Appendix 4.1-B Air Quality Modelling Report

TELKWA COAL
LIMITED

Air Quality Modelling Report

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
AAQC	Ambient air quality criteria
BC MECCS	British Columbia Ministry of Environment and Climate Change Strategy
BC MEMPR	British Columbia Ministry of Energy, Mines and Petroleum Resources
CARB	California Air Resources Board
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
ECCC	Environment and Climate Change Canada
GHG	Greenhouse gas
LSA	Local study area
N_2O	Nitrous oxide
NO	Nitric oxide
NO_X	Oxides of nitrogen
NO_2	Nitrogen dioxide
O_2	Oxygen
O_3	Ozone
PAH	Polycyclic aromatic hydrocarbon
PCIC	Pacific Climate Impacts Consortium
PM	Particulate matter
PM_{10}	Inhalable particulate matter less than 10 microns
$PM_{2.5}$	Fine particulate matter less than 2.5 microns
RAC	Railway Association of Canada
RSA	Regional study area
SO_2	Sulphur dioxide
TCL	Telkwa Coal Limited
TOG	Total organic gas
TSP	Total suspended particulate
US EPA	United States Environmental Protection Agency
WRF	Weather Research and Forecasting

LIST OF SYMBOLS AND UNITS OF MEASURE

Symbol / Unit of Measure	Definition
°C	degrees Celsius
%	percent
BTU/h	British thermal unit per hour
kg	kilogram
kg/t	kilogram per tonne
km	kilometres
km/h	kilometres per hour
m	metre
mm	millimetre
m^2	square metre
m/s	metres per second
s^{-1}	per second
t	tonne

1.0 INTRODUCTION

This appendix provides technical details and assumptions used in the air quality and greenhouse gas assessment for the Project. The air quality and greenhouse gas assessment include an emission estimation for all Project activities during Year 5 of the Operation Phase (**Section 2**), and a dispersion modelling study to estimate maximum ambient concentrations and deposition of air contaminants (**Section 3**).

2.0 EMISSION ESTIMATION

An emission estimation was completed for the following air contaminants:

- Particulate matter (PM), including total suspended particulate (TSP), inhalable particulate matter less than 10 microns in diameter (PM_{10}), and fine particulate matter less than 2.5 microns in diameter ($PM_{2.5}$)
- Oxides of nitrogen (NO_X), comprised of nitric oxide (NO) and nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2),
- Total organic gases (TOG)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

Section 2.1 through **Section 2.11** describe the equations and information sources used to estimate emissions of these air contaminants. An emission summary is provided in **Section 2.12**. Lastly, the speciation of metals and polycyclic aromatic hydrocarbons (PAHs) for the Health VC is discussed in **Section 2.13**.

2.1 Coal Extraction Activities

Coal extraction activities at the open pit include all activities to remove soil, overburden, and the underlying coal. Soil is first stripped with scrapers to expose the overburden. The soil is salvaged for reclamation. The overburden is then drilled, blasted, and removed using bulldozers, excavators, and haul trucks. Lastly, the underlying coal is removed and transported to the Coal Processing Plant via haul trucks.

2.1.1 Scraping

Emissions of TSP from scraping of soil were estimated using an emission factor of 0.029 kg TSP/t soil obtained from Section 11.9 of the United States Environment Protection Agency's Compilation of Air Pollutant Emission Factors known as AP-42 (US EPA 1998). The emission factor is expressed per tonne of soil scraped, which was provided by TCL for Year 5 of the Operation Phase. Since emission factors for PM_{10} and $PM_{2.5}$ are not provided for scraping activities, aerodynamic particle size multipliers from Section 13.2.4 of AP-42 (US EPA 2006), and reproduced in **Table 2.1**, were used to convert estimated TSP emissions to emissions of the smaller PM size fractions.

Table 2.1 Particle Size Multipliers for Scraping, Drilling, and Material Handling Activities

Size Fraction	Multiplier as a Ratio of Total Dust	Multiplier as a Ratio of TSP
< 30 microns	0.74	1.0
< 10 microns	0.35	0.47
< 2.5 microns	0.053	0.072

2.1.2 Drilling

Emissions of TSP from drilling of overburden were estimated using an emission factor of 0.59 kg/hole obtained from Section 11.9 of AP-42 (US EPA 1998). Based on information provided from TCL, it is estimated that there will be 8,045 drill holes required in Year 5. Similar to scraping activities, emission factors for PM_{10} and $PM_{2.5}$ are not provided for drilling activities, and emissions of these size fractions were estimated using the particle size multipliers shown in **Table 2.1**. There will be no drilling of coal associated with the Project.

2.1.3 Blasting

Emissions of PM from blasting of overburden were estimated using the following equations obtained from Section 11.9 of AP-42 (US EPA 1998):

$$E_{TSP} = 0.00022(A)^{1.5}$$

$$E_{PM10} = 0.52 \times E_{TSP}$$

$$E_{PM2.5} = 0.03 \times E_{TSP}$$

Where: E = emission rate in kg/blast

A = horizontal area of blast, in m^2

Blasting is expected to occur approximately once every second day in Year 5, with a horizontal area of 10,000 m^2 per blast.

Blasting also requires the use of explosives (65% ammonium nitrate/fuel oil, 35% emulsion), which may result in emissions of NO_X. Emissions associated with the use of explosives were estimated using emission factors obtained from the Australian Government (2016), and reproduced in **Table 2.1-2**, in conjunction with the estimated amount of explosives required in Year 5 as provided by TCL.

There will be no blasting of coal associated with the Project.

Table 2.2 Emission Factors for Use of Explosives

Explosive Type	NO_X (kg/t)
Heavy ANFO	2.0
Emulsion	0.2 [(a)]

Note: [a] Based on charge diameters > 150 mm as per TCL.

2.1.4 Bulldozing

Following extraction, bulldozers are used to move coal and overburden into position for loading onto haul trucks. Emissions of PM from bulldozing of overburden were estimated using the following equations obtained from Section 11.9 of AP-42 (US EPA 1998):

$$E_{TSP} = \frac{2.6(s)^{1.2}}{(M)^{1.3}}$$

$$E_{PM10} = 0.75 \times \frac{0.45(s)^{1.5}}{(M)^{1.4}}$$

$$E_{PM2.5} = 0.105 \times E_{TSP}$$

Where: E = emission rate, in kg per hour of bulldozer operation

s = material silt content, in %

M = material moisture content, in %

In the absence of site-specific data, a default silt content of 6.9% and a default moisture content of 7.9% was assumed for overburden at the open pit (US EPA 1998).

Similarly, emissions of PM from bulldozing of coal were estimated using the following equations obtained from Section 11.9 of AP-42 (US EPA 1998):

$$E_{TSP} = \frac{35.6(s)^{1.2}}{(M)^{1.3}}$$

$$E_{PM10} = 0.75 \times \frac{8.44(s)^{1.5}}{(M)^{1.4}}$$

$$E_{PM2.5} = 0.105 \times E_{TSP}$$

A moisture content of 5 to 6% was provided by TCL for run-of-mine (ROM) coal, and a default silt content of 8.6% was assumed (US EPA 1998).

2.2 Material Handling and Processing

Material handling and processing associated with the Project include:

- Loading of ROM coal and overburden onto haul trucks at the open pit
- Unloading of overburden at mine rock storage piles
- Loading of coal onto stockpiles at the Coal Processing Plant and Rail Loadout
- Loading of processed coal onto super B-train on-highway trucks and trains
- Conveyor transfers at the Coal Processing Plant and Rail Loadout

- Crushing and screening of coal at the Coal Processing Plant

The following equation from Chapter 13.2.4 of AP-42 (US EPA 2006) were used to estimate emissions associated with material loading and unloading (i.e., batch drop operations):

$$E = k(0.0016)\frac{(U/2.2)^{1.3}}{(M/2)^{1.5}}$$

Where: E = emission rate, in kg per tonne of material handled

k = aerodynamic particle size multiplier (see **Table 2.1**)

U = mean wind speed, in m/s

M = material moisture content, in %

As described above, a default moisture content of 7.9% was assumed for overburden at the open pit (US EPA 1998). Site-specific moisture contents of 5 to 6% was provided for ROM coal, and 8 to 9% for processed coal.

Emission estimates for material loading and unloading are dependent on the hourly wind speed. CALMET-derived wind speeds in the Project Area were used, resulting in a variable emission file for dispersion modelling.

Emissions associated with conveyor transfers, crushing, and screening were estimated using emission factors obtained from Section 11.19.2 of AP-42 (US EPA 2004). Emission factors are provided for uncontrolled sources, based on moisture contents ranging from 0.21 to 1.3%, and sources controlled with wet suppression technology, based on moisture contents ranging from 0.55 to 2.88%. Due to the high moisture contents expected, the emission factors for controlled sources were used.

2.3 Stockpile Wind Erosion

During periods of high winds, dust may be generated by wind erosion of open stockpiles. Factors influencing the magnitude of wind-blown dust emissions from open stockpiles include meteorological conditions, pile size and shape, frequency and extent of pile disturbances, and material silt content.

From previous project experience, it is expected that the mine rock storage piles will be of a size and the silt content sufficiently low that winds experienced in the Project Area will not be strong enough to pick up and entrain dust particles from the storage piles.

There are two methodologies to estimate emissions from coal stockpile wind erosion. Section 11.9 of AP-42 (US EPA 1998) provides a general emission factor based on the mean wind speed and was intended to consider emissions over a longer period rather than short-term durations. Section 13.2.5 of AP-42 (US EPA 2006b) provides an alternative methodology that considers the fastest mile wind speed and the threshold friction velocity of the exposed surface. To be conservative, the maximum emission rate based on the two methodologies was used, in conjunction with CALMET-derived wind speeds for the Project Area.

Water will be applied manually to the stockpiles to reduce emissions during dry and windy conditions. A control efficiency of 50% was therefore applied to estimated stockpile wind erosion emissions (Australian Government 2011).

2.4 Diesel Equipment

Exhaust emissions were calculated for haul trucks and diesel-fuelled non-road equipment such as bulldozers, excavators, and loaders following the methodology used in the US EPA Motor Vehicle Emission Simulator also known as MOVES (US EPA 2018). The list and specifications of haul trucks and equipment were provided by TCL and provided in **Table 2.3** (equipment activity for the Construction Phase are included for comparison). All haul trucks and equipment will be purchased new for the Project and were assumed to adhere to the latest US EPA emission standards for 2018 and newer model years.

The US EPA methodology does not provide emission factors for CH_4 and N_2O. Emissions of CH_4 and N_2O were scaled based on estimated CO_2 emissions using fuel-based emission factors from Environment and Climate Change Canada (ECCC 2020).

Table 2.3 Specifications of Haul Trucks and Non-Road Equipment

Truck / Equipment Type	Number of Units		Brake Horsepower	Annual Hours of Operation		Load Factor
	C	O		C	O	
CAT 6015 Shovel/Excavator	1	3	1040	3,570	7,140	0.80
Epiroc PV235 Rotary Drill	1	1	800	1,785	7,140	0.70
CAT 988K Front End Loader	1	4	588	3,570	7,140	0.75
CAT 14M Grader	1	3	238	3,570	7,140	0.70
CAT D8T Bulldozer	3	5	312	10,710	7,140	0.70
CAT 777G Haul Truck	6	12	765	21,420	7,140	0.40
CAT 745 Haul Truck	4	4	381	7,140	3,570	0.40
CAT 390F Excavator	2	2	524	3,570	3,570	0.80
Epiroc T45 Tophammer Drill	1	1	325	1,785	7,140	0.70
CAT 777G Water/Sanding Truck	1	2	765	3,570	7,140	0.40
Total	**21**	**37**	**-**	**60,690**	**242,760**	**-**

Note: C = Construction Phase, O = Operation Phase

2.5 Train Idling

Processed coal from the Project will be loaded onto trains for transport. During loading operations, trains will be idling, generating combustion emissions. A total of 66 trains are expected in Year 5, driven by two to three 2,500-hp locomotives.

