Particle size multipliers provided in AP-42 Section 13.2.5 *Industrial Wind Erosion* were used where appropriate (EPA, 1995).

The ore moisture content is estimated to be 5%, which is considered high-moisture ore according to the definition in Section 11.24.2 of US EPA's AP-42 and the corresponding emission factors were used for primary crushing. Emission rates for material handling and transfer were calculated from emission factors in kg/Mg and estimated daily transfer rates for each location and Project phase.

Natural mitigation for material transfer was calculated using the total number of days in a year with at least 0.254 mm of precipitation (see equation 2). Because the exposed areas and stockpiles are frequently disturbed, the number of days with frozen ground was not considered in this case. In the Project area, the total number of days with more than 0.254 mm of precipitation was equal to 154 between September 1, 2015 and August 31, 2016, yielding a natural control rate of 42% (i.e. Eext = 0.58*E).

To further reduce fugitive dust, BMC will water exposed surfaces and stockpiles, as required. The same control efficiency as for unpaved roads was used (42%). For primary crushing and material transfers occurring indoors, a control efficiency of 75% was assumed. Theoretically, a total enclosure would reduce dust emissions by close to 100% (Countess Environmental, 2006); however, a control efficiency of 75% was used in the model, for conservatism and to account for traffic in and out of the building. In addition, BMC will cover the coarse ore stockpile. The control efficiency for this mitigation measure was assumed to be 90% (Countess Environmental, 2006).

Controlled TSP, PM_{10} and $PM_{2.5}$ emission rates for volume sources are summarized in Table 4-4 for each Project phase.

Table 4-4: Volume Source and Emission Rates

Source	Location	Rate (Mg/day)			Construction Phase Emission Rates (g/s)			Operation Phase Emission Rates (g/s)			Closure Phase Emission Rates (g/s)		
		Construction Phase	Operation Phase	Closure Phase	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Primary Crushing	Process Plant Facility	-	5,500	-	-	-	-	0.0001591	6.366E-05	1.194E-05	-	-	-
Wet Grinding	Process Plant Facility	-	5,500	-	-	-	-	negligible			-	-	-
Material Handling and Transfer	Process Plant Facility (crusher loading)	-	5,472	-	-	-	-	0.1583	0.0007917	0.0001187	-	-	-
	Coarse Ore Stockpile	-	5,500	-	-	-	-	0.03183	0.01273	0.002387	-	-	-
	Tailings Filtration Area	-	4,350	-	-	-	-	0.1259	0.0006293	0.0000944	-	-	-
	Concentrate Area	-	803	-	-	-	-	0.02322	0.0001161	1.742E-05	-	-	-
	Open pit	55,305	40,425	328	0.0215	0.01075	0.001613	0.01572	0.007859	0.001179	0.0001275	6.377E-05	9.565E-06
	Class A WSF (waste rock)	1,620	1,890	1,040	0.0006299	0.000315	4.724E-05	0.0007349	0.0003675	5.512E-05	0.0004044	0.0002022	3.033E-05
	Class A WSF (tailings)	-	3,239	-	-	-	-	0.06297	0.02519	0.004723	-	-	-
	Class B WSF	4,950	9,270	1,320	0.001925	0.0009624	0.0001444	0.003605	0.001802	0.0002703	0.0005133	0.0002566	0.0000385
	Class C WSF	-	21,240	840	-	-	-	0.008259	0.004129	0.0006194	0.0003266	0.0001633	0.0000245
	Overburden Stockpile	13,770	3,150	2,500	0.005354	0.002677	0.0004016	0.001225	0.0006124	9.186E-05	0.0009721	0.000486	7.291E-05
	Topsoil Stockpiles	9,720	810	800	0.00378	0.00189	0.0002835	0.000315	0.0001575	2.362E-05	0.0003111	0.0001555	2.333E-05
	ROM and LGO pads	2,880	4,770	-	0.00112	0.0005599	8.399E-05	0.001855	0.0009274	0.0001391	3.111E-05	1.555E-05	2.333E-06
	Paste Fill Plant	-	1,107	-	-	-	-	0.0004304	0.0002152	3.228E-05	-	-	-

4.1.3 DOMAIN AND RECEPTORS

4.1.3.1 Domain and Sampling Grid

The modelling domain was chosen to be 40 km by 40 km, centered on mine site, such that the camp receptor is part of the domain. The sampling grid was set at 1 km x 1km. The modelling domain was selected to evaluate the potential effects of increased traffic on the Access Road, and the extent of predicted changes in baseline ambient concentrations associated with the Project activities.

4.1.3.2 Nested Grid and Discrete Receptors

A nested grid, centered on the process plant, with the following spacing was used, as recommended in the BC Guidelines for Air Dispersion Modelling (BCMOE, 2008):

- 50 m spacing within 500 m of source;
- 250 m spacing within 2 km of source;
- 500 m spacing within 5 km of source; and
- 1000 m spacing beyond 5 km of source.

Results are presented graphically as contours of constant concentrations.

In addition, to better assess potential effects of air pollutants, a discrete receptor was used. Table 4-5 presents the coordinates and description of the selected receptor, while it is shown on Figure 3-1.

Table 4-5: Discrete Receptor

Location	UTM Coordinates	Description
Camp	09V 413780 6819687	Camp facilities for off-duty workers

Camp was selected as a receptor because the ambient concentrations at camp will be representative of exposure to off-duty workers.

4.2 MODELLING RESULTS

Results presented in the following Sections are modelled ambient concentrations resulting from Project activities, to which baseline concentrations presented in Table 3-5 were added. For each averaging period, the maximum predicted ambient concentrations are presented, except for the annual values which represent averages calculated for the entire modelling period. Results are presented for the camp receptor and the spatial distribution of ambient concentrations is presented graphically for each contaminant.

