APPENDIX O

Air Quality Assessment

FIBRECO

Fibreco Export Terminal Enhancement
Permit Application Document

APPENDIX O

Air Quality Assessment - Executive Summary

The Project air quality assessment was prepared according to Port of Metro Vancouver's Project & Environment Review (PER) Guidelines – Environmental Air Assessment (July 2015). In the assessment, a facility and a supply chain emissions inventory were prepared for a baseline and a future project year to quantify pollutant emissions associated with current facility operations, its proposed future modifications and the supply chain. Following development of the emissions inventory, a dispersion modelling assessment was performed to determine potential air quality impacts of the Project.

As part of the expansion project, Fibreco is able to outfit many of the key particulate emission (PM) sources onsite with best achievable emissions control technology that significantly reduces PM emissions when the expansion is completed. Key upgrades that will reduce PM emissions with the expansion project completed are:

- Improved shiploader emissions controls for both pellet and grain handling – the current shiploader emissions represented the source with the largest impact on ambient particulate matter concentrations at Fibreco and the expansion will allow for significant improvements in fugitive dust emissions from this source;

- Better dust control measures implemented on the material handling transfers points throughout the facility, including at the railcar unloader, a key source of emissions at Fibreco;

- The elimination of open stockpiles of wood chips.

The air assessment conducted found that due to non-road equipment currently used onsite being eliminated with the project, combustion related emissions will be reduced. Other combustion related activity does not increase significantly as some efficiencies gained through the size of vessel being accommodated at the berth under the project scenario offsets the additional vessel calls. The dispersion modelling assessment shows that combustion-related emissions levels from the project will result in ambient pollutant concentrations well below Metro Vancouver Ambient Air Quality Objectives (AAQOs), even when considering the maximum impacts throughout the year.

Through project design focused on addressing the particulate matter emissions from the facility, the overall emissions and impact to ambient concentrations of PM10 and PM2.5 is reduced significantly with the implementation of the project. Many of these improvements result in reduction of PM emissions from pellet handling as well as the additional grain products. The dispersion modelling assessment shows that with these emission controls PM emissions from the facility are predicted to comply with AAQOs.

Given the predicted reductions in PM emissions from the implementation of the expansion, it would be expected that air quality surrounding the Fibreco Terminal will improve with the installation of the additional emission controls associated with the expansion.

REPORT N[O] 121-50629-00

FIBRECO GRAIN TERMINAL EXPANSION: ENVIRONMENTAL AIR ASSESSMENT

FINAL REPORT

SEPTEMBER 2016

FIBRECO GRAIN TERMINAL EXPANSION: ENVIRONMENTAL AIR ASSESSMENT

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1 INTRODUCTION

1.1 FACILITY AND ASSESSMENT OVERVIEW

The Fibreco Export Inc. (Fibreco) facility is located at 1209 McKeen Avenue in North Vancouver on the north shore of Burrard Inlet in Port of Metro Vancouver. Currently, wood chips arrive on-site by barge and rail while pellets are delivered to the facility by rail. These wood products are then shipped to clients by marine vessels while some wood chips are stockpiled on-site, while pellets are stored and stored in dry silos or the pellet shed. The facility location is provided in Figure 1-1.

Fibreco plans to replace its current wood chip shipments with grains by the year 2020 (the Project). In anticipation of this operational change, this air quality assessment has been prepared according to Port of Metro Vancouver's Project & Environment Review (PER) Guidelines – Environmental Air Assessment (July 2015).

In this assessment, a facility and a supply chain emissions inventory were prepared for a baseline and a future project year to quantify pollutant emissions associated with current facility operations, its proposed future modifications and the supply chain. Figure 1-1 shows the supply chain boundaries with respect to the facility location. The best available activity data from Fibreco and the most appropriate emission models and factors available to-date were used to compile these emissions inventory. Dispersion modelling of facility emissions has also been conducted to determine potential air quality impacts.

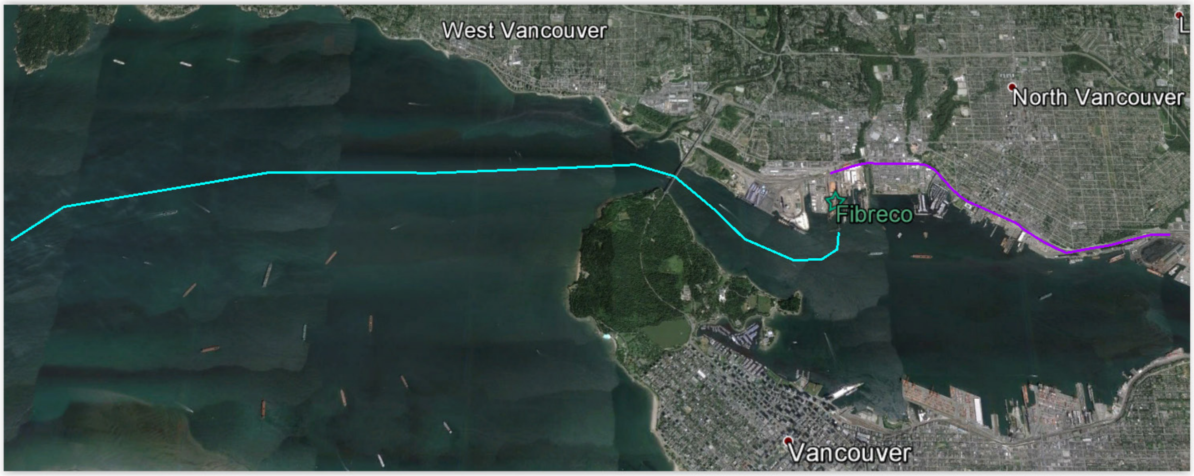

Figure 1-1 Facility Location and Marine Supply Chain Boundary (blue) and Rail Supply Chain Boundary (purple) of the Fibreco Terminal

2 PROJECT DESCRIPTION

2.1 EXPANSION OVERVIEW

Current wood chip shipments will be replaced with by expanding the facility to store and ship grain products. By the future project year of 2020, incoming grains will arrive by rail before being delivered to clients via Panamax and Handymax vessels. Highlights of the Project design elements are provided below.

- Demolition - Removal of 'woodchip only' handling equipment (5 reclaims, 4 conveyors) wood retaining walls, roll over dumper, rail dumper buildings and longshore lunchroom.
- Rail Yard - Switch adjustments and track extensions allowing the receiving and unloading of a 112 car unit train. This will also facilitate better movement to and through the rail car dumper. Addition of extra trackage to allow for more on-site rail car storage.
- Rail Car Dumper - Retrofit dumper with new gravity hopper. Install new enclosure with modern dust control and collection.
- Conveying Systems - Install covered conveying systems, with inbound to storage rates at 1,500 TPH and outbound rates at 2,000 TPH (includes outbound weighing).
- Storage - Construct 48 new 3400t silos and 8 - 1000t silos (all gravity drain), with a capacity of 171,200 tonnes of storage.
- Shiploader - Install new travelling shiploader to more efficiently load products, to accommodate Panamax vessels, and to minimize dust emissions.
- Dust Collection – dust collectors will be added to the new material transfer points for the grain handling system and current pellet handling transfer points without active dust collection will be upgraded with dust collectors.
- Site Infrastructure - Upgrade electrical, water and storm systems.

2.2 BASELINE CASE – ACTIVITY AND THROUGHPUT SUMMARY

Baseline, year 2015, throughput numbers was chosen as the baseline, which represented the most recent typical year of facility operation based on Fibreco's historical throughput presented in the permit application.

Table 2-1 2015 Baseline Year Assumed Activity Data for Pellets and Wood Chips

PRODUCT	THROUGHPUT (TONNES/Y)
Wood Chips	400,000
Pellets	1,300,000
Grains	---

2.3 PROJECT CASE – ACTIVITY AND THROUGHPUT SUMMARY

The future Project year of 2020 corresponds to the expected throughput year after project completion. The future project year activity/throughput summary for pellets and grains are shown in Table 2-2.

Table 2-2 2020 Future Project Year Activity Data for Pellets and Grains

PRODUCT	THROUGHPUT (TONNES/Y)
Wood Chips	---
Pellets	1,000,000
Grains	2,000,000

2.4 NO PROJECT CASE – ACTIVITY AND THROUGHPUT SUMMARY

Facility activities and product throughputs are not expected to change in 2020 if the Project is not implemented. Hence, for the No-Project case, the 2020 source emissions will be the same as the 2015 baseline.

3 GEOGRAPHIC SCOPE

3.1 FACILITY

The Fibreco Terminal is located on the north shore of Burrard Inlet in the Port of Vancouver (PoV). The facility boundary considered in the emissions estimation and dispersion modelling as the fenceline is shown in the Figure below.

3.2 SUPPLY CHAIN

The supply chain inventory takes into account the emissions from the marine vessels and rail that transport products to and from the Terminal. The supply chain boundaries have been shown in Figure 1-1. Detailed emission estimation methodologies for the supply chain are presented in Appendix A.

Marine traffic travels to the Terminal via English Bay before entering Burrard Inlet through the Lion's Gate Bridge. Since anchoring emissions are a significant portion of marine emissions and the supply chain boundary should be large enough to capture this activity, the supply chain boundary for ocean going vessels was set at the boundary of Georgia Strait and English Bay where these vessels would be anchoring while within the PoV's navigational jurisdiction.

For train traffic, the supply chain boundary was set at the nearby CN Lynn Creek Yard which is approximately 5 km away. Emissions from the Fibreco rail supply chain were based on estimated fuel consumption derived from locomotive engine fuel consumption rate and the number of train movements for transit to and from the CN Yard.

3.3 RECEIVER IDENTIFICATION AND PROXIMITY

Table 3-1 show the distance to various receiver types from the Fibreco Terminal. Figure 3-1 shows the location of the most sensitive receiver types near to the Terminal.