Emissions of PM, NO_X, SO_2, and total hydrocarbons were estimated using emission factors for line-haul locomotives from the Railway Association of Canada (RAC 2019). To be conservative, estimated emission factors for locomotives prior to implementation of emission standards were used. Emissions of TOG were estimated using a TOG to total hydrocarbon ratio of 1.07 for diesel engines, based on US EPA MOVES methodology for non-road equipment. Emissions of greenhouse gases (GHGs) were estimated using fuel-based emission factors for diesel trains from Environment and Climate Change Canada (ECCC 2020).

The operation of trains during transport will generate emissions. However, such emissions are attributable to Canadian National Railway rather than the Project. Project-related transport emissions are expected to be a small contributor to total emissions associated with freight transport along the existing rail corridor in the Air Quality RSA and LSA.

2.6 On-Road Vehicles

Project operation will be associated with the following on-road vehicle trips:

- Super B-train on-highway trucks for transport of processed coal along the Tenas Access Corridor
- Delivery trucks for transport of fuel, explosives, magnetite, other consumables, and parts from point of purchase to the Minesite
- Shuttle busses for transport of employees from Telkwa to the Minesite
- Mine buses for transport of employees to/from the mine dry and the open pit
- Onsite trucks for transport of explosives from the Explosive Magazines to the open pit
- Other onsite service vehicles

Emissions associated with on-road vehicles were estimated using US EPA MOVES based on travel distances provided by TCL. Emission estimation in MOVES is dependent on several factors including travel speeds, fuel characteristics, vehicle age, and climatic conditions. The user-specified input parameters used in this assessment are summarized in **Table 2.6-1**. For all other parameters, default US EPA data were used.

Table 2.4 MOVES Input Parameter Selection for On-Road Vehicles

Parameter	Value	Notes
Fuel type	Gasoline (onsite service vehicles) Diesel (trucks and busses)	Assumption
Vehicle speed	30 km/h (onsite access roads) 50 km/h (super B-train trucks) 60 km/h (other vehicles)	From TCL
Vehicle age	New (Telkwa owned vehicles) Default US EPA (delivery trucks)	From TCL
Daily temperature	-1.0 to 9.4 °C	Based on climate normal data at Smithers Airport
Relative humidity	59.9 to 86.3%	

2.7 Road Dust Re-entrainment

Onsite access roads and the Tenas Access Corridor will be unpaved and the operation of haul trucks and on-road vehicles along these roads will result in the re-entrainment of road dust particles. Emissions of PM from the use of unpaved roads were estimated using the following equation from Section 13.2.2 of AP-42 (US EPA 2006c):

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

Where: E = emission rate, in pounds per vehicle mile travelled

k, a, b = empirical constants (see **Table 2.5**)

s = surface silt content, in %

W = mean vehicle weight, in tons

Table 2.5 Empirical Constants for Road Dust Re-entrainment

Constant	TSP	PM_{10}	$PM_{2.5}$
k	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

Surface silt contents for all onsite access roads were assumed to be 5.1%, based on the average observed at other surface coal mining facilities (US EPA 2006c). For the Tenas Access Corridor, a surface silt content of 6.4% for typical gravel roads was used (Western Governors Association 2006). All vehicle weights were provided by TCL.

To reduce Project-related road dust emissions, water will be applied to all onsite access roads daily during favourable (i.e., non-freezing) weather conditions. A control efficiency of 75% was assumed for watering, representing an increase in the surface moisture content to twice that of the natural moisture level (US EPA 2006c). Calcium chloride, or other chemical dust suppressant, will be applied to the Tenas Access Corridor on a yearly basis. A control efficiency of 80% was assumed for the annual application of chemical dust suppressants (US EPA 1988). To further reduce potential effects at the horsemen camp, application of chemical dust suppressant will be increased to a daily basis during favourable weather conditions along a 500-m stretch in front of the camp (i.e., 250-m on either side of the camp), with an assumed control efficiency of 98% (US EPA 1988).

2.8 Road Grading

Emissions of PM associated with road grading activities were estimated using the following equations from Section 11.9 of AP-42 (US EPA 1998):

$$E_{TSP} = 0.0034(S)^{2.5}$$

$$E_{PM10} = 0.6 \times 0.0056(S)^{2.0}$$

$$E_{PM2.5} = 0.031 \times E_{TSP}$$

Where: E = emission rate, in kg per vehicle-kilometre-travelled

S = mean vehicle speed, in km/h

The annual vehicle-kilometres-travelled was estimated based on the total operating hours of the graders in Year 5 (see **Table 2.3**) and a mean vehicle speed of 9.66 km/h as provided by TCL.

As discussed in **Section 2.7**, onsite access roads will be watered on a daily basis and chemical dust suppressant will be applied to the Tenas Access Corridor on a yearly basis, at minimum. The control efficiencies for road dust re-entrainment were also applied to grading activities.

2.9 Space Heating

A waste oil boiler will be used to provide space heating for the maintenance facility at the Coal Processing Plant. A 500 million BTU/h Clean Burn coil tube boiler was assumed to operate for half the year (i.e., 4,380 hours per year).

Emissions associated with the combustion of waste oil in the boiler were estimated using emission factors from Section 1.11 of AP-42 (US EPA 1996). A default ash content of 0.1% was assumed for the waste oil (US EPA 1985). Since emission factors for $PM_{2.5}$ are not provided in Section 1.11 of AP-42, $PM_{2.5}$ emissions were estimated to be 56% of estimated PM_{10} emissions (Australia Government 2011). Emissions of CH_4 and N_2O were scaled based on estimated CO_2 emissions using emission factors for combustion of residual oil from Environment and Climate Change Canada (ECCC 2020).

2.10 Fugitive Methane

As part of the geological processes of coal formation, CH_4 may be produced and trapped in the coal seam. Fugitive emissions of CH_4 will be released when coal is exposed to air. Coalbed methane emissions were estimated by applying an emission factor of 0.86 kg CH_4 per tonne of coal mined for surface bituminous coal mining in BC (ECCC 2020).

Since this emission factor represents a provincial average, potential coalbed methane resources developed specifically for the Telkwa coalfield (Ryan 1993) were also reviewed. Total coal resource in Area 4 of the Telkwa coalfield, in which the Project is located, is estimated to be 68.6 million tonnes. Total coalbed methane resource for Area 4 is 439.6 million cubic metres. This suggests a coalbed methane factor of 6.4 m^3/t (approximately 4.2 kg/t). This is well below the provincial average of 10.2 m^3/t (approximately 6.7 kg/t) in BC (BC MEMPR 2004). While these values appear to be considerably higher than the emission factor of 0.86 kg/t, it should be noted that these values represent the total amount of coalbed methane trapped within the coal seams and not necessarily the amount of fugitive coalbed methane emissions. Total coalbed methane resources are developed based on a depth of about 2000 m. Conversely, the Project will only mine surface coal to a depth of about 150 m. Based on absorption isotherms for the Telkwa coalfield (BC MEMPR 2004), coalbed methane content in surface coal is approximately one-third that of coal at greater depths. In addition, only 60% of the coalbed methane content in the coal is expected to be released as fugitive emissions (ECCC 2020). Accounting for these factors, a revised emission factor for the Telkwa coalfield would be approximately 0.84 kg/t. Therefore, the emission factor of 0.86 kg/t used in this assessment is expected to be a reasonable and more conservative estimate of coalbed methane emissions from the Project.

After mining, any remaining adsorbed CH_4 will be released during subsequent handling, transport, and storage until the CH_4 in the coal reaches equilibrium with surrounding atmospheric conditions. In accordance with the Western Climate Initiative, post-mining fugitive methane emissions are attributable to the ultimate consumer of the coal and were not considered Project-related.

2.11 Borrow Pit Activities

Gravel will be obtained from two borrow pits located along the Tenas Access Corridor for routine maintenance of the road during Project operation. The borrow pits will operate only during the daytime (7 am to 7 pm) in the summer months (May to September). Material will be excavated and fed into a crushing/screening plant. From there, three stockpiles will be formed for coarse (4 inch to 0.75 inch), medium (0.75 inch to 0.25 inch), and fine (less than 0.25 inch) materials. Material will then be loaded onto haul trucks for application onto the road.

Borrow pit activities will result in the following emissions:

- Fugitive dust from material handling and processing
- Stockpile wind erosion
- Diesel equipment exhaust

Emissions associated with material handling and processing were estimated using the methodology described in **Section 2.2** with an average moisture content of 2.8% based on laboratory analyses of site-specific samples. Emissions from wind erosion of the stockpiles were estimated using the methodology described in Section 13.2.5 of AP-42 (US EPA 2006b). Results indicate that winds experienced in the Project Area will not be strong enough to pick up and entrain dust particles from the stockpiles, except for a few hours in January when the borrow pits will not be operating. Exhaust emissions from diesel-fuelled non-road equipment (see **Table 2.6**) were estimated following the methodology used in US EPA MOVES (US EPA 2018). Similar to Minesite equipment, all borrow pit equipment will be purchased new for the Project and were assumed to adhere to the latest US EPA emission standards for 2018 and newer model years.

Table 2.6 Specifications of Borrow Pit Equipment

Truck / Equipment Type	Number of Units	Brake Horsepower	Annual Hours of Operation	Load Factor
Shovel/Excavator	1	150	990	0.59
Rotary Drill	1	350	990	0.43
Front End Loader	1	250	990	0.59
Haul Truck	3	400	990	0.59

It is expected that some drilling and blasting will be required to assist with material excavation at the eastern borrow pit. Emissions from drilling and blasting of borrow pit material, including the use of ammonium nitrate/fuel oil, were estimated using the same methodology as drilling and blasting of overburden (see **Section 2.1.2** and **Section 2.1.3**). Based on information provided from TCL, it is estimated that there will be 322 drill holes annually at the borrow pit. Blasting is expected to occur only 5 times per year, with a horizontal area of 600 m^2 per blast.

2.12 Emission Summary

The estimated annual emissions of criteria air contaminants associated with Project operation are summarized in **Table 2.7**. The largest sources of PM emissions are expected to be road dust, stockpiles, and bulldozing. Diesel equipment is expected to be the largest source of NO_X, SO_2, and TOG emissions.

The estimated annual emissions of GHGs associated with Project operation are summarized in **Table 2.8**. Emissions of CO_2, CH_4, and N_2O are aggregated into CO_2 equivalents (CO_2e), which represent an equivalent quantity of CO_2 that would have the same global warming potential as the combined gases. The largest contributor to GHG emissions, in terms of CO_2e, is diesel equipment, followed by fugitive coalbed methane.

Table 2.7 Estimated Annual Emissions of Criteria Air Contaminants

Source		Annual Emissions (t/y)					
		TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	TOG
Coal Extraction Activities	Scraping	5.8	2.7	0.42	-	-	-
	Drilling	4.7	2.2	0.34	-	-	-
	Blasting	40.3	20.9	1.2	12.5	-	-
	Bulldozing	241	63.3	4.6	-	-	-
Material Handling and Processing	Open Pit	10.7	5.1	0.77	-	-	-
	Coal Processing Plant	2.8	1.1	0.16	-	-	-
	Rail Loadout	0.47	0.19	0.04	-	-	-
Stockpile Wind Erosion		52.1	26.1	3.9	-	-	-
Diesel Equipment		1.8	1.8	1.8	119	0.29	2.1
Train Idling		0.01	0.01	0.01	0.40	0.0009	0.02
On-Road Vehicles		0.08	0.08	0.02	0.41	0.003	0.05
Road Dust Re-entrainment		546	142	14.2	-	-	-
Road Grading		42.5	13.5	1.3	-	-	-
Space Heating		0.05	0.04	0.02	0.13	0.002	0.007
Borrow Pit Activities	Drilling	0.19	0.09	0.01	-	-	-
	Blasting	0.02	0.008	0.0005	0.07	-	-
	Material Handling and Processing	1.1	0.48	0.07	-	-	-
	Diesel Equipment	0.007	0.007	0.007	0.13	0.007	0.01
Total All Sources		**950**	**279**	**28.8**	**133**	**0.30**	**2.2**

Table 2.8 Estimated Annual Emissions of Greenhouse Gases

Source	Annual Emissions (t/y)			
	CO_2	CH_4	N_2O	CO_2e
Diesel Equipment – Minesite	44,156	1.2	3.7	45,300
Train Idling	101	0.006	0.04	113
On-Road Vehicles	388	0.012	0.02	395
Space Heating	156	0.006	0.003	157
Fugitive Methane	-	897	-	22,418
Diesel Equipment – Borrow Pit	575	0.02	0.05	590
Total All Sources	**45,377**	**898**	**3.8**	**68,973**

2.13 Speciation

Emissions of metals and PAHs were estimated by applying speciation profiles to estimated TSP and TOG emissions. Speciation profiles are obtained from site-specific assay data provided by TCL where available, or from publicly available sources as summarized in **Table 2.9**. Since the speciation profiles based on the various information sources are developed from different studies, the metals and PAH species included in the profiles may differ. To be conservative, the final speciation factors used in the air quality and greenhouse gas assessment were based on the maximum of all speciation factors available for the particular source and species.