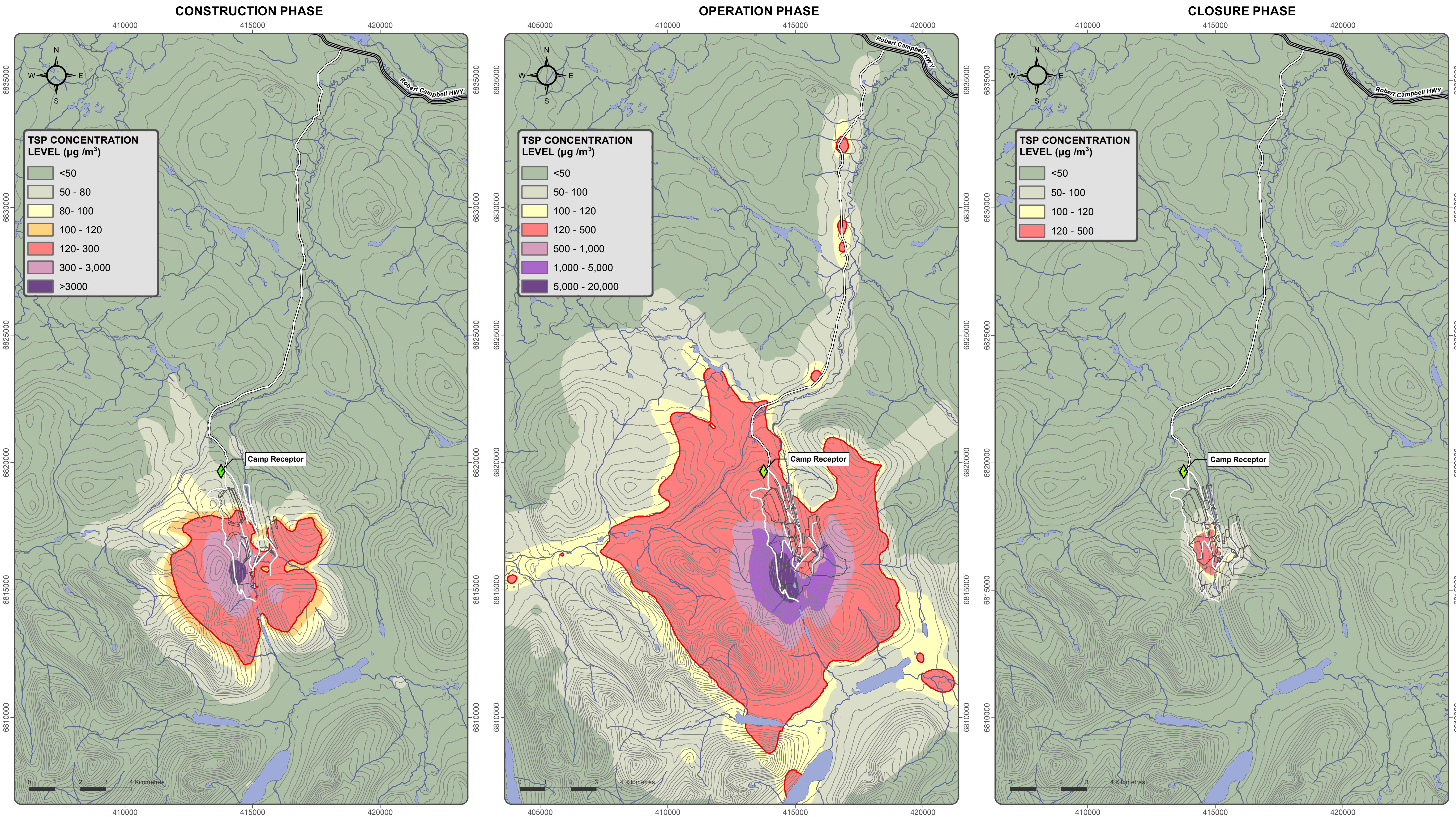
4.2.1 TOTAL SUSPENDED PARTICULATE (TSP)

Predicted maximum 24-hour and mean annual ambient concentrations at the camp receptor for all Project phases are presented in Table 4-6 below. While short duration (24-hour) exceedances could occur at camp during operations under the worst case meteorological and operational conditions, ranked model results indicate that only the top three 24-hour concentrations would be in exceedance of the YAAQS on an annual basis, with a predicted fourth ranked value in camp of 113 µg/m^3. Overall, TSP YAAQS exceedances in camp are predicted to occur less than 1% of the time.

Table 4-6: Predicted TSP Concentrations (µg/m^3)

Receptor	Maximum 24-hr Concentration			Annual Concentration		
	Construction Phase	Operation Phase	Closure Phase	Construction Phase	Operation Phase	Closure Phase
YAAQS	120			60		
Baseline	7			1		
Camp	43	147	8	2	15	1
Baseline + Camp	50	154	15	3	16	2

Figure 4-1 shows the maximum 24-hour predicted concentration contours for the construction, operation and closure phases.



Predicted ambient concentrations shown on this map were produced with CALPUFF Version 5.8.5

Datum: NAD 83; Map Projection: UTM Zone 9N

AEG

Receptor

Standard Boundary Contour at 120 μg /m³ (according to YAAQS)

Location of Proposed Mine Infrastructure

Tote Road/Proposed Access Road

Proposed Mine Road

Waterbody

Watercourse

Contour (40 m)