Table 3-1 Distance to the Nearest Receiver Types

RECEIVER TYPE	DISTANCE TO RECEIVER
Business	Border Fibreco Property
Residence	250 m
School	500 m
Child Care Facility	800 m
Seniors Facility	1.9 km
Hospital	3.0 km
Public area (park)	220 m

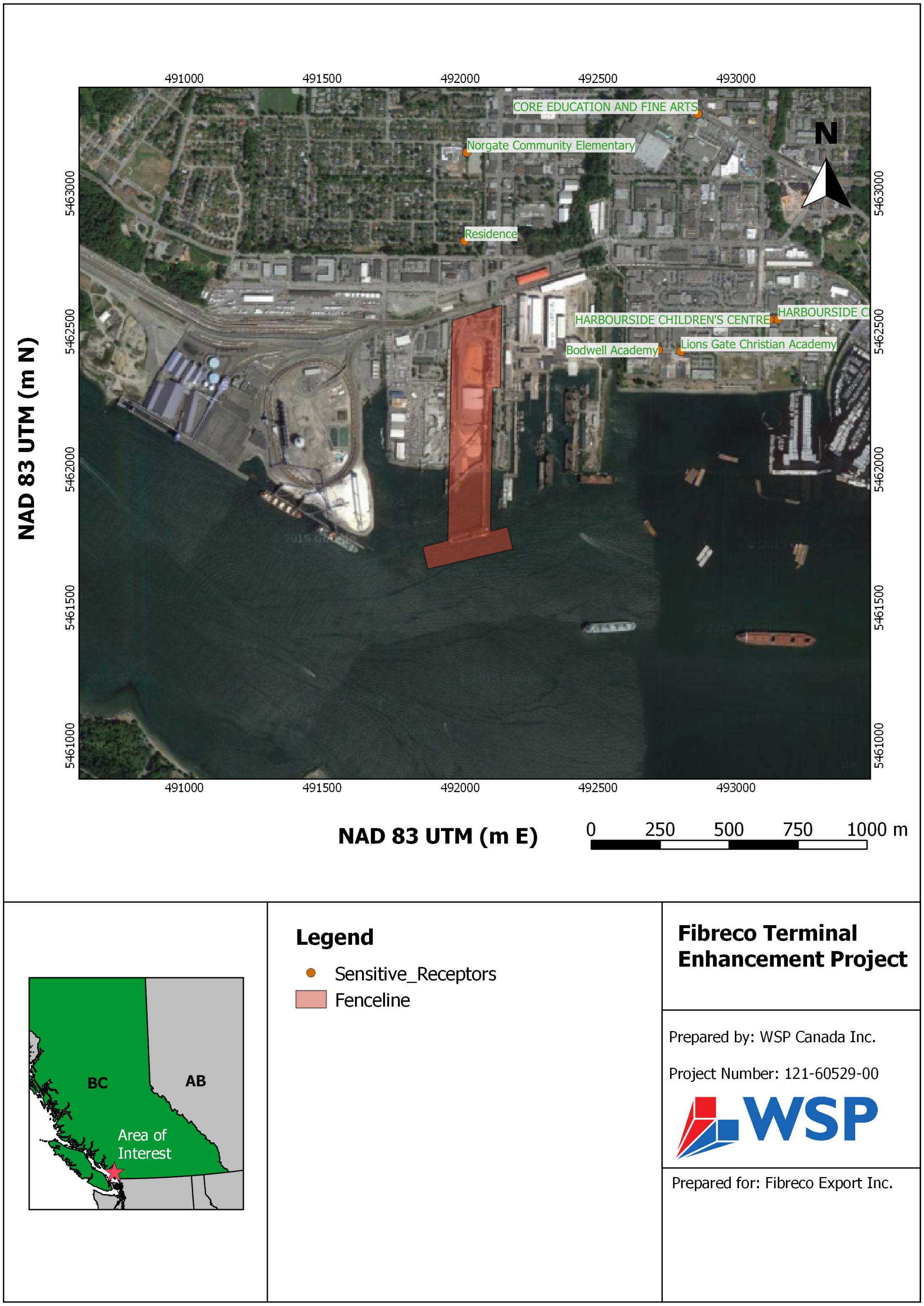

Figure 3-1 Facility Location, Fenceline and Nearby Sensitive Receptors

4 EMISSION SOURCES

In this assessment, a facility and a supply chain inventory were prepared for the baseline and the future Project year to quantify pollutant emissions associated with current facility operations, its proposed future modifications and the supply chain. As stated previously, the year 2015 was chosen as the baseline and 2020 as the future Project year, respectively. The best available activity data from Fibreco and the most appropriate emission models and factors available to-date were used to compile the facility emissions inventory.

4.1 PRIMARY SOURCES

Emissions from the following sources were included in this air quality assessment:

- Facility sources
  - process operations including material transfers and storage;
  - electricity consumption;
- Marine vessels including ocean-going vessels, barges and tugs;
- Rail; and
- Non-road diesel equipment (front-end loaders and bulldozers).

The activity matrices for these primary sources are shown in Tables 4-1 to 4-8 for the baseline and future Project years.

Table 4-1 Activity Matrix for Baseline Case – Facility Sources

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
Facility	Fugitives from Wood Chip Operations	Barge Receiving & Transfer Points	Throughput (tonnes/y)	83,365
		Rail Receiving & Transfer Points	Throughput (tonnes/y)	316,635
		Stockpiles	Surface Areas (m^2)	13,555
		Barge Loading & Transfer Points	Throughput (tonnes/y)	35,249
		Ship Loading & Transfer Points	Throughput (tonnes/y)	364,751
	Fugitives from Pellet Operations	Rail Receiving & Transfer Points	Throughput (tonnes/y)	1,300,000
		Ship Loading & Transfer Points	Throughput (tonnes/y)	1,300,000
	Electricity Use	Annual Usage	Annual Consumption (MW-hour)	3

Table 4-2 Activity Matrix for Future Project Case – Facility Sources

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
Facility	Fugitives from Grain Operations	Rail Receiving & Transfer Points	Throughput (tonnes/y)	2,000,000
		Ship Loading & Transfer Points	Throughput (tonnes/y)	2,000,000
	Fugitives from Pellet Operations	Rail Receiving & Transfer Points	Throughput (tonnes/y)	1,000,000
		Ship Loading & Transfer Points	Throughput (tonnes/y)	1,000,000
	Electricity Use	Annual Usage	Annual Consumption (MW-hour)	3.5

Table 4-3 Activity Matrix for Baseline Case – Rail Sources

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
Facility	Line Haul	Duty Cycle Average	#Engines/Train	2
			Engine Fuel Consumption (L/hour)	159
			Operating Time Onsite (hours/day)	0.9
			Annual Operating Days	268
Supply Chain	Line Haul	Duty Cycle Average	Train Speed (km/hour)	9.7
			Distance to Lynn Creek Yard (km)	5
			#Railcars/chip train	46
			#Railcars/pellet train	45
			Capacity of chip railcar (tonnes/railcar)	50
			Capacity of pellet railcar (tonnes/railcar)	92

Table 4-4 Activity Matrix for Future Project Case – Rail Sources

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
Facility	Line Haul	Duty Cycle Average	#Engines/Train	2
			Engine Fuel Consumption (L/hour)	159
			Operating Time Onsite (hours/day)	1.5
			Annual Operating Days	333
Supply Chain	Line Haul	Duty Cycle Average	Train Speed (km/hour)	9.7
			Distance to Lynn Creek Yard (km)	5
			#Railcars/grain train	112
			#Railcars/pellet train	45
			Capacity of grain railcar (tonnes/railcar)	100
			Capacity of pellet railcar (tonnes/railcar)	92

Table 4-5 Activity Matrix for Baseline Case – Marine Sources

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
Facility	Barge	Berth	Vessel Port Calls	52
	OGV[a] -Handymax	Berth	Vessel Port Calls	62
			Auxiliary Engine Power (kW)	1,727
			Auxiliary Engine Load Factor (%)	29
			Annual Avg.Berthing Time (hours)	5,154
			Boiler Fuel Consumption (t/hour)	0.08
			Boiler Operating Time (hours/day)	24
		Underway Warping	Main Engine Power (kW)	8,342
			Warping Time/Vessel Call (hours)	3.25

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
	Harbour Tugs	Berth	Barge Calls	52
			OGV Calls	62
			Engine Power (kW)	1,065
			Engine Load Factor (%)	79
			#Tugs/Barge Movement	1
			#Tugs/OGV[a] Movement	2
			Operating time/call (hours)	1
Supply Chain	OGV	Anchoring	Anchoring time/vessel call (hours/call)	59.4
			Distance to Burrard Inlet (km)	12

[a] OGV = ocean-going vessels

Table 4-6 Activity Matrix for Future Project Case – Marine Sources

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
Facility	OGV[a] - Handymax	Berth	Vessel Port Calls	50
			Auxiliary Engine Power (kW)	1,727
			Auxiliary Engine Load Factor (%)	29
			Annual Berthing Time (hours)	3,884
			Boiler Fuel Consumption (t/hour)	0.08
			Boiler Operating Time (hours/day)	24
		Underway Warping	Main Engine Power (kW)	8,342
			Engine Load Factor (%)	10
			Warping Time/Vessel Call (hours)	3.25

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
	OGV - Panamax	Berth	Vessel Port Calls	14
			Auxiliary Engine Power (kW)	1,777
			Auxiliary Engine Load Factor (%)	28
			Annual Berthing Time (hours)	1,321
			Boiler Fuel Consumption (t/hour)	0.08
			Boiler Operating Time (hours/day)	1,321
		Underway	Main Engine Power (kW)	8,928
			Engine Load Factor (%)	10
	Harbour Tugs	Berth	OGV Calls	64
			Engine Power (kW)	1,065
			Engine Load Factor (%)	79
			#Tugs/OGV[a] Movement	2
			Operating time/call (hours)	1
Supply Chain	OGV	Anchoring	Anchoring time/vessel call (hours/call)	59.4
			Distance to Burrard Inlet (km)	12

[a] OGV = ocean-going vessels

Table 4-7 Activity Matrix for Baseline Case – Non-road Sources

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
Facility	Railcar Movers	Cycle Average	#Movers	2
			Age	2012
			Engine Power (HP)	393
			Engine Load Factor (%)	18
			Annual Operating Time (hours)	617
	Bulldozers	Cycle Average	#Units	2
			Age	2002
			Engine Power (HP)	636
			Engine Load Factor (%)	59
			Annual Operating Time (hours)	2,600
	Front-end Loaders	Cycle Average	#Units	1
			Age	2012
			Engine Power (HP)	393
			Engine Load Factor (%)	60
			Annual Operating Time (hours)	619

Table 4-8 Activity Matrix for Future Project Case – Non-road Sources

GEOGRAPHIC BOUNDARY	DESCRIPTION	MODE	METRIC	VALUE
Facility	Railcar Movers	Cycle Average	#Movers	2
			Age	2012
			Engine Power (HP)	393
			Engine Load Factor (%)	18
			Annual Operating Time (hours)	617
	Front-end Loaders	Cycle Average	#Units	1
			Age	2012
			Engine Power (HP)	393
			Engine Load Factor (%)	60
			Annual Operating Time (hours)	619

4.2 EMISSION VARIABILITY

Facility emissions are highly dependent on product delivery and shipment volumes and schedules and therefore are variable throughout the year. Rail traffic and the size of trains also vary depending on supplier delivery needs and vessel requirements. Fibreco is available to operate 24 hours per day and the number of shifts are determined by operational demand. This assessment does not specifically address variable emissions, except in the formulation of peak, daily and annual average emission rates for the dispersion modelling.