Table 2.9 Speciation Profiles for Metals and Polycyclic Aromatic Hydrocarbons

Source Category	Basis of Speciation	Speciation Profile Information Source
Metals		
Coal Dust	TSP	TCL
Overburden Dust	TSP	TCL
Borrow Pit and Road Dust (a)	TSP	TCL
Soil Dust (Scraping)	TSP	BC MECCS 2019 (Skeena Region)
Diesel Equipment / Trains	TSP	CARB 2020 (Profile #6129)
On-Road Vehicles	TSP	Gasoline exhaust – CARB 2020 (Profile #4001) Diesel exhaust – CARB 2020 (Profile #425) Tire wear – CARB 2020 (Profile #472) Brake wear – CARB 2020 (Profile #473)
Space Heating	TSP	US EPA 1996; CARB 2020 (Profile #1104)
Polycyclic Aromatic Hydrocarbons		
Coal Dust	TSP	TCL
Overburden Dust	TSP	TCL
Borrow Pit and Road Dust [(a)]	TSP	TCL
Soil Dust (Scraping)	TSP	TCL

Source Category	Basis of Speciation	Speciation Profile Information Source
Diesel Equipment / Trains	TOG	CARB 2020 (Profile #818)
On-Road Vehicles	TOG	Gasoline exhaust – CARB 2020 (Profile #413); US EPA 2019 (Profile #8756) Diesel exhaust – US EPA 2019 (Profile #95335a)
Space Heating	TOG	CARB 2020 (Profile #504); US EPA 2019 (Profile #5645)

Note: [(a)] Includes fugitive dust from road grading activities.

3.0 DISPERSION MODELLING

Dispersion modelling was conducted using the CALPUFF modelling system to predict maximum ambient concentrations of CACs and TOG due to estimated emissions associated with Project operation. CALPUFF is a non-steady-state puff dispersion model approved for use in BC (BC MECCS 2015). Dispersion modelling was applied using the full three-dimensional CALMET mode because it has the ability to assimilate multiple meteorological stations and to simulate changes in mixing height and boundary layer mechanics that result from the variable land use in the Air Quality LSA.

In general, dispersion modelling was conducted in accordance with the BC Air Quality Dispersion Modelling Guideline (BC ENV 2015) and with a model plan approved by the BC MECCS. This section provides technical details of the CALMET and CALPUFF model methodology. A discussion of the CALMET model outputs is also provided to demonstrate that CALMET produces meteorological input for CALPUFF that qualitatively agrees with expected meteorological conditions.

3.1 CALMET Methodology

CALMET is a meteorological model that develops hourly three-dimensional meteorological fields of wind and temperature used to drive contaminant transport in CALPUFF. A summary of the CALMET model methodology is provided in the following subsections.

3.1.1 Model Domain

The CALMET model domain is a 27 km by 23 km area encompassing the 25 km by 21 km LSA and allowing for 1 km of buffer on all sides to avoid edge effects influencing dispersion at the boundaries of the LSA. The horizontal domain resolution was set at 250 m. In the vertical direction, 10 layers were chosen, with the top of the layers set at 20, 40, 80, 160, 300, 600, 1000, 1500, 2200, and 3000 m above ground level.

3.1.2 Model Period

CALMET was run for a one-year period from January 1 to December 31, 2015. This represents the most recent period during which surface observations in the model domain and prognostic meteorological data were available (see **Section 3.1.3**).

3.1.3 Meteorology

CALMET was initialized using the BC prognostic model dataset to enhance the accuracy of modelled meteorological fields. The BC prognostic model dataset was developed by Exponent using the Weather

Research and Forecasting (WRF) model, a mesoscale numerical prediction system designed to serve both atmospheric research and operational forecasting needs. The WRF model was run using the Advanced Research WRF core at a 4-km grid resolution. Model results have been quality tested with comparisons to observations at selected surface and upper air stations to provide assurance that the output can be used for dispersion modelling purposes (BC MECCS 2015).

The prognostic meteorological data was supplemented with surface observations from four meteorological stations as presented in **Table 3.1**. Upper air data was obtained from the nearest station at Annette Island, Alaska.

Table 3.1 Surface Meteorological Data for CALMET Modelling

Station	Data Source	Data Period	Parameters Measured
Smithers St. Josephs	BC MECCS 2020	January 1 to December 31, 2015	Wind speed and direction, Temperature, Relative humidity
Telkwa	BC MECCS 2020	January 1 to December 31, 2015	Wind speed and direction, Temperature, Relative humidity, Precipitation
Pine Creek	PCIC 2020	January 1 to December 31, 2015	Wind speed and direction, Temperature, Relative humidity, Precipitation
Smithers Airport / Terrace Airport [(a)]	Bramwell 2020	January 1 to December 31, 2015	Pressure, Cloud cover, Ceiling height

Note: [(a)] Cloud cover and ceiling height data at Smithers Airport are available during daytime only. Missing data were substituted with data from Terrace Airport.

3.1.4 Terrain Elevation and Land Cover Characterization

The terrain elevation used as input in the CALMET model was obtained from 0.75 arc-second Canadian Digital Elevation Model (Natural Resources Canada 2016). Land cover characterization was obtained from the Baseline Thematic Mapping land cover dataset (GeoBC 2020).

3.1.5 Geophysical Parameters

The CALMET model requires gridded geophysical parameters including surface roughness length, albedo, Bowen ratio, soil heat flux, anthropogenic heat flux, and leaf area index. To more accurately represent the seasonally dependent geophysical parameters in the CALMET model, five seasons were specified:

- Season 1: Midsummer with lush vegetation (July to August)
- Season 2: Autumn with cropland that has not been harvested (September)
- Season 3: Late autumn/winter after frost, no snow on ground (October)
- Season 4: Winter with snow on ground and sub-freezing temperatures (November to March)
- Season 5: Transitional spring with partially green short annuals (April to June)

All geophysical parameters, except for anthropogenic heat flux, were defined by land cover characterization and seasonal category as per the BC Air Quality Dispersion Modelling Guideline (BC MECCS 2015). An anthropogenic heat flux of zero was specified due to the low population density in the CALMET model domain.

3.1.6 Model Options

In general, the diagnostic model options for CALMET were chosen in accordance with the BC Air Quality Dispersion Modelling Guideline (BC MECCS 2015). A list of the CALMET model options are provided in **Table 3.1-2** and **Table 3.1-3**.

Table 3.2 CALMET Model Options Group 4 – Meteorological Data Options

Parameter	Default	Project	Comments
No Observation Mode			
NOOBS	0	1	Use surface station observations, use WRF prognostic dataset for upper air data
Number of Surface and Precipitation Meteorological Stations			
NSSTA	-	4	Four surface stations as per **Table 3.1**
NPSTA	-	2	Two precipitation stations as per **Table 3.1**
Cloud Data Options			
ICLDOUT	-	0	No CLOUD.DAT output written
MCLOUD	-	4	Gridded cloud cover from prognostic relative humidity as per BC model guidelines

Table 3.3 CALMET Model Options Group 5 – Wind Field Options and Parameters

Parameter	Default	Project	Comment
Wind Field Model Options			
IWFCOD	1	1	Diagnostic wind module used
IFRADJ	1	1	Froude number adjustment effects computed
IKINE	0	0	Kinematic effects not computed
IOBR	0	0	No adjustment to vertical velocity profile at top of model domain
ISLOPE	1	1	Slope flow effects computed
IEXTRP	-4	-4	Similarity theory used except layer 1 data at upper air stations ignored
ICALM	0	0	Calm winds not extrapolated aloft
BIAS	NZ*0	-1, -1, -1, -1, -1, -1, 0, 0.5, 1, 1	Weighting factor for surface vs. upper air data based on elevation of Bulkley River valley
RMIN2	4	-1	Used to ensure extrapolation of all surface stations for IEXTRP = -4
IPROG	0	14	WRF prognostic model data used as initial guess field
ISTEPPGS	3600	3600	Timestep (seconds) of prognostic model data
IGFMET	0	0	No coarse CALMET fields used as initial guess fields
Radius of Influence Parameters			
LVARY	F	F	Varying radius of influence not used

Parameter	Default	Project	Comment
RMAX1	-	5	Set to limit applicability of surface data to within the Bulkley River valley
RMAX2	-	5	Set to limit applicability of surface data to within the Bulkley River valley
RMAX3	-	50	Not used since no overwater data
RMIN	0.1	0.1	Small value used as recommended
TERRAD	-	7	Identified from main terrain feature of influence (Bulkley and Telkwa River valleys)
R1	-	0.5	Set to limit localized effect of surface data
R2	-	1	Set to limit localized effect of surface data
RPROG	-	0	Not used since IPROG = 14
DIVLIM	5×10^{-6}	5×10^{-6}	Not used since IKINE = 0
NITER	50	50	Not used since IKINE = 0
NSMTH	2, (NZ-1)*4	2, 4, 4, 4, 4, 4, 4, 4, 4, 4	Default number of passes in the smoothing procedure
NINTR2	99	99	All stations can be used
CRITFN	1	1	Default critical Froude number used
ALPHA	0.1	0.1	Not used since IKINE = 0
FEXTR2	NZ*0	0, 0, 0, 0, 0, 0, 0, 0, 0, 0	Not used since IEXTRP = -4
Barrier Information			
NBAR	0	0	Barriers not used
KBAR	NZ	10	Not used since NBAR = 0
XBBAR, YBBAR, XEBAR, YEBAR	-	0, 0, 0, 0	Not used since NBAR = 0
Diagnostic Module Data Input Options			
IDIOPT1	0	0	Surface temperatures computed internally
ISURFT	-1	-1	Diagnostic module surface temperatures based on 2-D spatially varying temperature field
IDIOPT2	0	0	Lapse rate computed internally
IUPT1	-1	-1	Domain-scale lapse rate based on 2-D spatially varying lapse rate
ZUPT	200	200	Lapse rate computed for default depth
IDIOPT3	0	0	Domain-averaged wind components computed internally
IUPWND	-1	-1	3-D initial guess fields used
ZUPWND	1, 1,000	1, 1,1000	Default used
IDIOPT4	0	0	Wind speed and direction read from surface data file
IDIOPT5	0	0	Wind speed and direction read from upper air data file
LLBREZE	F	F	Lake Breeze Module not used

Parameter	Default	Project	Comment
NBOX	-	0	Not used since LLBREZE = F
XG1, XG2, YG1, YG2	-	0, 0, 0, 0	Not used since LLBREZE = F
XBCST, YBCST, XECST, YECST	-	0, 0, 0, 0	Not used since LLBREZE = F
NLB	-	0	Not used since LLBREZE = F
METBXID	-	0	Not used since LLBREZE = F

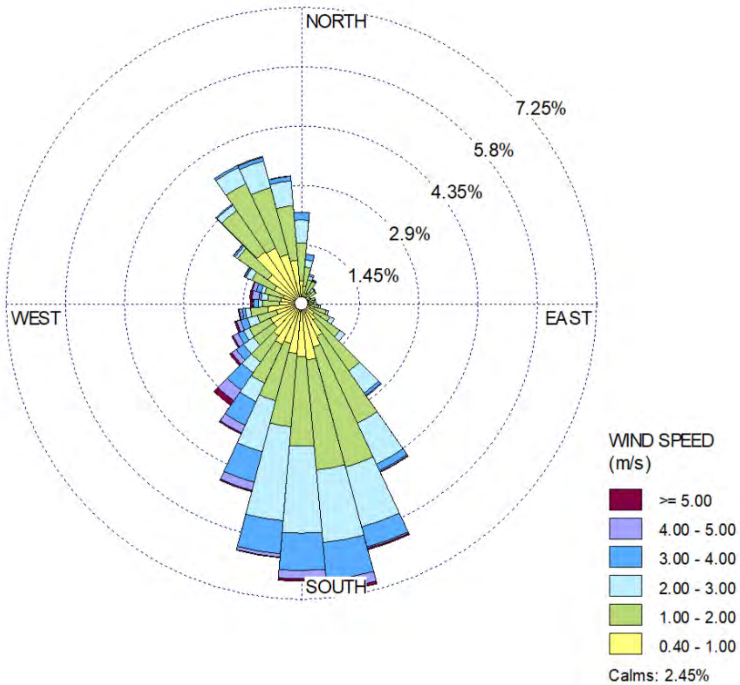
3.2 CALMET Outputs

The CALMET model was assessed by reviewing various model outputs and, where possible, comparing to observations. These outputs include surface wind roses for various monitoring locations, CALMET-derived stabilities and mixing heights, and domain wind vector plots under various stability and flow regimes.