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 4-1

PREDICTED MAXIMUM 24-HR TSP CONCENTRATIONS

NOVEMBER 2016

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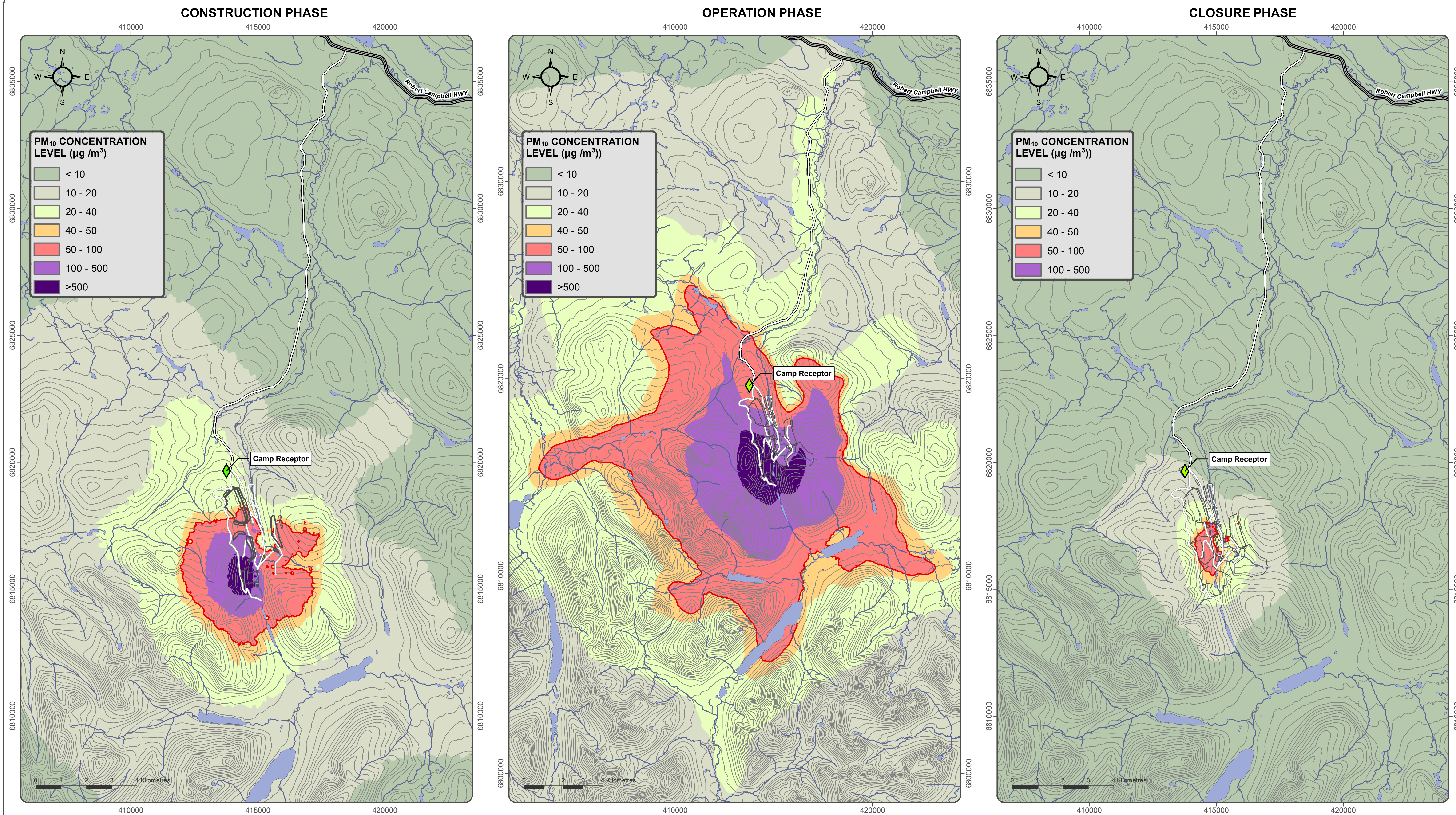
4.2.2 COARSE PARTICULATE MATTER (PM_{10})

Predicted maximum 24-hour and mean annual ambient concentrations at the camp receptor for all Project phases are presented in Table 4-7. While short duration (24-hour) exceedances could occur at camp during operations under the worst case meteorological and operational conditions, ranked model results indicate that only the top four 24-hour concentrations would be in exceedance of the YAAQS on an annual basis, with a predicted fifth ranked value in camp of 47 µg/m^3. Overall, PM_{10} YAAQS exceedances in camp are predicted to occur approximately 1% of the time.

Table 4-7: Predicted PM_{10} Concentrations (µg/m^3)

Receptor	Maximum 24-hr Concentration			Annual Concentration		
	Construction Phase	Operation Phase	Closure Phase	Construction Phase	Operation Phase	Closure Phase
YAAQS	50			n/a		
Baseline	6			1		
Camp	15	67	5	1	5	1
Baseline + Camp	21	73	11	2	6	2

Figure 4-2 shows the maximum 24-hour predicted concentration contours for the construction, operation and closure phases.



Predicted ambient concentrations shown on this map were produced with CALPUFF Version 5.8.5

Datum: NAD 83; Map Projection: UTM Zone 9N

AEG

- Receptor
- Standard Boundary Contour at 50 µg /m3 (according to YAAQS)
- Location of Proposed Mine Infrastructure
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Waterbody
- Watercourse
- Contour (40 m)

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 4 - 2

PREDICTED MAXIMUM 24-HR PM_{10} CONCENTRATIONS

NOVEMBER 2016

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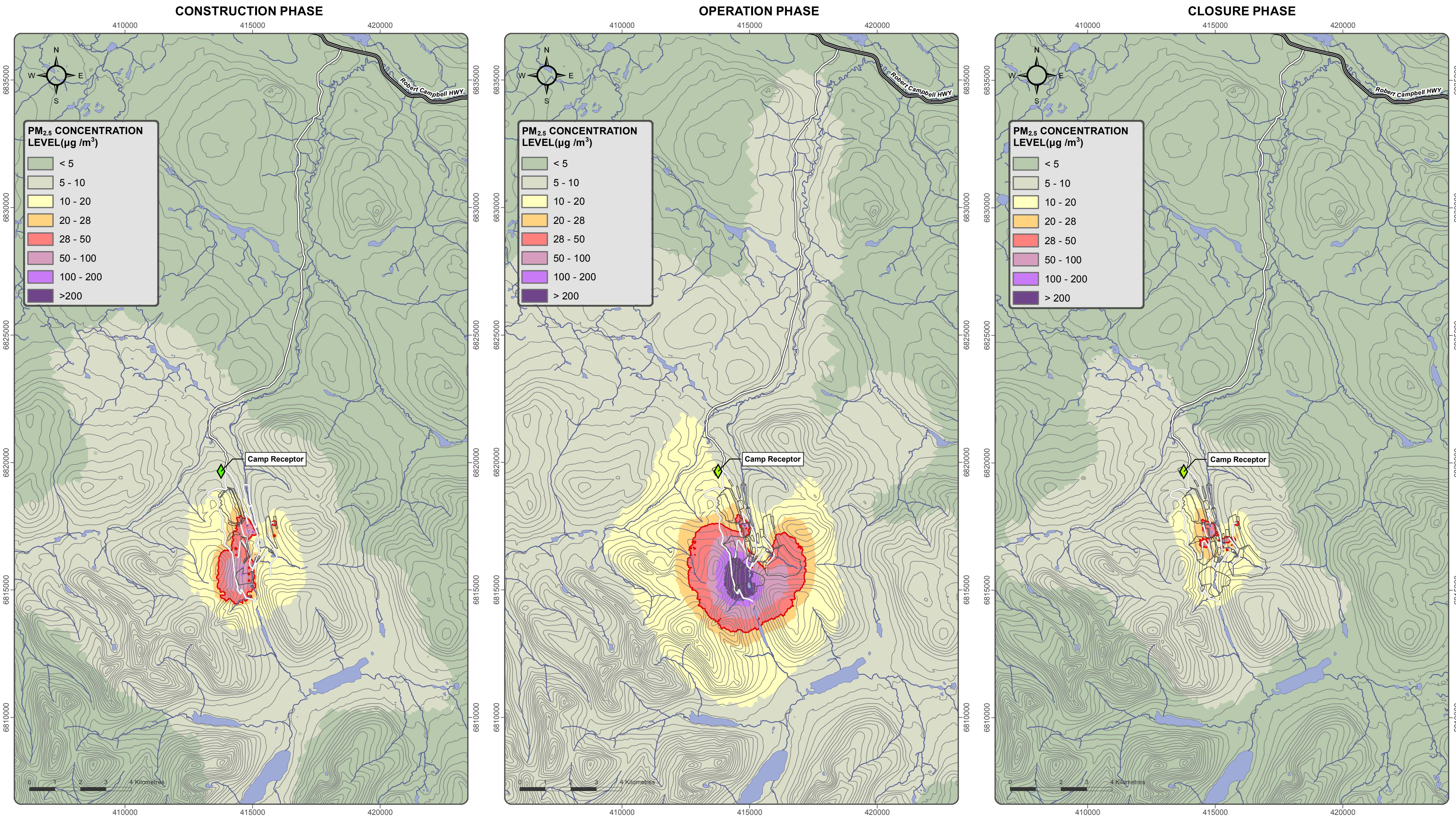
4.2.3 FINE PARTICULATE MATTER ($PM_{2.5}$)