4.3 POLLUTANTS OF CONCERN – EMISSIONS INVENTORY

For each of the emission sources, the pollutants that were inventoried included Criteria Air Contaminants (CACs), Greenhouse Gases (GHGs) and Black Carbon, which is a climate forcer. The CACs of interest were Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Sulphur Oxides (SO_x), Total Particulate Matter (TPM) and its smaller size fractions of PM_{10} (< 10μm diameter) and $PM_{2.5}$ (<2.5μm diameter), Diesel Particulate Matter (DPM), Volatile Organic Compounds (VOCs) and Ammonia (NH_3). Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxides (N_2O) are the GHGs that were quantified.

For reporting purposes, emissions of GHGs and black carbon have been estimated on a CO_2 equivalent tonnes based on the 100-year time horizon (CO_2e_{100}) and the 20-year time period (CO_2e_{20}). The Global Warming Potentials (GWPs), shown in Table 4-9 below, were applied to determine CO_2 equivalent emissions for these two time horizons. For CH_4 and N_2O, the GWPs shown are based on the Fourth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC)[1] and were adopted by BC Environment. For black carbon, the data was from a recent publication[2].

Table 4-9 Global Warming Potentials

POLLUTANT	20-YEAR	100-YEAR
CH_4	72	25
N_2O	289	298
Black Carbon	3,200	900

Since black carbon is a constituent of the particulate released from combustion sources, its emissions have been estimated by applying source-specific black carbon to $PM_{2.5}$ ratios published in a recent US EPA report[3]. These ratios are shown in Table 4-10.

[1] *IPCC, 2012, "IPCC Fourth Assessment Report (AR4) - Climate Change 2007: Working Group I: The Physical Science Basis". http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html#table-2-14*

[2] *Bond, T. C., Doherty, S. J., Fahey, D. W., Forster, P. M., Berntsen, T. K., DeAngelo, B. J., et al., 2013, "Bounding the Role of Black Carbon in the Climate System: A Scientific Assessment. Journal of Geophysical Research-Atmospheres", doi:10.1002/jgrd.50171.*

[3] *US EPA, 2012, "Report to Congress on Black Carbon", EPA-450/R-12-001, March, Table 4-2, pages 90-91.*

Table 4-10 Black Carbon to $PM_{2.5}$ Ratios

SOURCE	Black Carbon/$PM_{2.5}$ Ratio
On-road Diesel	0.74
Non-road Diesel	0.77
Non-road Liquefied Petroleum Gas[a]	0.1
Locomotive	0.73
Commercial Marine (C1 & C2 categories)	0.77
Commercial Marine (C3 category)	0.03
Natural Gas Combustion	0.38
Distillate Oil Combustion[b]	0.1

[a] Combustion source category was approximated from the Non-road Gasoline Category

[b] Ship boiler emissions used the Distillate Oil Combustion source category, which are based off fuels with a lower sulphur fuel percentage than marine distillate oil

4.1 POLLUTANTS OF CONCERN – DISPERSION MODELLING

For the purposes of dispersion modelling, only the CACs with Metro Vancouver Ambient Air Quality Objectives (AAQOs) were modelled. The following CACs were modelled:

<u>Criteria Air Contaminants:</u>

- → Carbon Monoxide (CO);
- → Nitrogen Oxides (NO_x);
- → Sulphur Oxides (SO_x);
- → Particulate matter less than 10 microns in diameter (PM_{10});
- → Particulate matter less than 2.5 microns in diameters ($PM_{2.5}$);

5 CURRENT CONDITIONS

5.1 AMBIENT AIR QUALITY OBJECTIVES

The federal and provincial governments, as well as Metro Vancouver, have developed ambient air quality objectives (AAQOs) to promote long-term protection of public health and the environment for most criteria air contaminants (CACs). The Metro Vancouver AAQOs are used in this assessment. As with the federal and provincial AAQOs, Metro Vancouver establishes AAQOs are based on the current knowledge regarding air quality and health science. A summary of the ambient air quality concentrations compared to their respective objectives is shown below in Table 5-1.

Table 5-1 Metro Vancouver's Ambient Air Quality Objectives

AIR CONTAMINANT	AVERAGING TIME	AAQOS (µG/M3)
Carbon Monoxide (CO)	1-Hour	30,000
	8-Hour	10,000
Nitrogen Dioxide (NO_2)	1-Hour	200
	Annual	40
Sulphur Dioxide (SO_2)	1-Hour	196[a]
	24-Hour	125
	Annual	30
Inhalable Particulate Matter (PM_{10})	24-Hour	50
	Annual	20
Fine Particulate Matter ($PM_{2.5}$)	24-Hour	25
	Annual	8 (6)[c]

a Interim SO_2 objective and is intended to apply to all applications for new or significantly modified discharge authorizations on or after May 15, 2015, but is not intended to apply to existing facilities.

b Ozone impacts were not considered in this assessment

c Annual $PM_{2.5}$ objective of 8 µg/m^3 and a planning goal of 6 µg/m^3 which is a longer term aspiration target to support continuous improvement.

5.2 BACKGROUND AMBIENT AIR QUALITY

Metro Vancouver operates an extensive network of ambient air quality monitoring stations (Figure 5-1). Data from three monitoring stations (T06 North Vancouver – Second Narrows, T024 Burnaby North, and T026 North Vancouver – Mahon Park) were used for characterizing the background air quality in the area surrounding Fibreco's location. The yellow circles identify the stations and the yellow star identifies the approximate location of Fibreco's facility. The monitoring stations were chosen based on their representativeness, proximity to the facility and the air quality parameters monitored.

Figure 5-1 Lower Fraser Valley Air Quality Monitoring Network[4]

Three years of data from 2012 from 2014 from T06 North Vancouver – Second Narrows, T024 Burnaby North, and T026 North Vancouver – Mahon Park were analyzed. Of the CACs of interest for this study, Table 5-2 indicate the parameters that were included in the background ambient air quality data analysis, and their respective ambient air quality monitoring station information.

Table 5-2 Ambient Air Quality Monitoring Station Information and Measurement Heights

STATION ID	STATION NAME	LOCATION (LAT., LONG)	MEASUREMENT HEIGHT ABOVE GROUND (M)						
			NO_2	NO_x	CO	SO_2	$PM_{2.5}$	PM_{10}	TRS
T06	North Vancouver – Second Narrows	49.3015° N, 123.0204° W	5.7	5.7	5.7	5.7	6.2	-	-
T024	Burnaby North	49.2875° N, 123.0080° W	-	-	-	4.1	-	4.7	4.1
T026	North Vancouver – Mahon Park	49.2152° N, 122.9857° W	11.0	11.0	11.0	11.0	11.7	-	-

The data is summarized in Table 5-3 below for each averaging time corresponding to the averaging times for the AAQOs. In addition, the 98th percentile concentrations were determined for 1-hour, 8-hour, and 24-hour averaging periods, with the exception of 1-hour SO_2 where the 99th percentile was used in accordance with guidance from the British Columbia Ministry of Environment[5]. The

[4] MV (2013), Metro Vancouver 2011 Lower Fraser Valley Air Quality Monitoring Report (April, 2013)

[5] *BC MOE (2015). Dispersion Modelling Guidance for 1-hour NO2 and SO2 Interim Ambient Air Quality Objectives. British Columbia Ministry of Environment. http://*www.bcairquality.ca/reports/pdfs/disp-model-guide-interim-2015.pdf

98th percentile values are used to characterize the background ambient air quality as these values are less extreme than the maximum observed concentrations, and are considered to be more representative of the expected background air quality, while being more conservative than using the arithmetic mean average. The methodology used to estimate the background air quality concentrations is consistent with the *British Columbia Air Quality Dispersion Modelling Guideline (AQMG*[6]*)* and other air quality assessments submitted to PoV.

Table 5-3 Summary of the Background Ambient Air Quality Concentrations

AIR CONTAMINANT	STATIONS(S) INCLUDED IN AVERAGES	AVERAGING TIME	BACKGROUND LEVELS (µG/M3)	CALCULATION BASIS
CO	Second Narrows (T06) Mahon Park (T026)	1-Hour	597	98th Percentile
		8-Hour	523	98th Percentile
NO_2	Second Narrows (T06) Mahon Park (T026)	1-Hour	59.6	98th Percentile
		Annual	23.8	-
SO_2	Second Narrows (T06) Burnaby North (T024) Mahon Park (T026)	1-Hour	28.0	99th Percentile
		24-Hour	13.8	98th Percentile
		Annual	3.8	-
PM_{10}	Burnaby North (T024)	24-Hour	21.8	98th Percentile
		Annual	9.3	-
$PM_{2.5}$	Second Narrows (T06) Mahon Park (T026)	24-Hour	14.0	98th Percentile
		Annual	5.4	-

5.3 METEOROLOGICAL INFLUENCES

The atmospheric conditions that contribute to the dispersion of pollutants are complex. In particular, the dispersion modelling assessment uses a meteorological model to recreate three-dimensional meteorological grid cells, defining key atmospheric processes such as wind speed and direction, temperature and atmospheric mixing heights and stability.