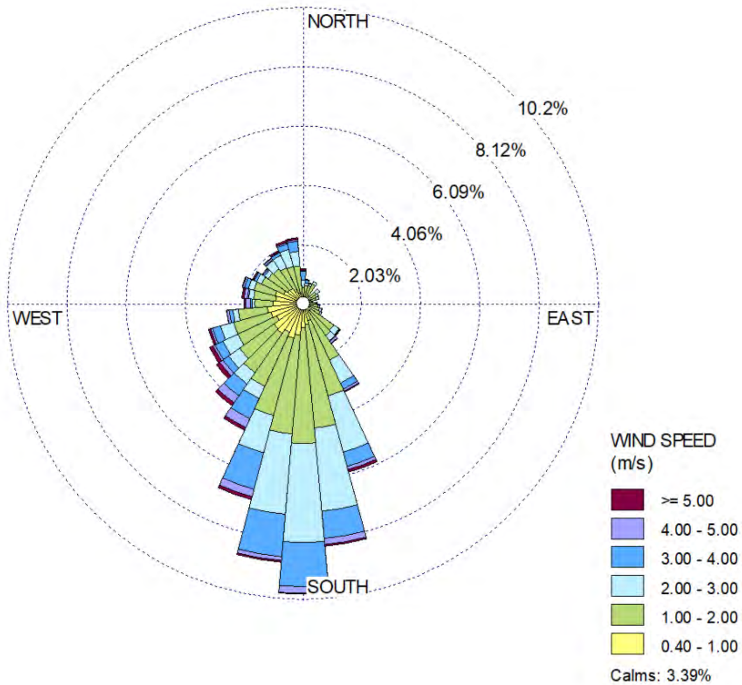
3.2.1 Surface Winds

The combined frequency distribution of wind speed and direction as observed and as modelled by CALMET at the Smithers St. Josephs, Telkwa and Pine Creek surface stations are shown as wind roses in **Figure 3.1** to **Figure 3.3**, respectively. Overall, observed, and modelled wind roses at the surface stations incorporated into the CALMET model are similar.

Modelled wind patterns at the Tenas Minesite are compared to 2018 baseline measurements in **Figure 3.4**. Observed and modelled wind roses at this location are different. While both wind roses show a predominant wind direction from the southwest, the observed wind rose is more evenly distributed whereas the modelled wind rose shows more distinct petals from the southeast and west-northwest. The modelled wind rose also shows higher wind speeds than observations. It should be noted that the modelled wind rose is extracted from the nearest grid cell located 139 m away from the meteorological tower. The terrain in this area is complex, with base elevations between the two locations differing by almost 10 m. Differences in the observed and modelled wind roses may also be attributed to the different time periods of data (i.e., 2015 model period versus 2018 measurement period).