Predicted maximum 24-hour and mean annual ambient concentrations at the camp receptor for all Project phases are presented in Table 4-8. No exceedances of the YAAQS are predicted at the receptor location.

Table 4-8: Predicted $PM_{2.5}$ Concentrations (µg/m^3)

Receptor	Maximum 24-hr Concentration			Annual Concentration		
	Construction Phase	Operation Phase	Closure Phase	Construction Phase	Operation Phase	Closure Phase
YAAQS	28			10		
Baseline	4			1		
Camp	4	6	4	<1	<1	<1
Baseline + Camp	8	10	8	1	1	1

Figure 4-3 shows the maximum 24-hour predicted concentration contours for the construction, operation and closure phases.



Predicted ambient concentrations shown on this map were produced with CALPUFF Version 5.8.5

Datum: NAD 83; Map Projection: UTM Zone 9N

AEG

Receptor

Standard Boundary Contour at 28 µg /m³ (according to YAAQS)

Location of Proposed Mine Infrastructure

Tote Road/Proposed Access Road

Proposed Mine Road

Waterbody

Watercourse

Contour (40 m)

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 4 - 3

PREDICTED MAXIMUM 24-HR $PM_{2.5}$ CONCENTRATIONS

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4.2.4 CARBON MONOXIDE (CO)

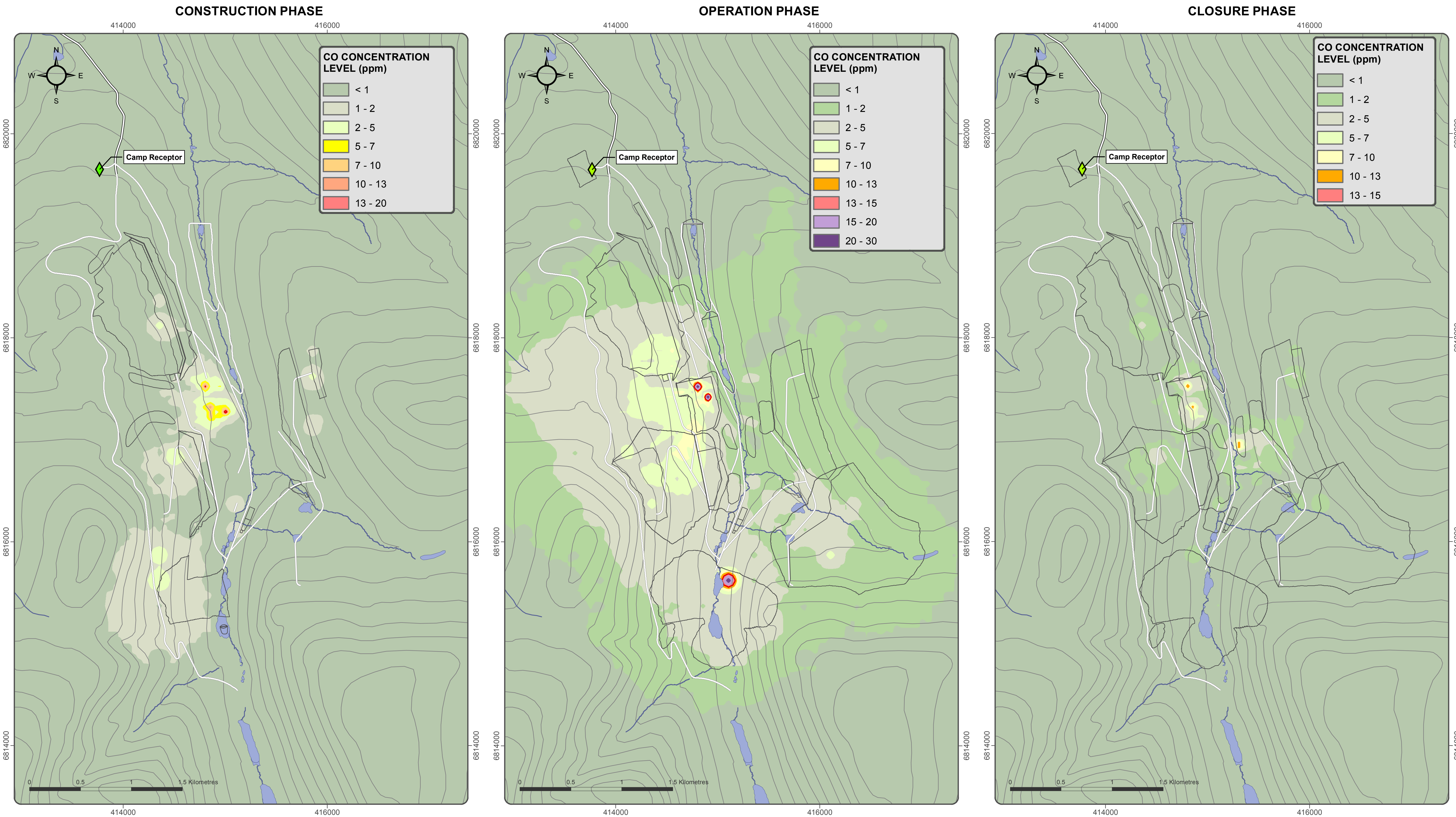
Modelled CO concentrations in µg/m^3 were converted to parts per million (ppm) based on carbon monoxide's molecular weight of 28.01 g/mol, to be comparable to YAAQS. Also, for CO, YAAQS exist for 1-hour and 8-hour averaging periods. CALPUFF outputs maximum concentration for a 1-hour averaging period, and a conversion factor was used to obtain results for the 8-hour averaging period. Averaging time adjustment factors recommended by the EPA (EPA, 1992) were presented in Table 3-6.