In order to create the meteorological dataset for the dispersion modelling, the meteorological model uses information from the Weather Research and Forecasting Model (WRF) and surface meteorological stations operated by Environment Canada (EC) and Metro Vancouver that record hourly weather data. Details on the observed surface station meteorology in the region around Fibreco is provided in Appendix B

The meteorological stations T06 (Second Narrows) and T26 (North-Vancouver Mahon Park indicate that the predominant winds are from the east and east-northeast, respectively, corresponding with the

[6] *BC MOE (2015), British Columbia Air Quality Dispersion Modelling Guideline. British Columbia Ministry of Environment, Environmental Protection Division, Environmental Standards Branch, Clean Air Section, Victoria, British Columbia. November 2015.*

alignment of Burrard Inlet. There is also a smaller portion of winds from the northerly directions, likely as a result of the outflow from the North Shore Mountains.

5.4 HISTORICAL TRENDS

The historical throughputs for wood chips and pellets have been shown in Table 2-1. While year-to-year fluctuations are shown, as a result of changes to market and hence client demands, the throughput volumes for the 2015 baseline year are believed to be representative of historical product volumes and associated source emissions.

6 FUTURE CONDITION

6.1 HORIZON YEAR – RATIONALE

The project is expected to be substantially delivered by 2018 and fully operational by the year 2020. Hence, 2020 has been chosen as the future Project year for this assessment as it corresponds to the expected maximum throughput year after project completion.

6.2 DESIGN CAPACITY LIMITATION

The design capacity limitations for the project are limited rail capacity both onsite at Fibreco and upstream rail, the throughput capacity of the handling system and the limits imposed by the grain storage capacity.

7 EMISSION ESTIMATES

For this air quality assessment, emissions associated with the following facility and supply chain scenarios were estimated.

Facility scenarios:

→ Baseline Case (2015) – wood chips and pellets;
→ Future Case (2020) - with Project (i.e. switch from wood chips to grains).

Supply chain scenarios:

→ Baseline Case (2015) – wood chips and pellets;
→ Future Case (2020) - with Project (i.e. switch from wood chips to grains).

7.1 BASELINE CASE

A summary of the baseline emissions from facility sources is shown in Table 7-1. A high proportion of facility fugitive particulate emissions are associated with pellet handling and transfer while wood chips handling contributes to the rest of the emissions. Rail emissions are from fuel combustion of the locomotive engines on the unit trains while marine emissions are from diesel combustions by tug boat engines, vessel auxiliary engines and boilers while at berth. For non-road equipment, this category includes bulldozers, railcar movers and front-end loaders which are used on site.

Table 7-1 2015 Baseline Emissions – Facility Sources

POLLUTANT	FUGITIVES	RAIL	MARINE VESSELS	NON-ROAD EQUIPMENT	ELECTRICITY	ALL SOURCES
CO	-	0.54	5.34	7.49	-	13.37
NOx	-	3.41	39.06	16.84	-	59.31
SOx	-	0.00	1.98	0.02	-	2.00
VOCs	-	0.15	1.51	0.68	-	2.35
TPM	85.25	0.08	1.10	0.89	-	87.32
PM_{10}	21.97	0.08	1.06	0.89	-	24.00
$PM_{2.5}$	4.28	0.08	0.98	0.87	-	6.20
NH_3	-	0.02	0.01	0.00	-	0.03
DPM	-	0.08	0.98	0.87	-	1.92
Black Carbon	-	0.05	0.58	0.67	-	1.30
CO_2	-	206.59	3242.15	2164.48	280.32	5893.54
CH_4	-	0.01	0.29	0.01	-	0.32
N_2O	-	0.08	0.08	0.00	-	0.17
CO_2e_{20}	-	407.59	5139.22	4301.87	280.32	10128.99
CO_2e_{100}	-	281.48	3795.00	2765.67	280.32	7122.48

The baseline supply chain emissions, as shown in table 7-2, are made up of engine combustion-related emissions from inbound and outbound trains travelling to and from the CN Lynn Creek railyard as well as from marine vessels travelling through Burrard Inlet to the anchoring area in English Bay and while anchoring.

Table 7-2 2015 Baseline Emissions – Supply Chain

POLLUTANT	RAIL	MARINE VESSELS	ALL SOURCES
CO	1.13	3.76	4.90
NOx	7.14	27.78	34.93
SOx	0.00	1.45	1.45
VOCs	0.32	1.11	1.44
TPM	0.16	0.77	0.94
PM_{10}	0.16	0.74	0.91
$PM_{2.5}$	0.16	0.68	0.84

POLLUTANT	RAIL	MARINE VESSELS	ALL SOURCES
NH_3	0.05	0.01	0.05
DPM	0.16	0.68	0.84
Black Carbon	0.12	0.393	0.51
CO_2	432.61	2,296.34	2,728.95
CH_4	0.02	0.21	0.23
N_2O	0.18	0.06	0.24
CO_2e_{20}	853.53	3,586.56	4,440.09
CO_2e_{100}	589.45	2,672.90	3,262.35

7.2 FUTURE PROJECT CASE

Tables 7-3 and 7-4 show the 2020 emissions from facility sources and the supply chain, respectively.

Table 7-3 2020 Emissions with Project – Facility Sources

POLLUTANT	FUGITIVES	RAIL	MARINE VESSELS	NON-ROAD EQUIPMENT	ELECTRICITY	ALL SOURCES
CO	-	1.10	5.47	0.10	-	6.67
NOx	-	6.93	40.31	1.02	-	48.26
SOx	-	0.00	2.03	0.00	-	2.04
VOCs	-	0.31	1.62	0.10	-	2.03
TPM	5.34	0.16	1.13	0.01	-	6.63
PM_{10}	1.65	0.16	1.08	0.01	-	2.89
$PM_{2.5}$	0.37	0.15	1.00	0.01	-	1.52
NH_3	-	0.05	0.01	0.00	-	0.06
DPM	-	0.15	1.00	0.01	-	1.16
Black Carbon	-	0.11	0.58	0.00	-	0.69
CO_2	-	419.98	3,290.35	390.82	327.04	4,428.19
CH_4	-	0.02	0.30	0.00	-	0.32
N_2O	-	0.17	0.08	0.00	-	0.26
CO_2e_{20}	-	828.60	5,186.49	404.58	327.04	6,746.72
CO_2e_{100}	-	572.24	3,843.26	394.70	327.04	5,137.24

Table 7-4 2020 Emissions with Project – Supply Chain

POLLUTANT	RAIL	MARINE VESSELS	ALL SOURCES
CO	0.98	3.89	4.87
NOx	6.16	28.68	34.85
SOx	0.00	1.50	1.50
VOCs	0.28	1.15	1.43
TPM	0.14	0.80	0.94
PM_{10}	0.14	0.77	0.91
$PM_{2.5}$	0.14	0.71	0.84
NH_3	0.04	0.01	0.05
DPM	0.14	0.71	0.84
Black Carbon	0.10	0.406	0.51
CO_2	373.22	2,375.33	2,748.55
CH_4	0.02	0.22	0.24
N_2O	0.15	0.06	0.21
CO_2e_{20}	736.35	3,707.17	4,443.52
CO_2e_{100}	508.52	2,764.07	3,272.59

8 LEVEL 2 – DISPERSION MODELLING

8.1 OVERVIEW OF MODELLING APPROACH

PoV determined that a Level 2 assessment was required for the proposed Fibreco expansion. The purpose of a Level 2 assessment is to quantify the impact of emissions from the facility on the surrounding neighbourhood. An atmospheric dispersion model is used to estimate pollutant concentrations in the community that result from facility emissions. These concentrations are then compared to air quality objectives.

Air dispersion modelling was conducted following the methods recommended in the *British Columbia Air Quality Modelling Guidelines*[7] (AQMG) in addition to guidance from PoV. This section presents a summary of the modelling methodology and results. Further details on the modelling methodology and contour plots of the model predicted pollutant concentrations are provided in Appendix B.

[7] http://www.bcairquality.ca/pdf/bc-dispersion-modelling-guideline-2015.pdf

8.2 CALPUFF

The CALPUFF modelling suite was used for this analysis. CALPUFF is a suite of numerical models (CALMET, CALPUFF, and CALPOST) that are used in series to determine the impact of emissions in the vicinity of a source or group of sources. Detailed three-dimensional meteorological fields were produced by the diagnostic computer model CALMET (version 5.8, BC Ministry of Environment (BC MOE) and US EPA approved version), based on surface and upper air weather data, digital land use data, terrain data, and prognostic meteorological data. The three-dimensional meteorological fields produced by CALMET were used by CALPUFF (version 5.8, BC MOE and US EPA approved version), a three-dimensional, multi-species, non-steady-state Gaussian puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport. Finally post-processing utilities CALSUM, POSTUTIL, CALPOST and CALAVE were used to post-process and summarize the modelling output from CALPUFF.

The three-dimensional CALMET meteorological fields were generated using meteorological data from numerous surface stations and upper air stations, prognostic meteorological data from the Weather Research and Forecasting (WRF) model, and digital terrain and land use data.

The model was used to predict concentrations for averaging periods as per the associated Metro Vancouver Ambient Air Quality Objectives (Table 5-1). Emission rates were developed from the emissions inventory by selecting representative rates for peak, daily average and annual as follows:

- 1-hour averaging: the peak hourly average emission rate for both combustion and fugitive dust sources were determined and assess for each hour of the modelling period;
- 24-hour averaging: the daily average emission rates were determined based on assumed maximum daily process throughputs and combustion source activity and were distributed over all hours of the day for each hour of the modelling period;
- Annual averaging: the annual emission totals based on the annual activity summarized in section 7 were distributed evenly throughout all hours of the modelling period.

8.3 MODEL RESULTS

8.3.1 PROJECT CASE

Model results for the criteria air contaminants considered in the assessment are summarized below for the project case (Table 8-1). As an estimate of potential cumulative impacts from the facility, the table also presents background concentrations which are added to modelled values and compared to the Metro Vancouver Air Quality Objectives. Predictions from the project case are compared to assumed baseline operations in section 10.