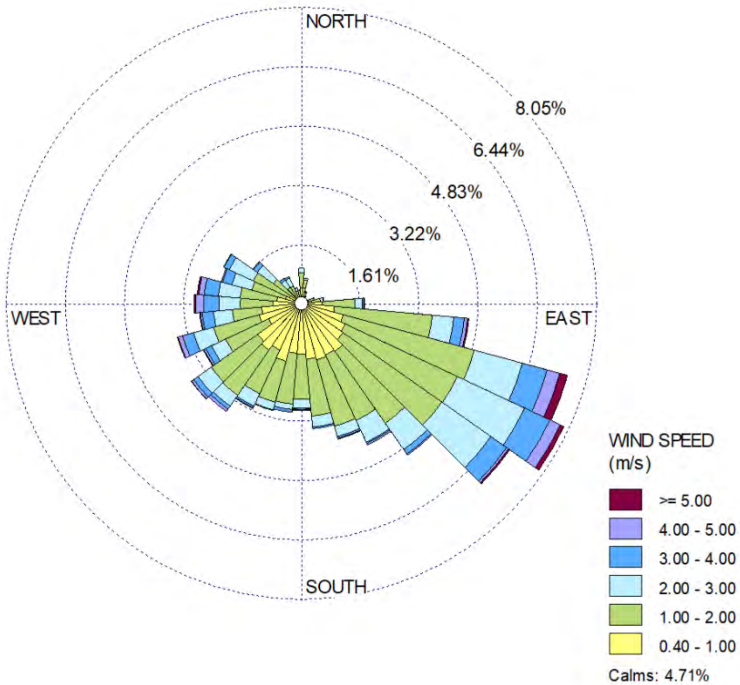


Observed

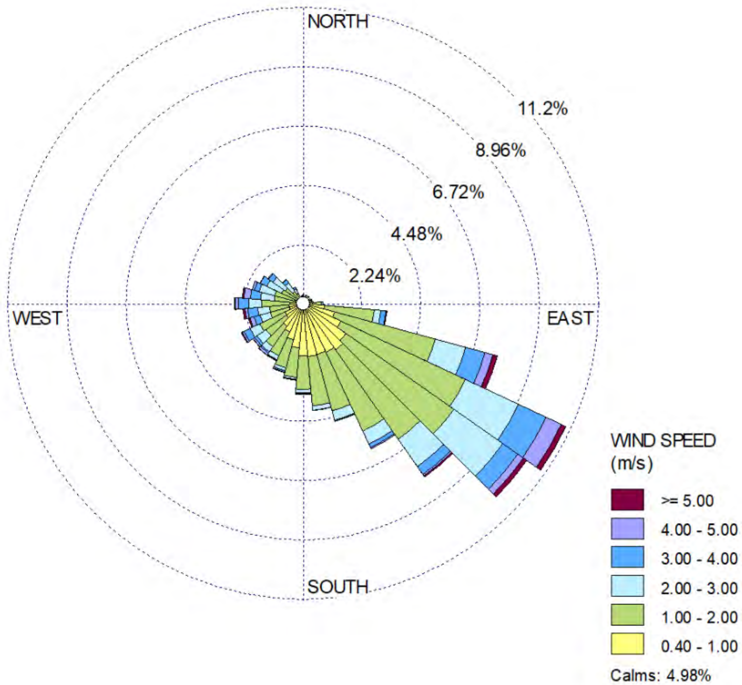


Modelled

Figure 3.1 Observed and Modelled Wind Roses at Smithers St. Josephs

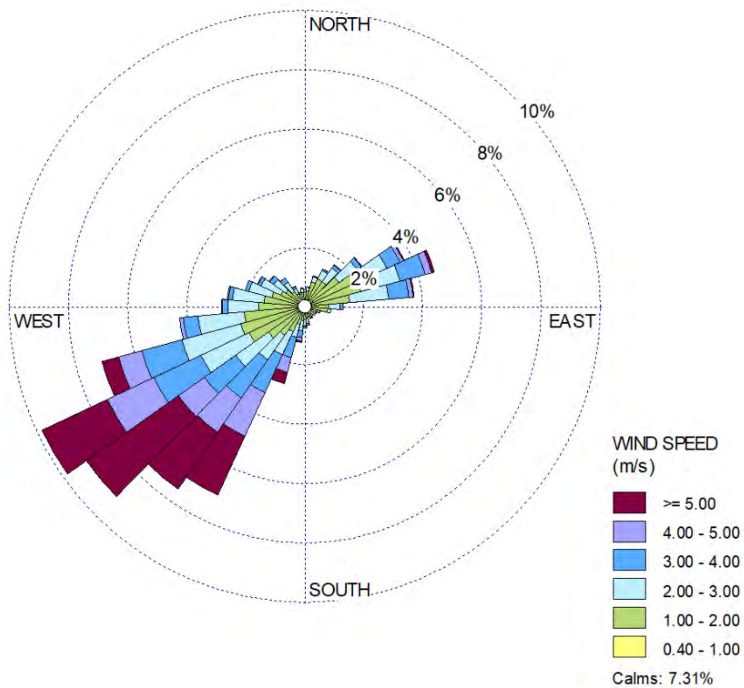


Observed

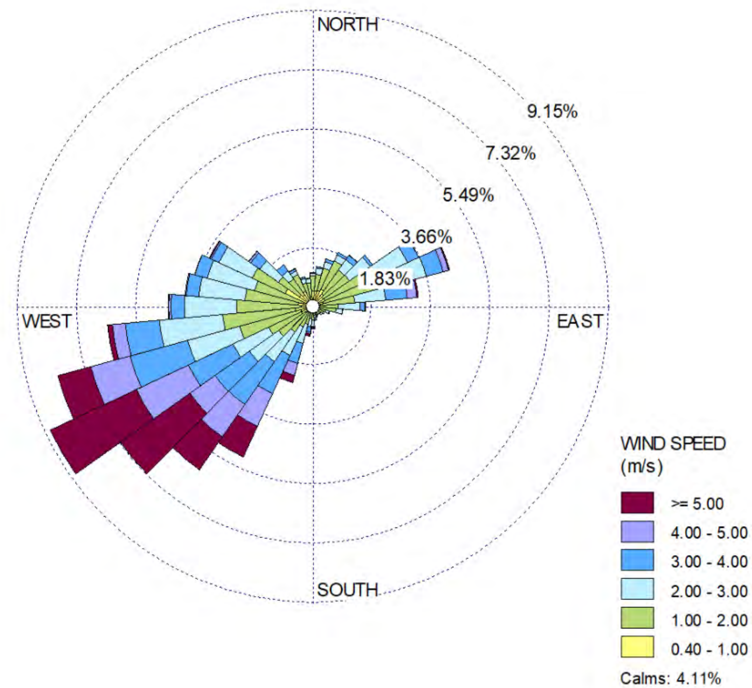


Modelled

Figure 3.2 Observed and Modelled Wind Roses at Telkwa

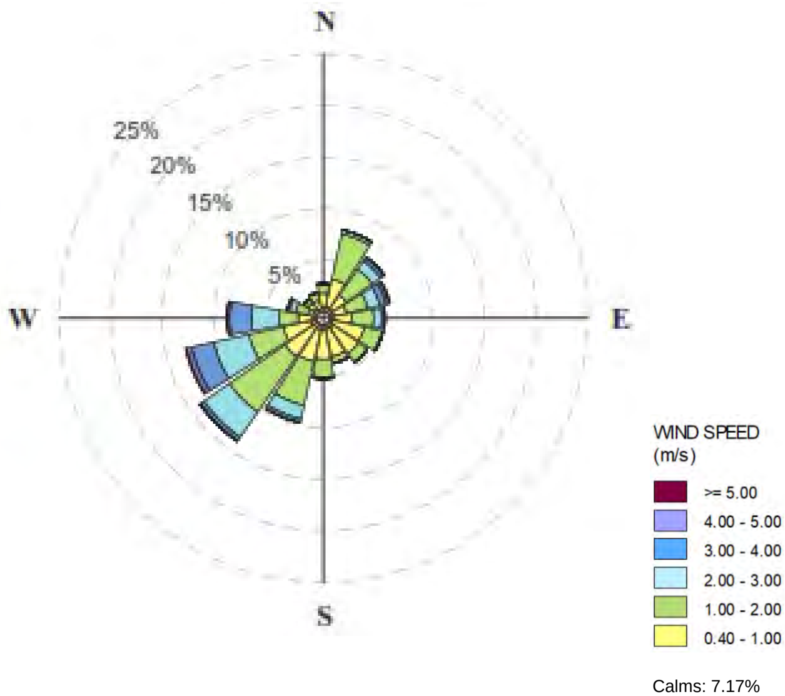


Observed

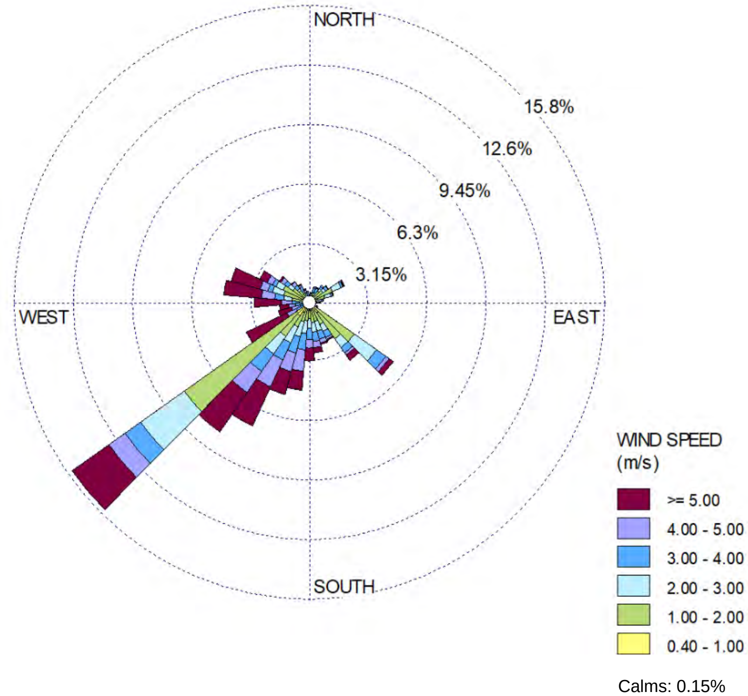


Modelled

Figure 3.3 Observed and Modelled Wind Roses at Pine Creek



Observed



Modelled

Figure 3.4 Observed and Modelled Wind Roses at Tenas Minesite

3.2.2 Pasquill-Gifford Stability Class

In CALMET, the Pasquill-Gifford stability scheme is used to classify atmospheric stratification in the boundary layer over land. These classes range from unstable (Classes A, B and C), through neutral (Class D) to stable (Classes E and F). Normally, unstable conditions are associated with daytime, ground-level heating, which results in thermal turbulence activity in the boundary layer. Stable conditions are primarily associated with nighttime cooling, which results in the suppression of turbulence levels and temperature inversions at lower levels. Neutral conditions are mostly associated with high wind speeds or overcast sky conditions.

The frequency distributions of CALMET-derived Pasquill-Gifford stability classes for the three surface stations and the Tenas Minesite are shown in **Figure 3.5**. For all four locations, the most frequent stability class is Class D or neutral, followed by Class F or stable. This is typical of atmospheric stabilities observed in the region. A higher percentage of Class D or neutral conditions are predicted at locations of higher elevation (i.e., Pine Creek and Tenas Minesite) due to the higher wind speeds expected at these locations.

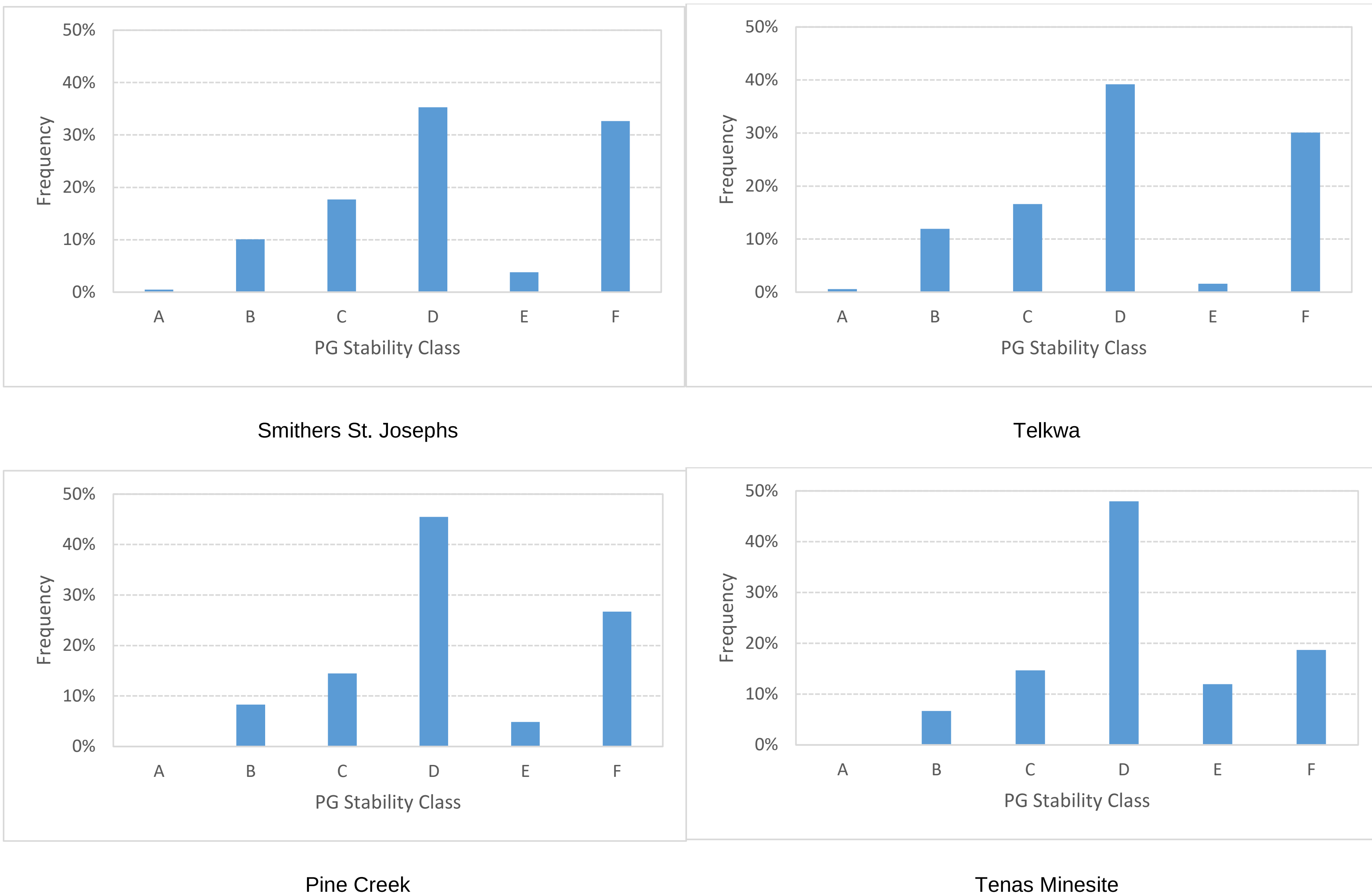
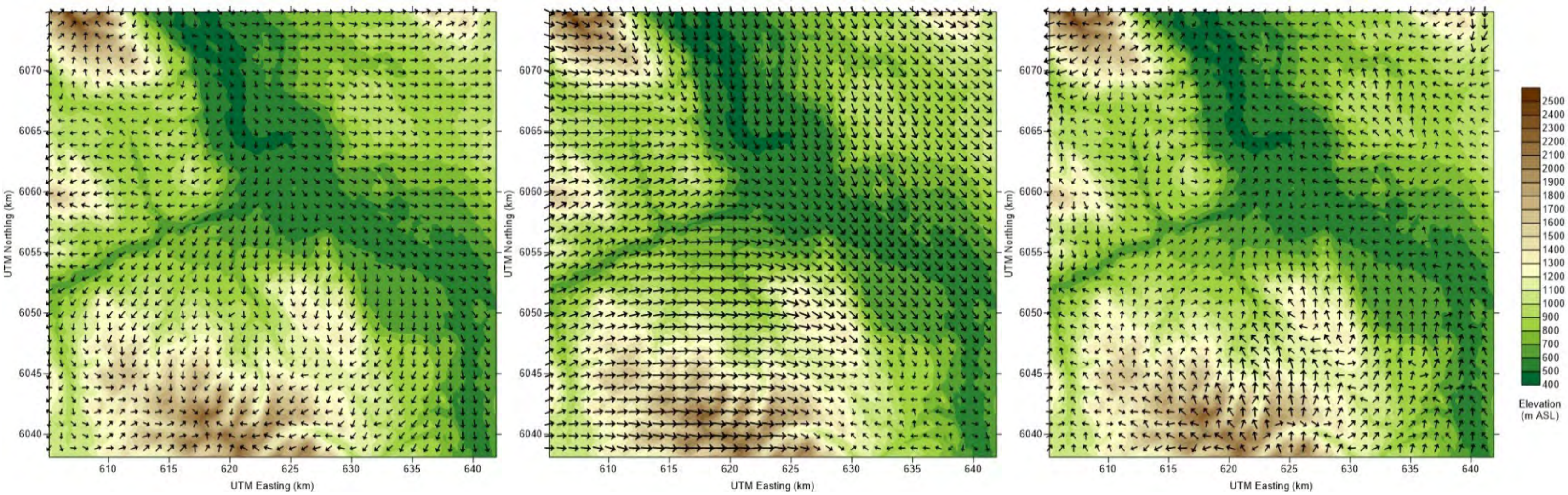


Figure 3.5 Frequency of Modelled Pasquill-Gifford Stability Class

3.2.3 Modelled Wind Fields

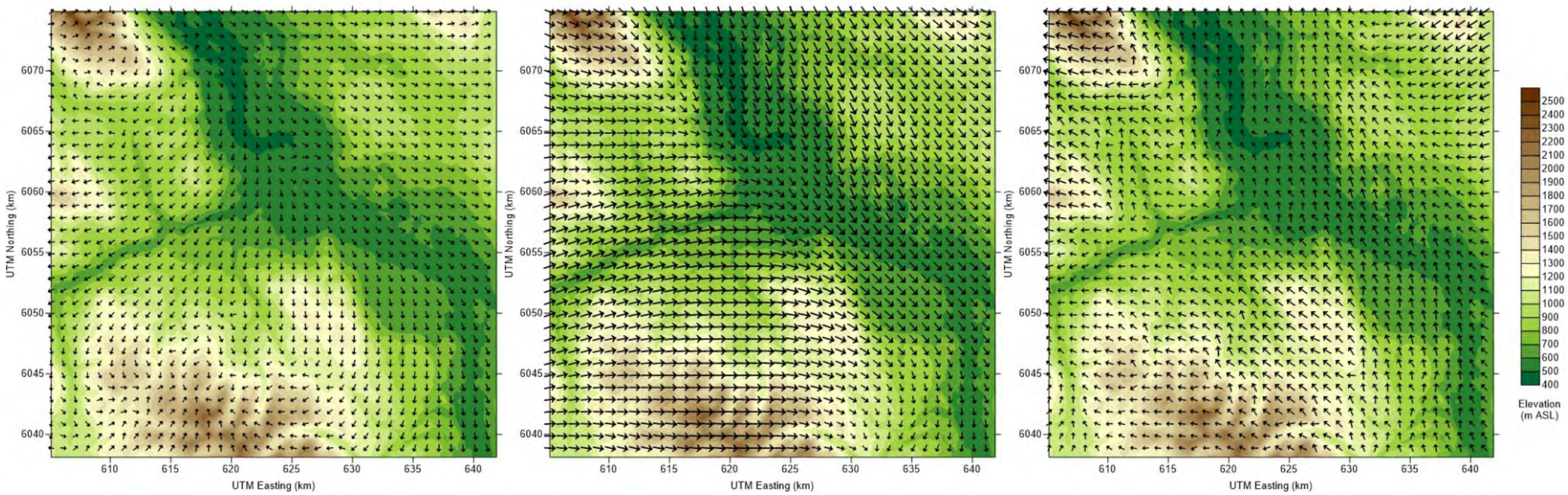
To evaluate how CALMET performed in replicating wind flow patterns in the model domain under different stability conditions, wind field plots representing unstable, neutral and stable conditions are illustrated in **Figure 3.6**, **Figure 3.7** and **Figure 3.8** for the surface layer, mid-layer and upper layer, respectively. In general, CALMET-derived wind fields follow the expected terrain flows under various stability and flow regimes, flowing up slope during unstable, daytime conditions and down slope during stable, nighttime conditions. Under neutral conditions, the characteristic high wind speeds result in less noticeable terrain effects and wind fields are largely uniform across the model domain. As expected, terrain flows are less evident in higher layers and more dominated by upper air winds.