Predicted maximum 1-hour and 8-hour ambient concentrations at the camp receptor for all Project phases are presented in Table 4-9. No exceedances of the YAAQS are predicted at the receptor location.

Table 4-9: Predicted CO Concentrations (ppm)

Receptor	Maximum 1-hr Concentration			Maximum 8-hr Concentration		
	Construction Phase	Operation Phase	Closure Phase	Construction Phase	Operation Phase	Closure Phase
YAAQS	13			5		
Baseline	0			0		
Camp	<1	<1	<1	<1	<1	<1

Figure 4-4 shows the maximum 1-hour predicted concentration contours for the construction, operation and closure phases.



Predicted ambient concentrations shown on this map were produced with CALPUFF Version 5.8.5

Datum: NAD 83; Map Projection: UTM Zone 9N

AEG

Receptor

Standard Boundary Contour at 13 ppm (according to YAAQS)

Location of Proposed Mine Infrastructure

Tote Road/Proposed Access Road

Proposed Mine Road

Waterbody

Watercourse

Contour (40 m)

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 4 - 4

PREDICTED MAXIMUM 1-HR CO CONCENTRATIONS

NOVEMBER 2016

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4.2.5 NITROGEN OXIDES (NO_X)

> *Total oxides of nitrogen (NO_X) are comprised of nitric oxide (NO) and nitrogen dioxide (NO_2). The concentration of NO_2 in the exhaust of typical combustion sources is generally in the order of five to 10% of the NO_X concentration. Transformation of NO to NO_2 continues in the atmosphere due to rapid reaction with atmospheric ozone.* (British Columbia Ministry of Environment, 2008)

YAAQS are specific to NO_2. Predicted NO_X concentrations must therefore be transformed into NO_2 using a conversion factor. The BC Guidelines recommend the following approach:

> *Report results as NO_X (100% conversion assumption). If the maximum NO_X concentrations are less than the ambient objective of NO_2, then no further refinement of the conversion factor is required. If the maximum NO_X concentrations are greater than the ambient objectives for NO_2, or if a more "realistic" estimate of NO_2 is desired, use [a conversion] method.* (British Columbia Ministry of Environment, 2008)

Table 4-10 presents the modelling results assuming a 100% conversion of NO_X to NO_2, where modelled NO_X concentrations in µg/m^3 were converted to parts per billion by volume (ppbv) based on NO_2 molecular weight of 46.01 g/mol, to be comparable to YAAQS.

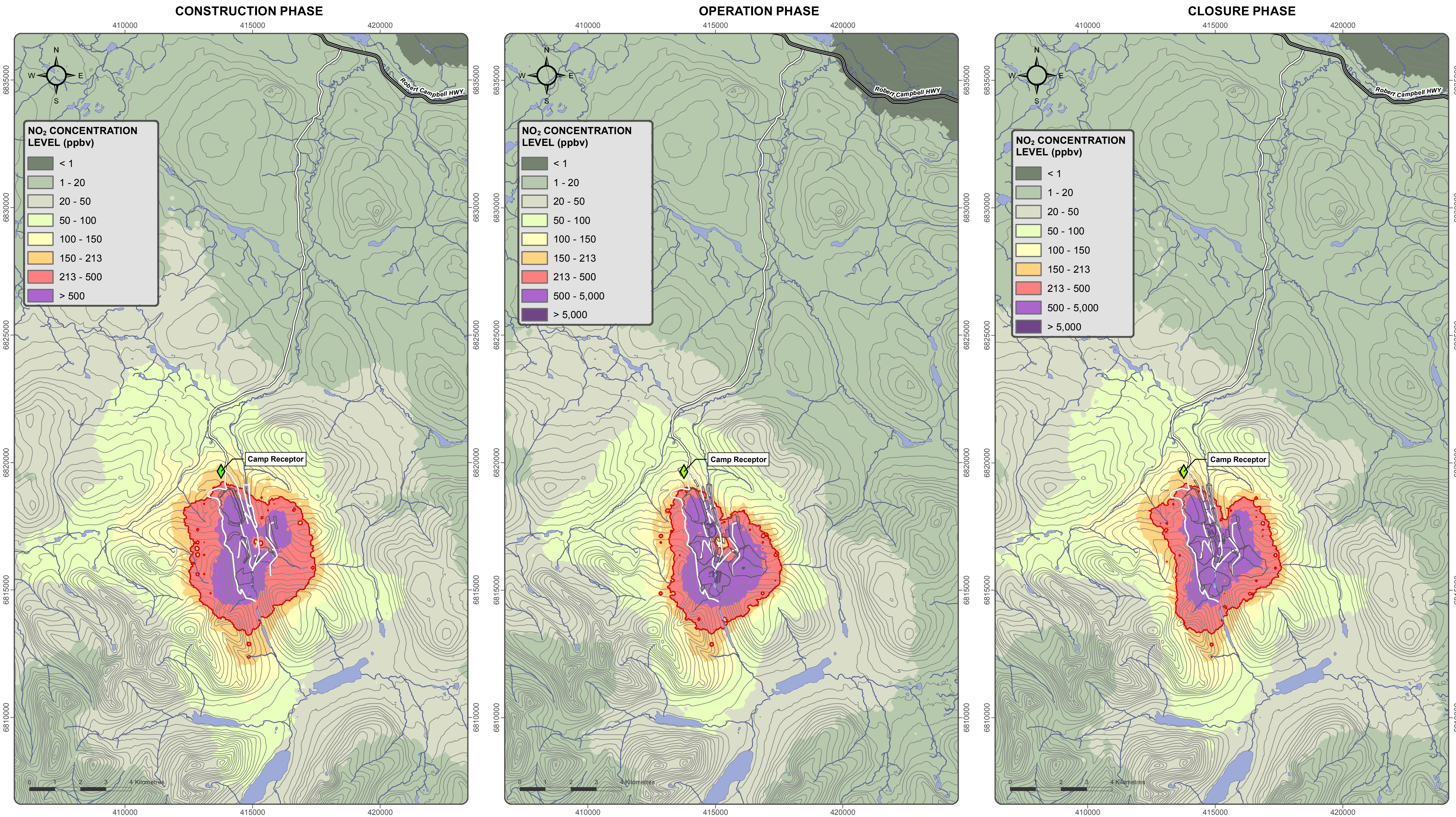
Predicted maximum 1-hour, 24-hour and mean annual ambient concentrations at the camp receptor for all Project phases are presented in Table 4-10. No exceedances of the YAAQS are predicted at the receptor location; therefore, no further refinement of the conversion factor was carried out, as per the BCMOE recommendations (2008).