Table 8-1 Project Maximum Pollutant Concentration Predictions

POLLUTANT	AVERAGING TIME	AAQO (µg/m³)	POLLUTANT CONCENTRATION (µg/m³)			% OF AAQO
			BACKGROUND	MODELLED	TOTAL PREDICTED	
CO	1-hour	30,000	597	248	845	3%
	8-hour	10,000	523	60	583	6%
NOx	1-hour	200	151.3	1,571	1,722	n/a
NO_2 (100% NOx)	1-hour	200	59.6	1,571	1,631	n/a
NO_2 (ARM)	1-hour	200	59.6	73	73	36%
NO_2 (100% NOx)	Annual	40	23.8	7	31	77%
SO_2	1-hour	450	28.0	21.7	49.7	11%
	24-hour	125	13.8	1.6	15.5	12%
	Annual	30	3.9	0.1	4.0	13%
$PM_{2.5}$	24-hour	25	14.0	6.0	20.0	80%
	Annual	8	5.4	0.2	5.6	70%
PM10	24-hour	50	21.8	26.6	48.4	97%
	Annual	20	9.3	0.9	10.2	51%

Table 8-2 provides an indication of the dispersion of the pollutants away from the facility at the nearby sensitive receptors. At these locations there are minor potential short-term impacts to air quality, but even the maximum impacts predicted remain below AAQOs. On an annual or long-term basis, the predicted concentrations are almost entirely attributable to the background concentrations applied in the assessment and impacts from the project would be expected to be negligible.

Table 8-2 Project Scenario Particulate Matter Concentrations Predicted at Select Nearby Sensitive Receptors

POLLUTANT	AVERAGING TIME	AAQO (µg/m³)	POLLUTANT CONCENTRATION (µG/M3)			MAX % OF AAQO
			RESIDENCE	BODWELL ACADEMY	NORGATE SCHOOL	
$PM_{2.5}$	24-hour	25	16.4	15.2	15.9	65%
	Annual	8	5.4	5.4	5.4	68%
PM10	24-hour	50	28	26.3	26.9	56%
	Annual	20	9.3	9.4	9.3	47%

9 MITIGATION POTENTIAL

9.1 USE OF BEST AVAILABLE TECHNOLOGY NOT ENTAILING EXCESSIVE COST

One of the key anticipated project benefits is the improvements to dust control at the facility. Both the emission estimates and the predicted impact to ambient particulate matter concentrations demonstrate the effect that these measures will have on air quality near the facility. Best Available Technology Not Entailing Excessive Cost (BAT) was selected for the key emission sources associated with the expansion as outlined below. Allowing for grain handling and shipping at the Terminal provides Fibreco the economic opportunity to:

- Invest in a new shiploader designed to control dust from wood pellets as well as the grain products associated with the expansion;
- Invest in the use of a cascading telescopic chute during ship loading to achieve a particulate control efficiency in excess of 98%
- Eliminate the shipping of wood chips onto barges
- Eliminate the open wood chip storage stockpiles;
- Install a new gravity hopper on rail car dumper and new enclosure with modern dust control and collection;
- construction of new silos equipped with gravity grains;
- the installation of covered conveying systems;
- the venting of emissions at transfer points to baghouses/fabric filters or to an enclosure where exhausts are directed to baghouse for an overall control efficiency of 99% or more;

Key elements of this investment in dust control are outlined below.

The new rail receiving system will utilize a gravity hopper along with an enclosure with baghouse dust control. The design specifications for the baghouse dust collector exhaust limit of particulate matter Is 4 mg/m^3. Combined with the hopper and enclosure this is considered BAT for both wood pellet and grain handling in a rail car unloader. For emission estimation purposes, the control efficiency applied to this source for the project case was 99%.

The new shiploader will improve dust control for both wood pellets and grain by employing a cascading, telescopic chute, along with dust collection with similar performance to the dust collection on the rail receiving system and material transfer points. The use of a cascading chute slows the material as it falls through the chute, eliminating the dust created from free fall of material from a drop height. This prevents material breakage and also slows the material as it exits the chute onto the material within the ship's hold, creating less dust in the process. The telescopic chute allows for the reduction of drop height during loading operations. Dust created will be captured by the dust collection system installed on the shiploader. For emission estimation purposes, the control efficiency applied to this source for the project case was 98%.

All new material transfer points associated with the grain handling system will be completely enclosed and equipped with dust collectors a the point of dust generation. The dust collectors contain a high-quality filter media that controls dust. The design specifications for the dust collectors at these emission points is 4 mg/m^3 particulate exhaust which represents BAT for this type of emission point.

For emission estimation purposes, the control efficiency applied to this source type equipped with a dust collector was 98%.

9.2 APPLICATION OF BEST AVAILABLE PROCEDURES

Following the installation of the above described technologies and measures, the majority of effort will be spent on good engineering and operational practices that are consistent with equipment design requirements. Specifically, the preceding permit application documents outline the rail operations plan, transportation plan and the marine operations plan associated with the project expansion which will allow for efficient delivery of product through the Terminal.

After the completion of the Project, Fibreco will be able to unload and release a 112 car train in 24 hours. This increase in productivity will lead to less trains for greater tonnes handled and will impact overall facility emissions. Furthermore, with the addition of Panamax sized vessels to handle larger parcels due to customer needs, the overall efficiency at Fibreco will improve requiring fewer vessels per tonne handled.

In addition to these operational plans, the Construction Environmental Management Plan for the project will specifically outline mitigation measures and environmental specifications for air quality.

10 IMPACT POTENTIAL

10.1 COMPARE BASELINE CASE TO PROJECT CASE

Table 10-1 shows an overall emission summary of the pollutant emissions for the 2015 and 2020 facility operation scenarios. For the 2015 base year, the majority of particulate emissions, with the exception of DPM, were attributable to facility processes that were associated with material handling activities during product loading and transfer operations. As discussed in Section 7, a high proportion of these particulate emissions are associated with pellet handling while wood chip handling accounts for the rest. With the implementation of the best available dust control technologies, such as the new shiploader, high efficiency baghouses, and the elimination of wood chips in 2020, a significant decline in particulate emissions has been observed as shown in Table 10-1.

For combustion-related emissions, emissions associated with marine vessel operations are comparable in magnitude between the 2015 baseline and the 2020 Project year as previously shown in Tables 7-1 and 7-3. These tables also show a significant drop in non-road equipment emissions. The reduction in non-road equipment can be attributable to the elimination of the use of the bulldozers, resulting in the overall reductions of combustion-related emissions shown in Table 10-1.

Table 8-3 provides a comparison of the two modelling cases. The project scenario shows a reduction in particulate matter concentrations primarily due to the improvements to fugitive dust control that will accompany the project, including:

→ Improved shiploader emissions controls for both pellet and grain handling – the current shiploader emissions represented the source with the largest impact on ambient particulate matter concentrations at Fibreco and the expansion will allow for significant improvements in fugitive dust emissions from this source;

- Better dust control measures implemented on the material handling transfers points throughout the facility, including at the railcar unloader, a key source of emissions at Fibreco;
- The elimination of open stockpiles of wood chips.

Although there are some increases to combustion related emissions, the model predictions remain well below the AAQOs for those pollutants.

Table 10-1 Emissions Comparison of Baseline to Project Case – Facility Sources

POLLUTANT	2015 BASELINE (TONNES)	2020 WITH PROJECT (TONNES)	CHANGE FROM BASELINE (%)
CO	13.37	6.67	-50.1%
NOx	59.31	48.26	-18.6%
SOx	2.00	2.04	1.8%
VOCs	2.35	2.03	-13.4%
TPM	87.32	6.63	-92.4%
PM_{10}	24.00	2.89	-88.0%
$PM_{2.5}$	6.20	1.52	-75.4%
NH_3	0.03	0.06	78.9%
DPM	1.92	1.16	-39.8%
Black Carbon	1.30	0.69	-46.7%
CO_2	5,893.54	4,428.19	-24.9%
CH_4	0.32	0.32	2.4%
N_2O	0.17	0.26	53.0%
CO_2e_{20}	10,128.99	6,746.72	-33.4%
CO_2e_{100}	7,122.48	5,137.24	-27.9%

Table 10-2 Baseline and Project Case Comparison of Predicted Pollutant Concentrations

POLLUTANT	AVERAGING TIME	AAQO (µg/m³)	POLLUTANT CONCENTRATION (µg/m³)	
			PROJECT	CHANGE FROM BASELINE %
CO	1-hour	30,000	845	0%
	8-hour	10,000	583	+ 24%
NOx	1-hour	200	1631	0%
NO_2 (100% NOx)	1-hour	200	1631	0%
NO_2 (ARM)	1-hour	200	73	0%
NO_2	Annual	40	31	+ 83%
SO_2	1-hour	450	49.7	+ 4%
	24-hour	125	15.5	+ 8%
	Annual	30	4.0	+ 3%
$PM_{2.5}$	24-hour	25	20.0	- 99%
	Annual	8	5.6	- 95%
PM10	24-hour	50	48.4	- 97%
	Annual	20	10.2	- 96%

The comparison of Fibreco's supply chain emission estimates for the baseline and future Project year scenarios is shown in Table 10-2. Fibreco rail supply chain emissions accounted for the CN train traffic to and from the CN Lynn Creek railyard which is the supply chain boundary. In 2020, the number of trains and associated emissions during transit to Lynn Creek are estimated to decline as longer trains will be used. As for marine vessels, the supply chain emissions included underway releases during transit through Burrard Inlet as well as ship anchoring emissions at English Bay. Panamax vessels will be used to handle grain shipments while barges will not be used as chip shipments will be eliminated. As shown in Table 10-2, emissions for the base and future scenarios shown are generally comparable as decreases resulting from reduced rail traffic and the elimination of wood chip shipments are offset by the use of the Panamax vessels to handle the new grain shipments.

Table 10-3 Emissions Comparison of Baseline to Project Case – Supply Chain

POLLUTANT	2015 BASELINE (TONNES)	2020 WITH PROJECT (TONNES)	CHANGE FROM BASELINE (%)
CO	4.90	4.87	-0.6%
NOx	34.93	34.85	-0.2%
SOx	1.45	1.50	3.4%
VOCs	1.44	1.43	-0.6%
TPM	0.94	0.94	0.3%
PM_{10}	0.91	0.91	0.2%
$PM_{2.5}$	0.84	0.84	0.1%
NH_3	0.05	0.05	-11.7%
DPM	0.84	0.84	0.1%
Black Carbon	0.51	0.51	-0.6%
CO_2	2,728.95	2,748.55	0.7%
CH_4	0.23	0.24	1.7%
N_2O	0.24	0.21	-9.5%
CO_2e_{20}	4,440.09	4,443.52	0.1%
CO_2e_{100}	3,262.35	3,272.59	0.3%

10.2 COMPARE PROJECT CASE TO BEST AVAILABLE TECHNIQUE

The proposed control technologies and facility efficiency measures are considered the best available currently according to industry standard. The effectiveness of these controls are demonstrated in the significant emission reductions for facility particulate matter sources shown in the preceding emissions and predicted ambient air quality comparison tables.