Unstable	Neutral	Stable
May 26, 2015 09:00	August 20, 2015 14:00	January 5, 2015 00:00

Arrow lengths show relative wind speed from 0 to 10 m/s.

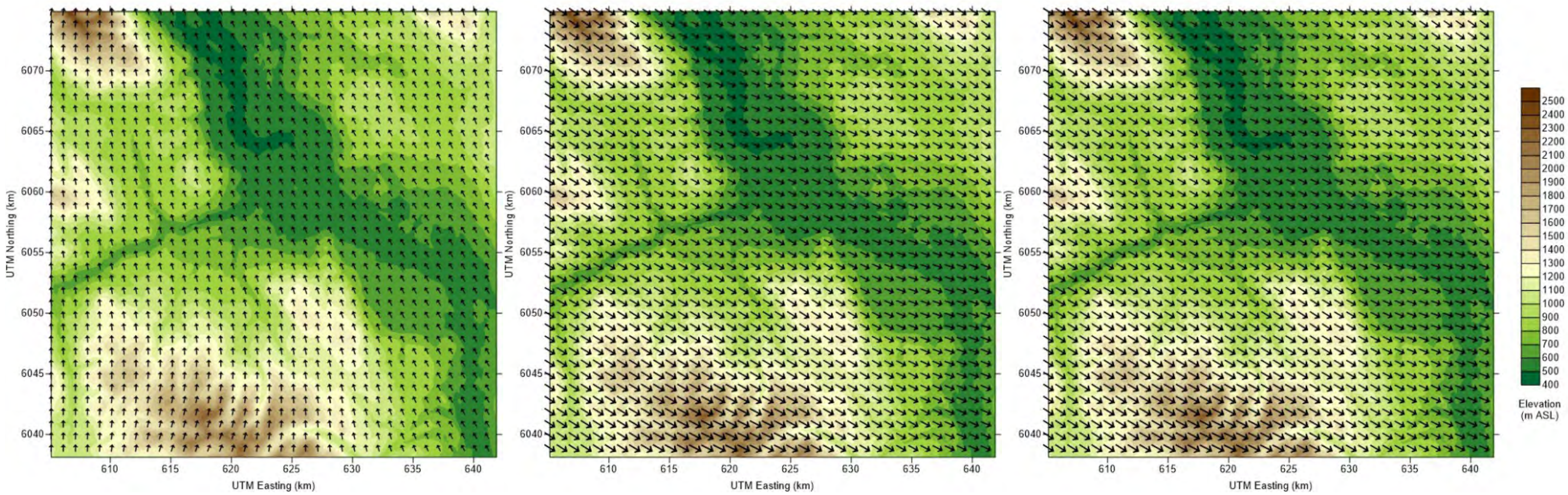
Figure 3.6 Modelled Wind Fields at 10 m Above Ground Level During Unstable, Neutral, and Stable Conditions



Unstable	Neutral	Stable
May 26, 2015 09:00	August 20, 2015 14:00	January 5, 2015 00:00

Arrow lengths show relative wind speed from 0 to 13.5 m/s.

Figure 3.7 Modelled Wind Fields at 230 m Above Ground Level During Unstable, Neutral, and Stable Conditions



Unstable	Neutral	Stable
May 26, 2015 09:00	August 20, 2015 14:00	January 5, 2015 00:00

Arrow lengths show relative wind speed from 3 to 13 m/s.

Figure 3.8 Modelled Wind Fields at 2,600 m Above Ground Level During Unstable, Neutral, and Stable Conditions

3.2.4 Mixing Heights

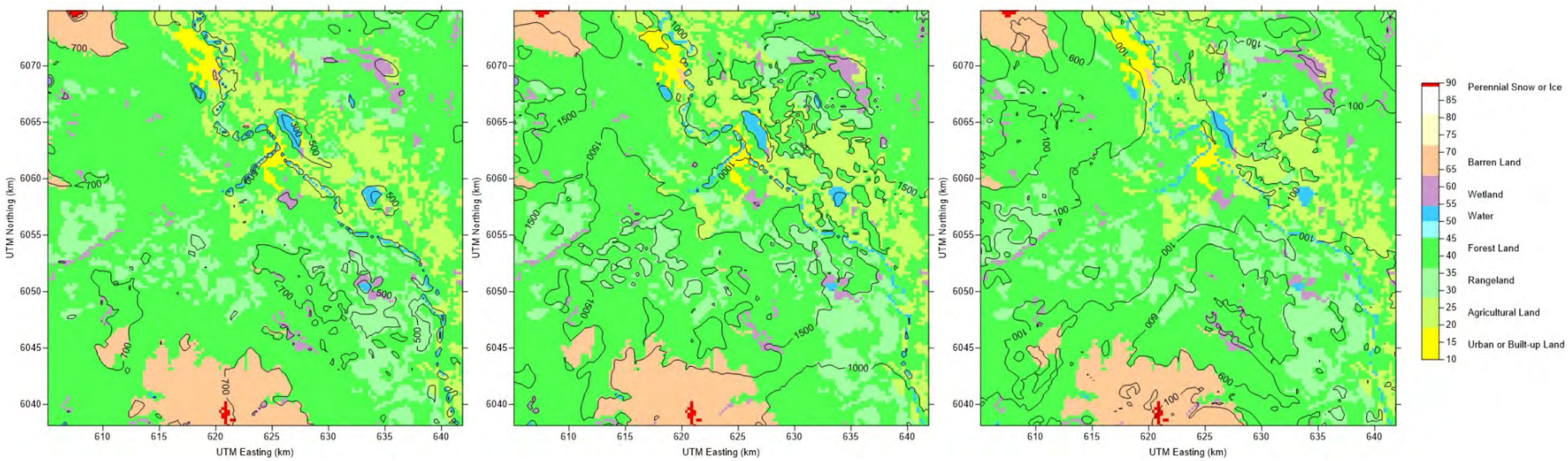
Mixing heights are estimated in CALMET through methods that are based on either surface heat flux (thermal turbulence) and vertical temperature profiles, or friction velocities (mechanical turbulence). **Table 3.4** shows the average modelled mixing heights by Pasquill-Gifford stability class. Overall, the highest mixing heights are associated with unstable conditions (Classes A, B and C), while the lowest mixing heights are associated with stable conditions (Classes E and F).

The spatial distribution of mixing heights under unstable, neutral and stable conditions is shown in **Figure 1.1-1**. Spatial changes in mixing height align with changes in land use. Mixing heights tend to be lowest over water and increases with distance more quickly in areas where surface roughness is greater (i.e., where surface elements are larger).

Diurnal variations in mixing heights are shown in **Figure 1.1-2** for a typical summer day (July 25, 2015) and a typical winter day (January 30, 2015). Mixing heights tend to increase during the day and decrease during the night, although daytime mixing heights may be suppressed during stable winter conditions due to weak solar insolation, high reflectivity of snow-covered surfaces, low wind speeds and synoptic subsidence.

Table 3.4 Average Modelled Mixing Height by Pasquill-Gifford Stability Class

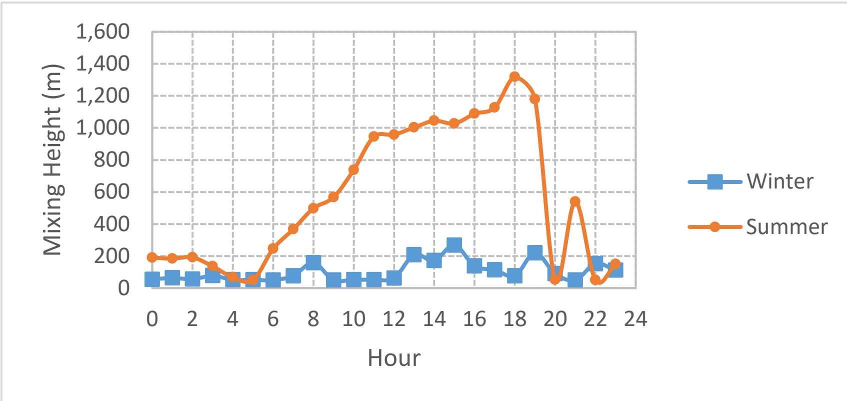
Location	Average Mixing Height (m)					
	A	B	C	D	E	F
Smithers St. Josephs	986	859	592	529	581	280
Telkwa	893	795	485	333	434	99
Pine Creek	1,093	859	655	745	680	218
Tenas Minesite	726	682	630	1,014	971	286

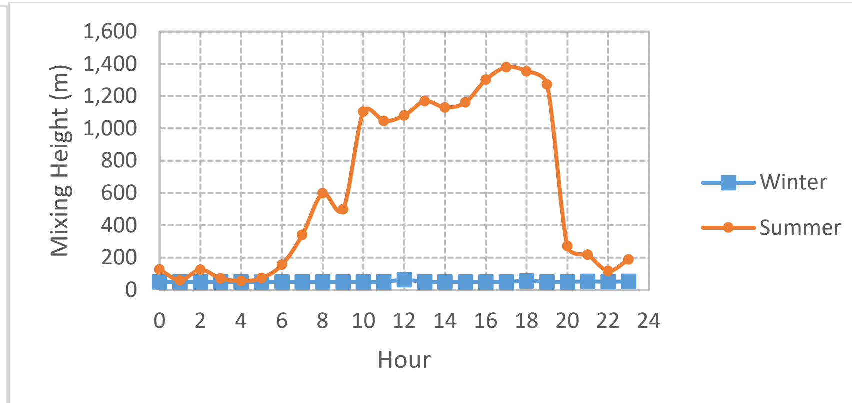


Unstable | Neutral | Stable

May 26, 2015 09:00 | August 20, 2015 14:00 | January 5, 2015 01:00

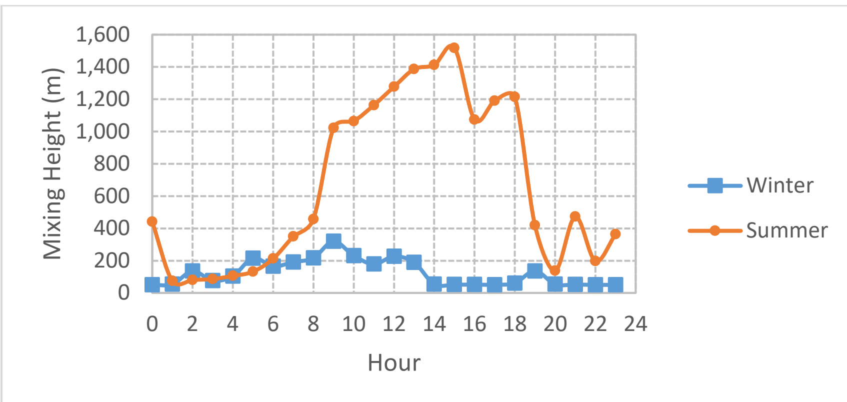
Figure 3.9 Modelled Mixing Height (in metres) During Unstable, Neutral, and Stable Conditions