Table 4-10: Predicted NO_2 Concentrations (ppbv)

Receptor	Maximum 1-hour Concentration			Maximum 24-hour Concentration			Annual Concentration		
	Construction Phase	Operation Phase	Closure Phase	Construction Phase	Operation Phase	Closure Phase	Construction Phase	Operation Phase	Closure Phase
YAAQS	213			106			32		
Baseline	0			0			0		
Camp	161	120	149	56	14	56	5	1	2

It should be noted that higher ambient concentrations at the camp receptor during construction and closure compared to operation are associated with the use of diesel generators in camp, which will be replaced with dual-fuel generators located at the process plant facility during the operation phase.

Figure 4-5 shows the maximum 1-hour predicted concentration contours for the construction, operation and closure phases.



Predicted ambient concentrations shown on this map were produced with CALPUFF Version 5.8.5

Datum: NAD 83; Map Projection: UTM Zone 9N

AEG

- Receptor
- Standard Boundary Contour at 213 ppbv (according to YAAQS)
- Location of Proposed Mine Infrastructure
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Waterbody
- Watercourse
- Contour (40 m)

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 4 - 5

PREDICTED MAXIMUM 1-HR NO_2 CONCENTRATIONS

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4.2.6 SULPHUR OXIDES (SO_X)

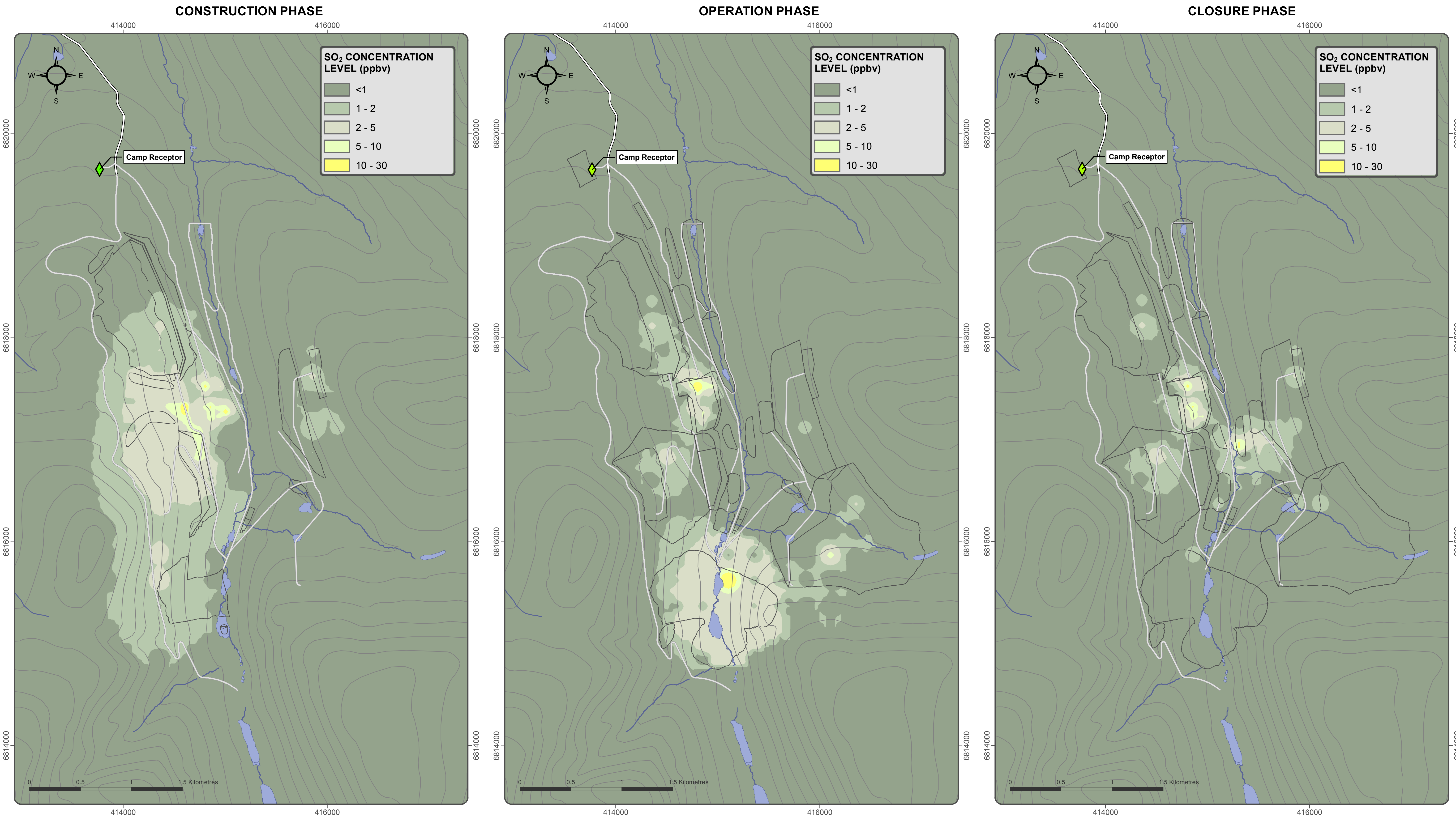
Assuming 100% conversion of S to SO_2 as a conservative estimate, modelled SO_X concentrations in µg/m^3 were converted to parts per billion by volume (ppbv) based on SO_2 molecular weight of 64.06 g/mol, to be comparable to Yukon Ambient Air Quality Standards.