10.3 CONCLUSION

The Environmental Air Assessment Report for the Fibreco Grain Terminal Expansion Project evaluated the change in emissions and the potential impact on air quality due to expansion to accommodate grain handling activities at the Terminal. As part of the expansion project, Fibreco is able to outfit many of the key particulate emission (PM) sources onsite with best achievable emissions control technology that significantly reduces PM emissions when the expansion is completed.

The air assessment conducted found that due to non-road equipment currently used onsite being eliminated with the project, combustion related emissions will be reduced. Other combustion related activity does not increase significantly as some efficiencies gained through the size of vessel being accommodated at the berth under the project scenario offsets the additional vessel calls. The dispersion modelling assessment shows that combustion-related emissions levels from the project will result in ambient pollutant concentrations well below AAQOs, even when considering the maximum impacts throughout the year.

Through project design focused on addressing the particulate matter emissions from the facility, the overall emissions and impact to ambient concentrations of PM_{10} and $PM_{2.5}$ is reduced significantly with the implementation of the project. Many of these improvements result in reduction of PM emissions from pellet handling as well as the additional grain products. The dispersion modelling assessment shows that with these emission controls PM emissions from the facility are predicted to comply with AAQOs.

Given the predicted reductions in PM emissions from the implementation of the expansion, it would be expected that air quality surrounding the Fibreco Terminal will improve with the installation of the additional emission controls associated with the expansion.

Appendix A

ESTIMATION METHODOLOGIES

TABLE OF CONTENTS

TABLES

A ESTIMATION METHODOLOGIES

The following sections detail the emissions quantification methods used and the assumptions applied for each primary emissions source category for the baseline and future project scenarios. Primary sources consist of facility processes, including material handling and product loading/unloading operations, non-road vehicles and equipment, electricity use as well as marine vessel and rail activities within the facility boundary.

A.1 FACILITY SOURCES

Emissions are released from a variety of facility sources which are shown in Table A-1 for the 2015 baseline and the future project year of 2020, respectively. Although wood chips are currently handled by the facility, the shipment of this product will be phased out and replaced by grains in 2020.

Table A-1 Summary of Facility Emission Sources

YEAR	EMISSION CATEGORY	SOURCE	SOURCE DESCRIPTION
Baseline 2015	Fugitive Emissions	Wood Chips	Barge Receiving
			Barge Receiving Transfer Points
			Rail Receiving
			Rail Receiving Transfer Points
			Receiving Slingers
			Stockpiles
			Ship Loading Transfer Points
			Ship Loading
			Barge Loading Transfer Points
			Barge Loading
		Wood Pellets	Rail Receiving
			Rail Receiving Transfer Points
			Ship Loading Transfer Points
			Ship Loading
	Combustion Emissions	Rail	Unit Trains
		Marine	Tugs
			Handymax Main Engines
			Handymax Auxiliary Engines
			Handymax Boilers
			Panamax Main Engines

YEAR	EMISSION CATEGORY	SOURCE	SOURCE DESCRIPTION
			Panamax Auxiliary Engines
			Panamax Boilers
		Non-road Equipment	Bulldozers
			Front-End Loaders/Mobile Railcar Movers
		Electricity	Electricity Consumption
Future Year 2020	Fugitive Emissions	Wood Pellets	Same as Baseline Sources
		Grains	Rail Receiving
			Rail Receiving Transfer Points
			Ship Loading Transfer Points
			Ship Loading
	Combustion Emissions	Rail	Same as Baseline Sources
		Marine	Same as Baseline Sources
		Non-road Equipment	Same as Baseline Sources
		Electricity	Same as Baseline Sources

Details on the emissions quantification methodologies used for each of the source types listed in Table A-1 are presented in the following sections.

A.2 MATERIAL HANDLING AND TRANSFERS

As shown in Table A-1, there are a variety of material handling and transfer points within the facility where products are being received, transferred and loaded. These include rail and barge receiving, marine vessels loading and their respective transfer points. Wood chip storage piles also contribute to fugitive dust releases.

The fugitive dust released from these sources were estimated based on the following general equation:

$$E_i = EF_i * Activity * (1 - CE)$$

where:

E_i = Emissions of pollutant i

EF_i = Emission factor for pollutant i

Activity = Quantity of materials handled/processed

CE = Control equipment efficiency (fraction)

The activity data associated with the 2015 base case and future 2020 Project scenario has been presented in the Main Report while the emission factors for wood chip and grain transfers and handling are shown in Table A-2. These factors were primarily taken from the US EPA AP-42, Chapter 9.9.1 – Grain Elevators and Processes[1] and Chapter 11.9.2 – Crushed Stone Processing & Pulverized Mineral Processing[2]. Since particulate emission factors for pellet handling are not available from AP-42, these were estimated by applying adjustment ratios to published emission factors for other products. These emission factor adjustment ratios are shown in Table A-3.

Table A-2 Material Handling Particulate Emission Factors for Baseline and Future Years

ACTIVITY	TPM KG/MG	PM_{10} KG/MG	$PM_{2.5}$ KG/MG	REFERENCE
Receiving - Barge	0.0015	0.00055	0.00014	AP-42 Chapter 11.19.2
Receiving - Rail	0.016	0.0039	0.00065	AP-42 Chapter 9.9.1
Receiving - Slingers	0.008	0.002	0.00275	AP-42 Chapter 11.19.2
Loading – Ships*	0.024	0.006	0.0011	AP-42 Chapter 9.9.1
Loading - Barge	0.008	0.002	0.00275	AP-42 Chapter 9.9.1
Stockpiles - Chips	0.009	0.0077	0.0012	WGA 2006 Section 9.3
Material Transfer Points	0.0015	0.00055	0.00014	AP-42 Chapter 11.19.2

* *The emission factors shown reflect the use of telescopic chute.*

Table A-3 Particulate Emission Factor Adjustment Ratios for Product Handling

ADJUSTMENT DESCRIPTION	RATIO	REFERENCE
Wood Chip to Pellet	0.32	Boersma et al (2009)[3]
Wood Pellet to Grain	2.12	Genesis Engineering (2011)[4]
Wood Chip to Grain	0.68	Combining the two factors listed above

At the Fibreco facility, control equipment and/or dust emission abatement measures have been put in place to minimize dust releases. The range of measures and their associated control efficiencies[5] are shown in Table A-3. Published control equipment efficiencies, as shown in Table A-4, were adopted to estimate emissions from respective controlled sources.

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[1] US EPA, 2003, "Grain Elevators and Processes", Chapter 9.9.1, AP-42 Manual, May.
[2] US EPA, 2004, "Crushed Stone Processing and Pulverized Mineral Processing", Chapter 11.19.2, AP-42 Manual, August.
[3] Boersma, A.R. et al, 2009, "Air Pollutant Emissions from Stationary Installations Using Bioenergy in the Netherlands, BOLK Phase 2", ECN-E-09-067, November.
[4] Genesis Engineering Inc., 2011, "Wood Pellet Theoretical Assessment for Fibreco", Prepared for the BC Maritime Employers Association, September 6.
[5] Air Pollution Engineering Manual, 2000, Air & Waste Management Association, Second Edition.

Table A-4 Efficiencies of Control Equipment and Measures

EQUIPMENT/MEASURE	CONTROL EFFICIENCY (%)
Enclosure	70
Enclosure & Water Suppression	85
Fabric Filter	99
Telescopic Chute & Water Suppression	88
Wind Guard	50

A.3 ELECTRICITY USE

Fibreco is an end user of electricity purchased from BC Hydro. According to IPCC protocols[6], greenhouse gas (GHG) emissions due to electricity consumption are grouped under scope 2 as indirect GHG emissions. Indirect GHG emissions are a consequence of the activities of the reporting entity (Fibreco), but occur at sources owned or controlled by another entity (BC Hydro).

A CO_2 emission factor for the production of provincial grid electricity has been calculated as an average of BC Hydro's reported GHG intensities for the past three years[7]. This approach is consistent with that reported in the BC's Best Practice Methodology Manual for Quantifying Greenhouse Gas Emissions from the BC Ministry of Environment[8]. A summary of 2015 and 2020 electricity consumption and the CO_2 emission factor applied is shown in Table A-4.

Table A-5 Summary of 2015 and 2020 Electricity Consumption and GHG Emission Factor

	BASELINE (2015)	FORECAST (2020)
Annual Electricity Consumption (MWh)	3.0	3.5
CO_2 Emission Factor* (tCO_2/GWh)	10.667	10.667

** Assumed same factor for CO_2e_{20} and CO_2e_{100}*

A.4 RAIL

Rail emissions at the Fibreco facility arise from the combustion of diesel fuel in locomotive engines on line haul unit trains while at the site. Emissions from on-site mobile railcar movers, which are

6 *IPCC (Intergovernmental Panel on Climate Change), 2006. Guidelines for National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/*

7 *https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/environmental-reports/ghg-intensities-2004-2014.pdf*

8 *BC Ministry of Environment (2014). 2014 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions. Including Guidance for Public Sector Organizations, Local Governments and Community Emissions. Victoria, B.C. November, 2014.*

non-road equipment used for railcar handling within the yard, are discussed separately in Section A.1.1.7.

The general equation below is used to calculate rail engine emissions.

$$E_r = FC * EF_r * C$$

where:

E_r = emissions of a given pollutant from a locomotive engine (t/y)

FC = fuel consumption rate (L/y)

EF_r = fuel-based locomotive emission factors for a given pollutant (g/L fuel)

C = unit conversion factor to tonnes (10^{-6} tonne/g)

Currently, the unit trains arrive at the site delivering wood chips and pellets. This train then remains on-site primarily to spot the railcars onto the Fibreco tracks and to pull the empties before it leaves for nearby Lynn Creek Yard. Hence, its locomotive engines remain running while within the facility. The unit trains serving Fibreco are operated by CN and are typically EMD SD-40 models.