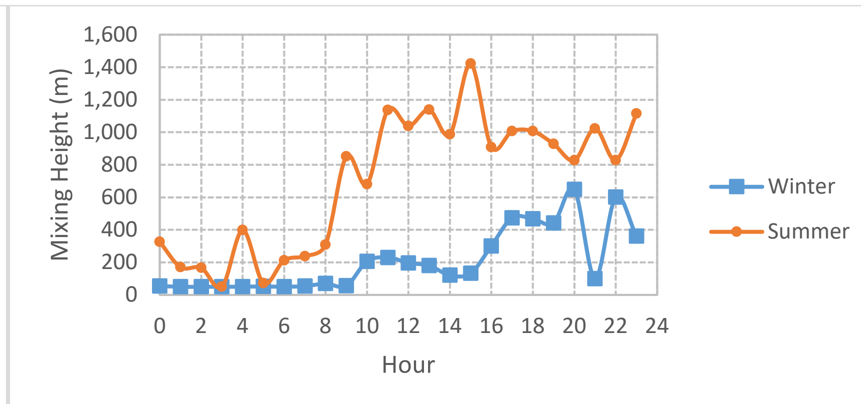




Smithers St Josephs

Telkwa





Pine Creek

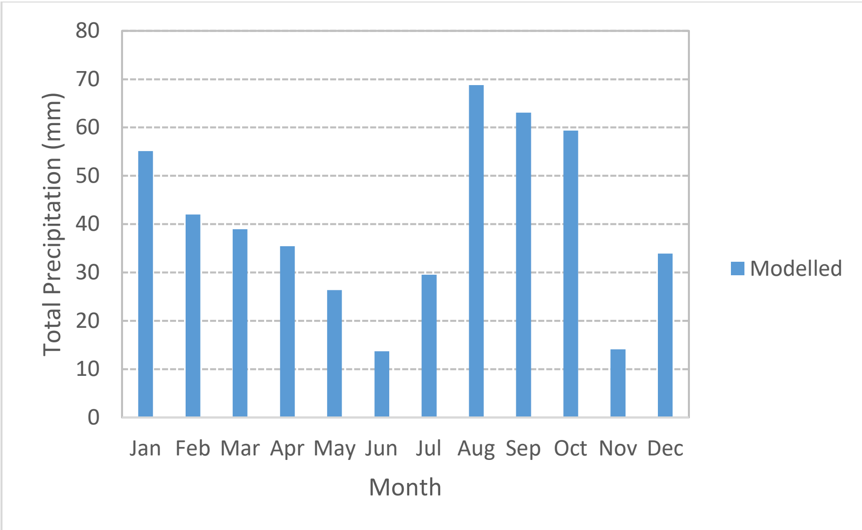
Tenas Minesite

Figure 3.10 Diurnal Variation of Modelled Mixing Heights

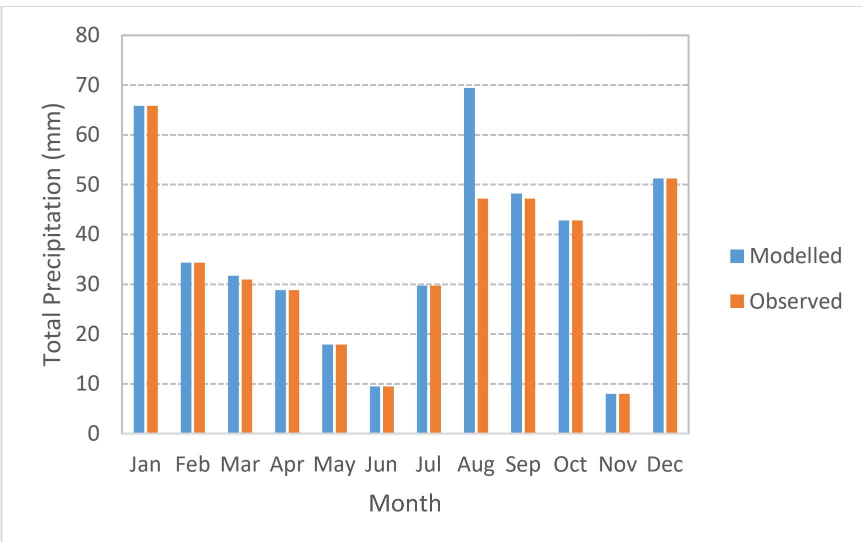
3.2.5 Precipitation

CALMET-derived monthly precipitation patterns at the Smithers St Josephs, Telkwa, and Pine Creek surface stations are illustrated in **Figure 3.11** and compared to observation data where available. Overall, observed, and modelled precipitation patterns are similar.

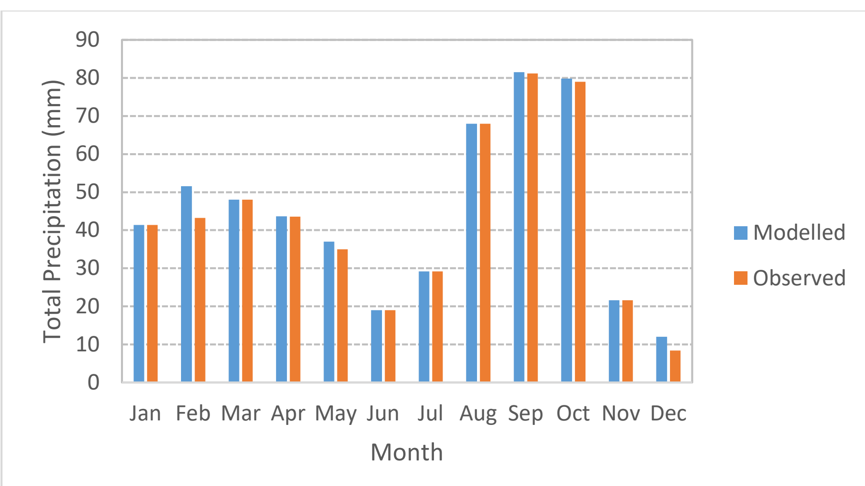
CALMET-derived monthly precipitation patterns at the Tenas Minesite are compared to 2018 baseline measurements and to 30-year climate normals at the Smithers Airport in **Figure 3.12**. While the amount of precipitation may differ, the precipitation patterns predicted by the CALMET model appear to reflect expected conditions, with somewhat greater precipitation during the summer and fall. Some differences are expected between the Tenas Minesite, located at a base elevation of 984 m above sea level (ASL), and Smithers Airport, located at a base elevation of 522 m ASL. Differences between observed and modelled precipitation levels also reflect year-to-year fluctuations. For example, the region was noted to have experienced above average precipitation during the 2017/2018 and 2018/2019 winter seasons, and below average precipitation during the 2018 growing season (Agriculture and Agri-Food Canada 2019).



Smithers St. Josephs



Telkwa



Pine Creek

Figure 3.11 Monthly Observed versus Modelled Precipitation at Surface Stations

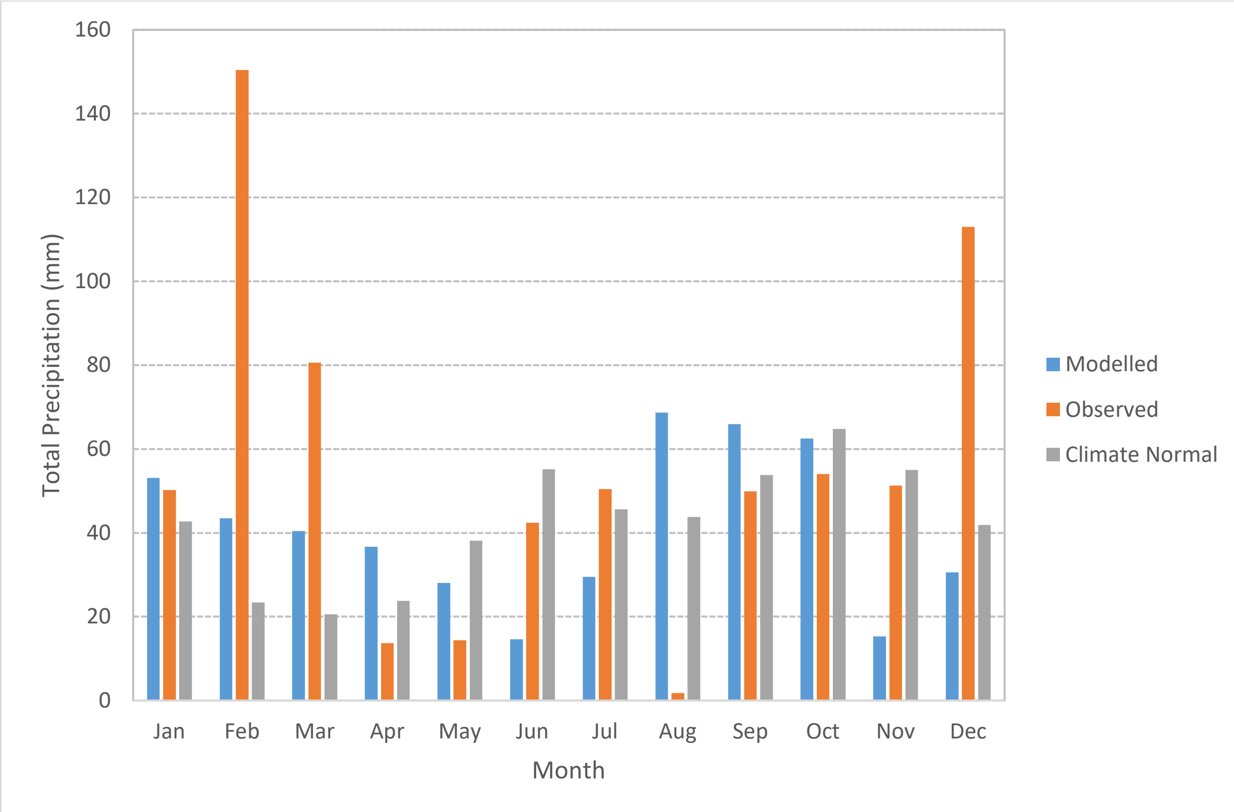


Figure 3.12 Comparison of Modelled Precipitation with Observations at Climate Normal at Tenas Minesite

3.3 CALPUFF Methodology

CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model that simulates the influence of time- and space-varying meteorological conditions on contaminant transport, transformation, and deposition to predict ambient concentrations and deposition rates of contaminants resulting from estimated emissions from Project operation. A summary of the CALPUFF model methodology is provided in the following subsections.

3.3.1 Model Domain

The CALPUFF model domain within which ambient concentrations and deposition rates were predicted is the 25 km by 21 km LSA described in the **S4-C1-3.2.4** of the EAC Application (Atmospheric VC, Assessment Boundaries). Puff transport and dispersion is computed in CALPUFF for the entire CALMET domain (see **Section 3.1.1**).

3.3.2 Receptor Locations

In the CALPUFF model, a discrete set of receptor points are specified at which ambient concentrations and deposition rates are predicted. A Cartesian grid of nested receptors was defined within the Air Quality LSA as per the BC Air Quality Dispersion Modelling Guideline (BC MECCS 2015) with receptor spacing as follows:

- 20-m spacing along the boundaries of the Minesite and Rail Loadout
- 50-m spacing within 500 m of the Minesite, Tenas Access Corridor, and Rail Loadout
- 250-m spacing within 2 km of the Minesite, Tenas Access Corridor, and Rail Loadout
- 500-m spacing within 5 km of the Minesite, Tenas Access Corridor, and Rail Loadout
- 1,000-m spacing within the remainder of the LSA

To avoid under-prediction in populated areas, the gridded receptor spacing above was modified to include a maximum spacing of 250 m applied over the populated area of Telkwa.

In addition to the gridded receptors described above, a number of sensitive receptors were defined at locations where sensitive individuals may be present and exposed to ambient concentrations. These include private residences outside of Telkwa, cabins, schools, and childcare facilities. The Backcountry Horsemen of BC's camp (the horsemen camp) located within Telkwa Coal property, just off the Tenas Access Corridor, was also included for community interest and due diligence.

Terrain elevations for all receptors were extracted from the 0.75 arc-second Canadian Digital Elevation Model used in CALMET.

3.3.3 Source Parameters

To understand the contribution of various source groups and to enable scaling of data to predict metals and PAHs, emission sources were grouped into various model runs as summarized in **Table 3.5**. Results from all model runs were then summed to determine the combined effect of all sources.