Predicted maximum 1-hour, 24-hour and mean annual ambient concentrations at the camp receptor for all Project phases are presented in Table 4-11. No exceedances of the YAAQS are predicted at the receptor location.

Table 4-11: Predicted SO_2 Concentrations (ppbv)

Receptor	Maximum 1-hour Concentration			Maximum 24-hour Concentration			Annual Concentration		
	Construction Phase	Operation Phase	Closure Phase	Construction Phase	Operation Phase	Closure Phase	Construction Phase	Operation Phase	Closure Phase
YAAQS	172			57			11		
Baseline	0			0			0		
Camp	<1	<1	<1	<1	<1	<1	<1	<1	<1

Figure 4-6 show the maximum 1-hour predicted concentration contours for the construction, operation and closure phases.



Predicted ambient concentrations shown on this map were produced with CALPUFF Version 5.8.5

Datum: NAD 83; Map Projection: UTM Zone 9N

AEG

- Receptor
- Location of Proposed Mine Infrastructure
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Waterbody
- Watercourse
- Contour (40 m)

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 4 - 6

PREDICTED MAXIMUM 1-HR SO_2 CONCENTRATIONS

NOVEMBER 2016

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5 GREENHOUSE GASES INVENTORY

Greenhouse gases emissions were estimated for each Project phase based on equipment and vehicle use presented in Table 4-1 and Table 4-2. In addition to the activities listed in Table 4-1 and Table 4-2, air travel and ore transport to Stewart were included in this inventory, because GHGs are assessed for global impact, as opposed to CACs which were evaluated on at local and regional scales. The emission factors used for each source and GHG are summarized in Table 5-1.

Table 5-1: Greenhouse Gas Emission Factors

Source	Unit	Emission Factor	Reference
Carbon Dioxide (CO_2)			
Diesel Generators	lb/(hp*hr)	1.16	EPA AP-42 Section 3.4 *Large Stationary Diesel and all Stationary Dual-fuel Engine* (EPA, 1995)
Dual-fuel Generators	kg/mmBtu	53.06	*Emission Factors for Greenhouse Gas Inventories* (EPA, 2014)
Boiler	kg/mmBtu	53.06	*Emission Factors for Greenhouse Gas Inventories* (EPA, 2014)
Incinerator	Mg/Mg	0.415	IPCC *Emissions from Waste Incinerators* (IPCC, No date)
Diesel Fired Equipment	lb/(hp*hr)	1.15	EPA AP-42 Section 3.3 *Gasoline and Diesel Industrial Engines* (EPA, 1995)
Light Vehicles	g/mi	531	*Update in Methane and nitrous oxide emission factors for on-highway vehicles* (EPA, 2004)
Heavy Vehicles	g/mi	1,588	*Update in Methane and nitrous oxide emission factors for on-highway vehicles* (EPA, 2004)
Air Travel	g/passenger-mile	0.275	*Emission Factors for Greenhouse Gas Inventories* (EPA, 2014)
Methane (CH_4)			
Diesel Generators	g/L	0.133	National Inventory Report. 1990-2014 (EC, 2016b)
Dual-fuel Generators	g/mmBtu	1	*Emission Factors for Greenhouse Gas Inventories* (EPA, 2014)
Boiler	g/mmBtu	1	*Emission Factors for Greenhouse Gas Inventories* (EPA, 2014)
Incinerator	mg/m^3	0	IPCC *Emissions from Waste Incinerators* (IPCC, No date)
Diesel Fired Equipment	g/l	0.15	National Inventory Report. 1990-2014 (EC, 2016b)
Light Vehicles	g/mi	0.001	*Update in Methane and nitrous oxide emission factors for on-highway vehicles* (EPA, 2004)
Heavy Vehicles	g/mi	0.004	*Update in Methane and nitrous oxide emission factors for on-highway vehicles* (EPA, 2004)
Air Travel	g/passenger-mile	0.0091	*Emission Factors for Greenhouse Gas Inventories* (EPA, 2014)
Nitrous Oxide (N_2O)			
Diesel Generators	g/L	0.4	National Inventory Report. 1990-2014 (EC, 2016b)
Dual-fuel Generators	g/mmBtu	0.1	*Emission Factors for Greenhouse Gas Inventories* (EPA, 2014)
Boiler	g/mmBtu	0.1	*Emission Factors for Greenhouse Gas Inventories* (EPA, 2014)
Incinerator	mg/m^3	2	IPCC *Emissions from Waste Incinerators* (IPCC, No date)
Diesel Fired Equipment	g/l	1	National Inventory Report. 1990-2014 (EC, 2016b)
Light Vehicles	g/mi	0.002	*Update in Methane and nitrous oxide emission factors for on-highway vehicles* (EPA, 2004)
Heavy Vehicles	g/mi	0.005	*Update in Methane and nitrous oxide emission factors for on-highway vehicles* (EPA, 2004)
Air Travel	g/passenger-mile	0.0087	*Emission Factors for Greenhouse Gas Inventories* (EPA, 2014)

Average annual GHGs emission per source type and per Project phase are summarized in Table 5-2. Total emissions are reported in CO_2 equivalent, which is calculated based on a global warming potential of 25 for CH_4 and 298 for N_2O (EC, 2015b). The average fuel consumption of diesel engines (generators and other equipment) was estimated based on the power output (kW). For air travel, an average of four flights of five passengers per week was used for construction and closure phase, while seven flights of 18 passengers per week were estimated for the operation phase.

Table 5-2: Average Annual Project GHG Emissions (tonnes of CO_2 equivalent)

Source	Construction Phase	Operation Phase	Closure Phase
Diesel Generators	2,790	0	1,189
Dual-fuel Generators*	0	24,132	0
Boiler	1,582	1,582	1,582
Incinerator	1.4	1.4	1.4
Diesel Fired Equipment	7,388	26,457	7,334
Light Vehicles	10.5	20.4	65.0
Heavy Vehicles	126	6,814	877
Air Travel	0.4	6.4	0.4
TOTAL	**11,898**	**59,014**	**11,049**

**Assume 99% natural gas and 1% diesel*

When comparing to the 2014 Canada and Yukon GHG emissions (see Table 3-7), predicted Project emissions represent a very small fraction of the total Canadian emissions (< 0.01% for all Project phases). When comparing to the 2014 Canadian emissions from the mining sector, the predicted Project emissions are below 1% for all Project phases. Predicted Project emissions represent about 4% of the 2014 total Yukon GHG emissions during the construction and closure phases and 22% during the operation phase.