A published average fuel consumption rate of 159.11 L/h (35 gallons/h) for each EMD SD-40 locomotive engine has been provided by the client. This value is subsequently confirmed by another literature source[9] and adopted for this assessment the 2015 baseline and Project future year of 2020. A total of two locomotive engines have been assumed for each unit train, which is consistent with the assumption used in the Port Metro Vancouver Landside Emission Inventory[10].

The total annual locomotive engine fuel consumption is dependent on the amount of time the unit trains spent on-site and the consumption rate given above. The percentage of time during which unit rails are operating within the facility boundary was estimated based on CN spots and pulls records provided by the client for the period of September 2014 to October 2015. During this period, CN trains were active on-site for approximately 327 hours over 363 days, or on average 0.9 h/d [327h / 363 d]. To determine the total annual rail operating time for 2015, this 0.9h/d average was applied to the total facility operating days of 268, which represented the sum of rail receiving days for all products. The average 2020 daily rail activity time of 1.47h, which was prorated from the 2015 estimate based on the ratio of the 2020 daily product throughput to that of 2015, was applied to the 333 days of facility product rail receiving days to arrive at the annual rail operating time.

Published fuel-based emission factors from the Railway Association of Canada's (RAC) Locomotive Emissions Monitoring (LEM) Program 2013[11] were used to estimate CAC and GHG emissions from the unit trains. These factors are shown in Tables A-6 and A-7. Since the diesel sulphur content representative of the 2013 Canadian locomotive fleet was 15 ppm, no adjustments to the SOx and particulate emission factors were required. Black Carbon is a constituent of the $PM_{2.5}$ particulate from rail engine combustion; therefore a ratio of 0.73, as shown in Table A-8, was applied to the $PM_{2.5}$ factor to determine the emission factor for Black Carbon for rail.

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[9] Transport Canada, 2001 "Diesel Fuel Quality and Locomotive Emissions in Canada", Report no. TP 13783E, April.

[10] SNC Lavalin, 2010, "Port Metro Vancouver 2010 Landside Emission Inventory", March.

[11] RAC, "Locomotive Emissions Monitoring Program 2013".

Table A-6 CAC Emission Factors for Locomotives (g/L)

SOURCE	CO	NO_X	SO_X	VOCS	TPM	PM_{10}	$PM_{2.5}$	DPM	NH_3
Train	7.05	44.41	0.02	2	1.01	1.01	0.98	0.98	0.3

Table A-7 GHG and Black Carbon Emission Factors for Locomotives (g/L)

SOURCE	CO_2	CH_4	N_2O	BLACK CARBON	CO_2E_{20}	CO_2E_{100}
Train	2,690	0.15	0.1	0.72	5,307.3	3,665.2

Table A-8 Black Carbon to $PM_{2.5}$ Ratios

COMBUSTION SOURCE CATEGORY	BLACK CARBON/$PM_{2.5}$ RATIO
On-road Diesel	0.74
Non-road Diesel	0.77
Non-road Liquefied Petroleum Gas[a]	0.1
Locomotive	0.73
Commercial Marine (C1 & C2 categories)	0.77
Commercial Marine (C3 category)	0.03
Natural Gas Combustion	0.38
Distillate Oil Combustion[b]	0.1

[a] *Combustion source category was approximated from the Nonroad Gasoline Category*

[b] *Ship boiler emissions used the Distillate Oil Combustion source category, which are based off fuels with a lower sulphur fuel percentage than marine distillate oil*

A.5 MARINE VESSELS

There are several types of marine vessels which are engaged in routine Fibreco product shipment operations, namely the ocean-going Handymax and Panamax vessels as well as barges and tug boats. Tug boats are used to maneuver the ships into the Fibreco berths.

OCEAN GOING VESSELS

Ship emissions were calculated following the methodology used to calculate the 2010 National Marine Emissions Inventory for Canada[12], where ship emissions are divided into three categories: anchoring, berthing, and underway. Anchoring activities occur when a ship is stationary not at an identifiable berth, berthing activity occurs when the ship is at berth, and underway activity include all movements of the ship. For the purposes of this assessment, anchoring and underway emissions were considered supply chain emissions and discussed in Section A.7.2 as these releases do not occur within the facility boundaries. Only berthing emissions were considered as facility boundary releases, which occur as the ship is docked at the berth and are defined as any emissions released while the ship is sitting idle at the berth at the facility and also during times when the ship is undergoing warping along the berth for loading. The methodology for estimating berthing emissions is discussed below.

There are three main sources that contribute to the ship's overall emissions: the main engines, the auxiliary engines, and the ship's boiler. The following general equation is used to calculate the emissions released by ships.

$$E = ME * LLF * LF * T * EF_{act} + AE * LF * T * EF_{act} + BO * T * EF_{fuel} * M_{adj}$$

where:

E	=	Emissions (grams)
ME	=	Main engine capacity (maximum continuous rating or MCR) in kW
AE	=	Auxiliary engine capacity in kW
LF	=	Engine load factor (fraction)
LLF	=	Engine low load adjustment factor
EF_{act}	=	Emission factor – activity based factors in g/kW-hr
EF_{fuel}	=	Emission factor – fuel based factors in kg/tonne fuel
BO	=	Boiler fuel consumption in tonnes/hr
T	=	Time (hours)
M_{adj}	=	Conversion factor from kg to grams

The activity data used to calculate the Handymax and Panamax ship emissions are summarized in Table A-9 and A-10. Engine capacities, vessel calls and operating hours of various engine modes were estimated based on facility information provided by Fibreco. The load factors and boiler fuel consumption are based on factors used in the *Canadian 2010 National Marine Emissions Inventory*[12]. Tier 1 ships were assumed as a conservative measure.

[12] *SNC-Lavalin Environment (2012), 2010 National Marine Emissions Inventory for Canada. Prepared for: Environment Canada. March 31, 2012.*

Table A-9 Handymax Ship Activity Data and Load Factors

SHIP ENGINE PARAMETERS	2015 BASELINE			2020 FUTURE		
	MAIN ENGINE	AUXILLIARY ENGINE	BOILER	MAIN ENGINE	AUXILLIARY ENGINE	BOILER
Engine Capacity	8,342	1,727	---	8,342	1,727	---
Warping Hours per Vessel Call	3.25	---	---	3.25	---	---
Annual Operating Hours	202	5,154	5,154	163	3,884	3,884
Max Fuel S (%)	0.1	0.1	0.1	0.1	0.1	0.1
Load Factor	0.1	0.29	---	0.1	0.29	---
Boiler Fuel Use (t/h)	---	---	0.08	---	---	0.08

Table A-10 Panamax Ship Activity Data and Load Factors

SHIP ENGINE PARAMETERS	2020 FUTURE		
	MAIN ENGINE	AUXILLIARY ENGINE	BOILER
Engine Capacity	8,928	1,777	---
Warping Hours per Vessel Call	7.25	---	---
Annual Operating Hours	99	1,321	1,321
Max Fuel S (%)	0.1	0.1	0.1
Load Factor	0.1	0.29	---
Boiler Fuel Use (t/h)	---	---	0.08

The emission factors used to estimate emissions for the base and future years are tabulated in Table A-11 and these are based on the Marine Inventory report referenced above[12] for marine engines using marine distillate oil. SO_x, and PM emission factors are calculated based on the maximum allowable fuel sulphur percentage of 0.1% in an Emissions Controlled Area (ECA)[13] and according to the equations shown in Table A-12. For the purposes of this assessment, all SO_x from ship exhaust is assumed to be released in the form of SO_2. The NO_x emission factor was calculated based on limits[14] established by the International Maritime Organization for Tier 1 vessels. Low Load Adjustment Factors from the *Canadian 2010 National Marine Emissions Inventory*[4] ,as shown in Table A-13, were used for the main engines during warping operations while at berth and were applied to the emission factors published in the Canadian 2010 National Marine Emissions Inventory report.

As a conservative measure and for lack of more precise data, we assumed that the ships operating in 2020 may still be of similar manufacture date as the ships calling in 2015. Estimation for Black Carbon emissions was based on the Black Carbon to $PM_{2.5}$ ratios provided previously in Table A-8.

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[13] *International Maritime Association (IMO, 2015a). Sulphur oxides (SOx) – Regulation 14. Accessed from: http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-%28SOx%29-%E2%80%93-Regulation-14.aspx.*

[14] *International Maritime Association (IMO, 2015b). Nitrogen oxides (NOx) – Regulation 13. Accessed from: http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-%28NOx%29-%E2%80%93-Regulation-13.aspx.*

Table A-11 Ship Emission Factors for 2015 Baseline and 2020 Future Years

POLLUTANT	MAIN ENGINES G/KW-HR 2-STROKE[c]	AUXILIARY ENGINES G/KW-HR 4-STROKE	BOILER EFFUEL KG/TONNE FUEL
CO	2.2	1.1	4.6
NOx[a]	19.8	11.30	12.3
SOx[b]	0.42	0.42	2
VOCs	1.6980	0.4	0.38
TPM	0.4092	0.30	0.5270
PM_{10}	0.3928	0.28	0.5059
$PM_{2.5}$	0.3614	0.26	0.4654
NH_3	0.02	0.0010	0.006
DPM	0.3614	0.26	0.4654
Black Carbon	0.0108	0.20	0.0465
CO_2	588	670	3,188
CH_4	0.06	0.06	0.29
N_2O	0.017	0.017	0.081
CO_2e_{20}	632	1,325	3,381
CO_2e_{100}	604	858	3,261

[a] *n=164 rpm for main engine and n=1,000 rpm for auxiliary engine*

[b] *S=0.1% for ECA area*

[c] *ow load scale factors incorporated*

Table A-12 SOx and PM Emission Factor Equations

SOURCE	ENGINE EF (G/KWH) OR BOILER EF (KG/TONNE)			PARTICULATE FRACTIONS	
	NOx[a]	SOx[b]	TPM[b]	PM_{10}/TPM Ratio	$PM_{2.5}/PM_{10}$ Ratio
Main Engines	45*n^(-0.2)	4.2(S)	0.4653(S) + 0.25	0.96	0.92
Auxiliary Engines	45*n^(-0.2)	4.2(S)	0.4653(S) + 0.25	0.96	0.92
Boilers	12.3	20.0(S)	1.17(S) + 0.41	0.96	0.92

[a] *n is the Engine rpm, where n is from 130 – 2000 for Tier 1*

[b] *S is the Sulphur content of fuel in %*

Table A-13 Main Engine Low Load Scale Factors

POLLUTANT	LOW LOAD AJUSTMENT FACTOR
CO	2.00
NOx	1.22
SOx	1.00
VOCs	2.83
TPM	1.38
PM_{10}	1.38
$PM_{2.5}$	1.38
DPM	1.38
NH_3	1.00
CO_2	1.00
CH_4	1.00
N_2O	1.00
CO_2e	1.00

TUG BOATS

Tugs are used to assist barges and ships in docking at the Fibreco berth and to assist them in departing from the facility once product loading is complete. The engine power rating, counts and operational hours are based on information provided by Fibreco. Tug engine characteristics and activity data, by vessel type, are shown in Table A-14.