Table 3.5 CALPUFF Model Runs by Source Group

Emission Source Group	CALPUFF Source Type (Point, Area, or Volume)	Nature of Emissions (Constant or Variable)
Scraping of soil	Volume	Constant
Drilling, blasting, and bulldozing of overburden	Volume	Constant
Bulldozing of coal	Volume	Constant
Material handling of coal	Volume	Variable
Material handling of overburden	Volume	Variable
Conveyor transfers, crushing, and screening	Volume	Constant
Stockpile wind erosion	Area	Variable
Diesel equipment at Minesite	Area	Constant
Train idling	Point	Constant
On-road vehicles, road dust, and grading [(a)]	Volume	Constant
Space heating	Point	Constant
Drilling and blasting at borrow pit	Volume	Constant
Crushing and screening at borrow pit	Volume	Constant
Material handling at borrow pit	Volume	Variable
Diesel equipment at borrow pit	Area	Constant

Note: [a] Includes exhaust emissions from graders and water trucks which operate along roads. This source group was further split into several model runs for run-time efficiency.

3.3.3.1 Point Source Parameters

Emissions from space heating and train idling were modelled as point sources in CALPUFF with source parameters summarized in **Table 3.6**. Space heating emissions were modelled as a single point source on the roof of the maintenance facility with stack parameters estimated based on manufacturer specifications. Train idling emissions were modelled as three separate point sources (i.e., one from each locomotive) with stack parameters estimated based on verification testing of an Electro-Motive Diesel Model GP-40 locomotive (US EPA 2005).

Table 3.6 Point Source Parameters

Source	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Temperature (K)
Space heating	12.2	0.3	0.1	333
Train idling	5.0	0.2	1.0	380

3.3.3.2 Area Source Parameters

Stockpile wind erosion emissions were modelled as area sources in CALPUFF. The emission source height and the initial vertical plume sigma were specified to be approximately half the height of the pile. This effectively gives the plume an initial width that represents the height of the pile. Time-varying stockpile wind erosion emissions were estimated for each hour of the model period and incorporated into CALPUFF through the use of an external BAEMARB.DAT file for arbitrarily varying buoyant area emissions. This file is designed for buoyant area emission sources such as wildfires. To limit the buoyancy in this case, the vertical velocity was set to a minimum and the temperature of the emissions was set by extracting the ambient temperature from the CALMET meteorological field.

Exhaust emissions from diesel equipment were modelled as constant area sources at the open pit and at the borrow pits. A release height of 3 m and an initial vertical plume sigma of 0.1 m were chosen to represent the exhaust from a typical unit.

3.3.3.3 Volume Source Parameters

All other emission sources were modelled as volume sources in CALPUFF. These include fugitive emissions from coal extraction activities, material handling and processing, and emissions along Minesite haul roads and the Tenas Access Corridor. Volume source parameters were defined in accordance with US EPA guidance (US EPA 1995, 2012) to reflect the size of dust clouds expected from each release point. Typical volume source parameters are provided in **Table 3.7**.

Table 3.7 Volume Source Parameters

Source	Release Height (m)	Initial Horizontal Plume Sigma (m)	Initial Vertical Plume Sigma (m)
Coal extraction activities	0.0	1.2	2.3
Material handling	Varies	0.2 to 0.5	0.2
Conveyor transfers	Varies	0.2	0.2

Source	Release Height (m)	Initial Horizontal Plume Sigma (m)	Initial Vertical Plume Sigma (m)
Crushing and screening	1.0	0.5	0.5
On-road vehicles, road dust, and grading	1.3 to 4.0	6.8 to 11.0	1.2 to 3.7

3.3.4 Building Downwash

Buildings located close to point sources may influence dispersion. The effect of the maintenance facility building at the Coal Processing Plant and the train at the Rail Loadout on the modelled point sources was incorporated using the Building Profile Input Program Plume Rise Model Enhancement (BPIP-PRIME) algorithm. The algorithm explicitly treats the trajectory of the plume near the building and uses the position of the plume relative to the building to calculate interactions with the building wake. Building dimensions were estimated based on renderings provided by TCL for the maintenance facility building and photos of typical coal trains.

3.3.5 Wet and Dry Deposition

Wet and dry deposition of PM was enabled for all sources to more accurately predict ambient PM concentrations, and to predict dustfall deposition rates. Dry deposition was modelled using PM size parameters from the Newfoundland Guideline for Plume Dispersion Modelling (Newfoundland and Labrador Department of Environment and Conservation 2012). Wet deposition was modelled using scavenging coefficients of 1×10^{-4} per second (s^{-1}) in liquid rain and 3×10^{-5} s^{-1} in frozen precipitation for all size categories. These represent the default CALPUFF values for PM_{10} and were assumed to be representative of TSP and $PM_{2.5}$ due to the lack of size-specific information.

3.3.6 Technical Dispersion Options

In general, technical dispersion options in CALPUFF were chosen in accordance with the BC Air Quality Dispersion Modelling Guideline (BC MECCS 2015) or with CALPUFF model defaults. A list of the CALPUFF model options is provided in **Table 3.8**.

Table 3.8 CALPUFF Input Group 2 – Technical Options

Parameter	Default	Project	Comments
MGAUSS	1	1	Gaussian distribution used in near field
MCTADJ	3	3	Partial plume path terrain adjustment
MCTSG	0	0	Sub-grid scale complex terrain not modelled
MSLUG	0	0	Near-field puffs not modelled as elongated
MTRANS	1	1	Transitional plume rise modelled
MTIP	1	1	Stack tip downwash modelled
MRISE	1	1	Briggs plume rise used
MTIP_FL	0	0	Stack tip downwash not applied to flare sources
MRISE_FL	1	1	Briggs plume rise used for flare sources
MBDW	1	2	PRIME method used for building downwash as recommended

Parameter	Default	Project	Comments
MSHEAR	0	0	Vertical wind shear not modelled
MSPLIT	0	0	No puff splitting
MCHEM	1	0	Chemical transformation not modelled
MAQCHEM	0	0	Not used since MCHEM = 0
MLWC	1	1	Not used since MAQCHEM = 0
MWET	1	1	Wet deposition modelled
MDRY	1	1	Dry deposition modelled
MTILT	0	0	Gravitational settling not modelled
MDISP	3	2	Near-field dispersion coefficients internally calculated using micrometeorological variables as recommended
MTURBVW	3	3	Not used since MDISP = 2
MDISP2	3	3	Not used since MDISP = 2
MTAULY	0	0	Draxler default used for Lagrangian timescale
MTAUADV	0	0	No turbulent advection
MCTURB	1	1	Standard CALPUFF subroutines used
MROUGH	0	0	No adjustment for surface roughness
MPARTL	1	1	Partial plume penetration of elevated inversion modelled for point sources
MPARTLBA	1	1	Partial plume penetration of elevated inversion modelled for buoyant area sources
MTINV	0	0	Strength of temperature inversion computed from default gradients
MPDF	0	1	PDF used for dispersion under convective conditions for MDISP = 2 as recommended
MSGTIBL	0	0	Sub-grid TIBL module not used for shoreline
MBCON	0	0	Boundary conditions not modelled
MSOURCE	0	0	Individual source contributions not saved
MFOG	0	0	Not configured for FOG model output
MREG	1	0	Options not tested for conformance to US EPA regulatory values

3.3.7 Model Output Interpretation

3.3.7.1 Determination of Combined Effects

The CALSUM post-processing software was used to sum the predicted ambient concentrations at each receptor for each of the model runs to obtain the combined effect of all sources associated with Project operation. Since the CALPUFF modelling was done based on predicted peak hourly emission rates, a direct summation of results from the model runs would yield maximum possible one-hour average concentrations. To estimate 24-hour and annual average concentrations, as well as 30-day average deposition rates, in accordance with the metrics of the ambient air quality criteria (AAQC), scaling factors were applied in CALSUM to account for activity frequency. While the Project can operate continuously, not all Project activities will occur continuously. For example, blasting is expected to occur only once every second day. No scaling factors were applied for activities that operate continuously (e.g., material handling and processing), or for sources that emit dust continuously regardless of activity (e.g., stockpile wind erosion).

The CALPUFF dispersion model simulates and predicts dry and wet deposition of PM separately. To determine the combined effects and dry and wet deposition, the POSTUTIL post-processing software was used. Scaling factors were applied in POSTUTIL to account for activity frequency as described above.

3.3.7.2 Metals and Polycyclic Aromatic Hydrocarbons

Ambient concentrations and deposition rates of metals and PAHs were estimated based on CALPUFF model results and provided to the Health VC for assessment. A set of results for each metal and PAH was calculated, providing a conservative concentration and deposition rate for each contaminant at each receptor point.

The individual model runs were first grouped according to speciation profiles (see **Table 2.9**) and CALPUFF results for all sources with a common speciation profile were added together using the CALSUM and POSTUTIL post-processing software. The maximum ambient concentrations and deposition rates of TSP and TOG (concentrations only) for each of these summed speciation groups were then extracted using CALPOST.

For each receptor point, an estimate of the maximum concentration and deposition rate of each metal and PAH was calculated using the following equation:

$$Max\ for\ species\ i = \sum_{j=1}^{n} Source\_max_j \times Speciation\_factor_j$$

This method essentially estimates the maximum for each metal and PAH by taking a weighted sum of the maximum for all individual source groups. Since the maximum for each individual source group may occur at a different time, this provides a conservative estimate of each metal and PAH species.

3.3.7.3 NO_X to NO_2 Chemistry

Emissions of NO_X from Project activities are comprised of NO and NO_2. The primary emission is in the form of NO with reactions in the exhaust and in the atmosphere resulting in the conversion of NO to NO_2. Health effects and AAQC are based on NO_2, not NO_X or NO. Therefore, predicted ambient NO_X concentrations from CALPUFF need to be converted to NO_2 for comparison to the AAQC.

The reaction between NO and tropospheric ozone (O_3) is one of the most important means of converting NO to NO_2, especially in non-urban areas:

$NO + O_3 \rightarrow NO_2 + O_2$

As per the BC Air Quality Dispersion Modelling Guideline (BC MECCS 2015), the first and most conservative method of estimating NO_2 is to assume 100% conversion of NO_X into NO_2. If a more accurate estimate is desired, the ambient ratio method is preferred. For the air quality assessment, NO_2 concentrations were estimated using the ambient ratio method based on five years of monitoring data for

NO and NO_2 at Smithers St. Josephs. The resulting equation for conversion of 1-hour average NO_X is shown in **Figure 3.13**. For annual average NO_X conversion, an average NO_2/NO_X ratio of 0.63 was used.

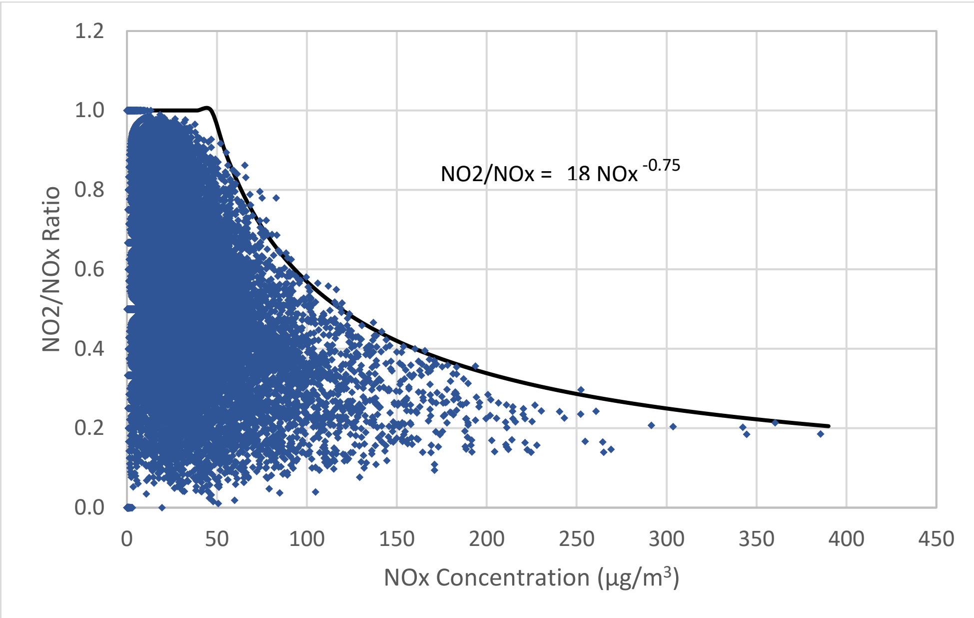


Figure 3.13 Dependence of NO_2/NO_X Ratio on One-Hour Average NO_X Concentrations

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