6 DISCUSSION

While short duration (24-hour) YAAQS exceedances could occur at camp for TSP and PM_{10} during operations under the worst case meteorological and operational conditions, ambient concentrations are predicted to decrease rapidly with distance with annual mean concentrations being modelled to be well within the applicable YAAQ. Ambient concentrations for the other parameters modelled are predicted to remain below the YAAQS at the camp receptor during all Project phases. As shown on Figure 4-1 through Figure 4-6, higher ambient concentrations could occur in close proximity to the sources; however, these concentrations are not comparable to the YAAQS as they occur in an industrial area. Workers will be equipped with adequate PPE, where required.

Modelling results presented for each averaging period (except annual) represent the maximum predicted value over the one-year period modelled. Ambient concentrations will therefore be below values reported in Section 4.2 the rest of the year. The scenarios modelled are conservative as they assume the simultaneous operation of all non-continuous sources, and only include the main operational mitigations. Additional mitigation measures presented in BMC's Air Quality Management Plan, such as construction of wind breaks or stationary misters, orientation of stockpiles parallel with prevailing wind and regular vehicle and equipment maintenance, could contribute to further reduce ambient concentrations. In addition, road and exposed surfaces watering frequency can be adjusted as necessary (as a function of meteorological conditions) to increase efficiency, and ensure that YAAQS for TSP and PM10 are not exceeded in camp.

Predicted Project GHG emissions represent a very small fraction of 2014 Canadian total and mining sector emissions. They represent 4 to 22% of the 2014 total territorial emissions depending on the Project phase. It should however be noted that Yukon GHG emissions are generally very low (less than 0.1% of total Canadian emissions) due to limited industrial activity and low population and were particularly low in 2014. Canadian mining facilities that have reported their emissions to the National Pollutant Release Inventory (NPRI) in 2014 had GHG emissions ranging from 320 to 258,120 tonnes of CO_2 equivalent (EC, 2016c). The average for 21 facilities (excluding tar sands facilities) was 102,217 tonnes of CO_2 equivalent. Predicted GHGs emissions during the operation phase of the Project are well below the Canadian average for mining facilities. In comparison, the Casino mine project in Yukon, currently under YESAB review, has predicted average GHG emissions of 609,000 t CO_2 equivalent during the operation phase (Casino Mining Corporation, 2014b), which represent about 227% of the 2014 Yukon emissions. The Casino mine production is expected to be 120,000 tpd with a main power plant of 150 MW (Casino Mining Corporation, 2014b), or about 10 times the capacity of KZK Project's power plant. Predicted Project GHG emissions are therefore in line (proportionally) with predicted emissions from other facilities in a similar setting.

7 MODEL LIMITATIONS AND UNCERTAINTY

The overall accuracy of the model predictions depends on the accuracy of the data input and the accuracy of the air dispersion model.

In terms of the input emission data, emission factors provided in the EPA AP-42 have associated ratings ranging from A (Excellent) to E (Poor). A-rated emission factors are developed primarily from A and B rated source test data taken from many randomly chosen facilities in the industry population and the source category population is sufficiently specific to minimize variability. On the contrary, E-rated emission factors are developed from C and D rated test data from a very few number of facilities, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability in the source category population. Table 7-1 summarizes the emission factors ratings for the various sources types used in this study.

Table 7-1: Emission Factors Ratings (EPA, 1995)

Source Type	AP-42 Section	TSP	PM_{10}	$PM_{2.5}$	CO	NO_X	SO_X
Large Stationary Diesel Engines	3.4	C	E	E	C	B	B
All Dual-fuel Engines	3.4	n/a	n/a	n/a	D	D	B
Natural Gas Combustion	1.4	D	D	D	B	A	A
Refuse Combustion	2.1	D	D	D	D	D	D
Wind erosion of exposed areas	11.9	C	C	C	n/a	n/a	n/a
Blasting	11.9	C	D	D	n/a	n/a	n/a

Source Type	AP-42 Section	TSP	PM_{10}	$PM_{2.5}$	CO	NO_X	SO_X
Material Handling and Transfer	11.19	E	E	E	n/a	n/a	n/a
Unpaved Industrial Roads	13.2	B	B	B	n/a	n/a	n/a
Primary crushing	11.24	C	C	C	n/a	n/a	n/a

Note: A = Excellent, B = Above Average, C = Average, D = Below Average, E = Poor

The accuracy of the meteorological data input into the model is a function of the accuracy of the measuring instruments and sensors. Table 7-2 presents the published accuracy of the Project Campbell Scientific meteorological station's sensors.

Table 7-2: Meteorological Station Components Accuracy

Component	Model	Accuracy
Air Temperature and Relative Humidity Sensor	HC-S3-XT-L	± 0.1 - 0.6°C (temperature dependent); ± 1.5% RH
Total Precipitation Gauge	Geonor T-200B (3 sensors)	0.1% FS
Wind Speed and Direction Sensor	RM Young 05103AP-10-L	± 0.3 m/s; ± 3°
Barometric Pressure Sensor	Vaisala CS106	± 0.3 - 1.5 mb (temperature dependent)
Pyranometer	Kipp & Zonen CMP3-L	5 - 20 µV/W/m^2

The accuracy of the air dispersion model depends largely on the modelling options selected and on the objectives of the study. No model calibration or validation could be conducted for the current study due to the lack of local ambient data to compare the modelling results with. Various independent studies have evaluated the performance of different air dispersion models and results generally indicate that models predicting capabilities vary with conditions. Rodd (2014) found that Lagrangian puff models (such as CALPUFF) generally exhibit smaller variances, higher correlation, and higher percentage of predictions within a factor of two compared to the steady-state models.

Overall, conservative assumptions were made to produce reasonable worst case scenarios and confidence is high that the model is not under-predicting ambient concentrations.

8 CONCLUSION

In conclusion, the air dispersion scenarios modelled for each Project phase indicate that no exceedances of the YAAQS are expected to occur at the camp location. The scenarios modelled include design mitigations as well as some operational mitigations, but are otherwise considered to be reasonable worst-case scenarios.

Predicted Project greenhouse gas emissions are low compared to national total and mining sector emissions. During the operation phase, they could represent up to 23% of the total territorial emissions (assuming 2014 emission levels), however Yukon emissions are overall very low. Predicted annual Project emission are well below the average annual GHG emissions of other mining facilities in Canada.

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