Table A-14 Tug Activity Data by Vessel Type for the 2015 Baseline and 2020 Future Years

TUG ENGINE PARAMETER	2015 BASELINE VESSELS			2020 FUTURE VESSELS		
	BARGE	HANDYMAX	PANAMAX	BARGE	HANDYMAX	PANAMAX
Engine Size (kW)	1,065	1,065	1,065	1,065	1,065	1,065
Port Calls	52	62	---	---	50	14
Tugs/Vessel Movement	1	2	---	---	2	2
Operating Time/Vessel Movement (h)	1	1	---	---	1	1
Load Factor	0.79	0.79	---	---	0.79	0.79

The CAC and GHG emissions were estimated based on the following equation for diesel fuel-fired engines for harbour tug boats.

$$E_m = EC * LF * EF_m / T_{adj}$$

where:

- E_m = Emission rate of a given pollutant from a tug boat engine (g/s)
- EC = Engine capacity (kW)
- LF = Engine load factor (fraction)
- EF_m = Activity-based emission factors for a given pollutant (g/kWh)
- T_{adj} = Conversion factor (seconds/h)

Tug combustion emission factors from the Environment Canada (EC) Canadian 2010 National Marine Emissions Inventory were adopted for this study and are shown in Table A-15. For SO_2 and PM, their respective emission factor equations and particulate size distribution for auxiliary engines are shown in Table A-12. For the purposes of this assessment, all SOx from tug exhaust is assumed to be released in the form of SO_2. A fuel sulphur content of 15 ppmw (mg/kg) was used in the corresponding emission factor calculations according to the level stipulated in the Regulations

Amending the Sulphur in Diesel Fuel Regulations[15] (2012) for diesel fuel produced, imported or sold for use in vessel engines after May 31, 2014. Black Carbon emissions were calculated using the ratio given in Table A-8 while GHG emission factors followed those from the previously referenced Canadian 2010 Marine Emissions Inventory.

Table A-15 Tug Emission Factors for 2015 Baseline and 2020 Future Years

POLLUTANT	EMISSION FACTOR (G/KW-H)
CO	1.6
NOx[a]	10
SOx[b]	0.0063
VOCs	0.27
TPM	0.35
PM_{10}	0.34
$PM_{2.5}$	0.33
NH_3	0.001
DPM	0.33
Black Carbon	0.25
CO_2	670
CH_4	0.06
N_2O	0.017
CO_2e_{20}	1,482
CO_2e_{100}	902

A.6 NON-ROAD EQUIPMENT

Non-road emission sources include vehicles or pieces of equipment that operate exclusively within the site and are not licensed to travel on public roads. Diesel-fired non-road equipment at the Fibreco facility consists of two 636 HP bulldozers, one 393 HP front-end loader operating in the pellet shed and two 393 HP railcar movers. For the bulldozers, these would be eliminated in 2020 since no more chips will be handled at the facility.

[15] *Canada Gazette (2012), Regulations Amending the Sulphur in Diesel Fuel Regulations, June 20, 2012. (www.gazette.gc.ca/rp-pr/p2/2012/2012-07-04/html/sor-dors135-eng.html)*

The equipment type, age, horsepower ratings, and equipment operating hours were estimated based on facility information provided by Fibreco. Emissions for these equipment were estimated based on the following:

$$E_i = EF_i * HP * LF * H * TM * C$$

where:

E_i	=	Emissions of a given pollutant (t/y)
EF_i	=	EPA NONROAD Model emission factor for a given pollutant i and for a specific non-road equipment category (g/HP-hr)
HP	=	Equipment horsepower rating (HP)
LF	=	Engine loading factor (fraction)
H	=	Equipment operating hours (h/y)
TM	=	Total equipment count
C	=	Unit conversion factor to tonnes (10^{-6} tonne/g)

Table A-16 to A-18 show the engine characteristics and NONROAD model emission factors applied for each non-road equipment type operating at Fibreco for the 2015 base case and the 2020 future year. For diesel fuel combustion, the PM_{10} emission factor has been assumed to be the same as the TPM factor while the $PM_{2.5}$ emission factor has been approximated to be 97% of the PM_{10} factor. For diesel particulate, its emission factor was assumed to be the same as the factor for $PM_{2.5}$. Black Carbon is a constituent of the $PM_{2.5}$ particulate from diesel engine combustion; therefore a ratio of 0.77 was applied to the $PM_{2.5}$ factor to determine its emission factor, as shown in Table A-8. For GHG emission factors, these were based on a recent US EPA publication[16].

Table A-16 Bulldozer Engine Characteristics and Associated NONROAD Model Emission Factors

HEADING	2015 BASELINE
Engine HP Rating	636
Age/Model Year	2002
No. of Units	2
Fuel Type	Diesel
Annual Hours of Operation (each unit)	1,300
Load Factor	0.59

[16] *US EPA, 2010,"Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling – Compression-Ignition", Assessment and Standards Division, Office of Transportation and Air Quality, July.*

HEADING	2015 BASELINE
Emission Factors (g/HP-h):	
CO	2.2350
NOx	4.7837
SO_2	0.0049
VOCs	0.1744
TPM	0.2688
PM_{10}	0.2688
$PM_{2.5}$	0.2607
NH_3	na
DPM	0.2607
Black Carbon	0.2008
CO_2	536
CH_4	0.0027
N_2O	na
CO_2e_{20}	1,179
CO_2e_{100}	717

na= not available

Table A-17 Railcar Mover Engine Characteristics and Associated NONROAD Model Emission Factors

HEADING	2015 BASELINE	2020 FUTURE YEAR
Engine HP Rating	393	393
Age/Model Year	2012	2012
No. of Units	2	2
Fuel Type	Diesel	Diesel
Annual Hours of Operation (each unit)	617	617
Load Factor	0.18	0.18
Emission Factors (g/HP-h):		
CO	0.1350	0.1413
NOx	1.3929	1.3964
SO_2	0.0035	0.0035
VOCs	0.1378	0.1390

HEADING	2015 BASELINE	2020 FUTURE YEAR
TPM	0.0103	0.0117
PM_{10}	0.0103	0.0117
$PM_{2.5}$	0.0100	0.0114
NH_3	na	na
DPM	0.0100	0.0114
Black Carbon	0.0077	0.0087
CO_2	536.4134	536.4098
CH_4	0.0021	0.0021
N_2O	na	na
CO_2e_{20}	561.2214	564.5547
CO_2e_{100}	543.4006	544.3356

na= not available

Table A-18 Front-end Loader Engine Characteristics and Associated NONROAD Model Emission Factors

PARAMETERS	2015 BASELINE	2020 FUTURE YEAR
Engine HP Rating	393	393
Age/Model Year	2012	2012
No. of Units	1	1
Fuel Type	Diesel	Diesel
Annual Hours of Operation (each unit)	619	619
Load Factor	0.60	0.60
Emission Factors (g/HP-h):		
CO	0.1350	0.1413
NOx	1.3929	1.3964
SO_2	0.0035	0.0035
VOCs	0.1378	0.1390
TPM	0.0103	0.0117
PM_{10}	0.0103	0.0117
$PM_{2.5}$	0.0100	0.0114
NH_3	na	na
DPM	0.0100	0.0114
Black Carbon	0.0077	0.0087
CO_2	536.4134	536.4098

PARAMETERS	2015 BASELINE	2020 FUTURE YEAR
CH_4	0.0021	0.0021
N_2O	na	na
CO_2e_{20}	561.2214	564.5547
CO_2e_{100}	543.4006	544.3356

na= not available

A.7 SUPPLY CHAIN

The supply chain consists of rail and marine vessel transportation modes for the shipment and delivery of products to the Fibreco Terminal.

A.7.1 RAIL

Emissions are released from the rail supply chain due to fuel combustion by the locomotive diesel engines when the unit trains travel a distance of approximately 5km between the Fibreco facility and the supply chain boundary at the CN Lynn Creek Yard. The train speed during transit between the two locations has been assumed to be at 9.66 km/h (or 6 mph), as provided by CN for the air quality assessment of a nearby terminal. The one-way transit time of 0.52h for each train was subsequently estimated based on the above travel distance and train speed [5km/9.66km/h].

The same emission factor-based emissions quantification methodology, as described in Section A-4, was followed. The same duty cycle average fuel consumption rate of 159.11L/h (or 35 Imp gal/h) for each of the two EMD SD-40 locomotive engine on each train travelling to and from Lynn Creek Yard have been adopted. By applying this fuel rate to the above 0.52h one-way transit time and after accounting for the two-way travel to and from Lynn Creek Yard per train, the total fuel consumption for each train was obtained [159.11 L/h x 0.52h x 2 movements/train]. To estimate the annual total fuel consumption for trains travelling from Fibreco to and from the supply chain boundary, the annual train count is required. To determine the number of trains for 2015 and 2020, the data provided by Fibreco were utilized and is summarized in Table A-19. The number of trains for each product type was estimated for 2015 and 2020, respectively, by dividing the throughput with the product of railcar counts per train and the railcar capacity [e.g. the 2015 wood chip train counts equal 400,000t/y / (100 x 92) t/train].

Table A-19 Parameters for Estimating Annual Train Traffic

PARAMETERS		2015 BASELINE	2020 FUTURE YEAR
Wood Chips	Throughput (t)	400,000	---
	Railcars/Train	100	---
	Railcar Capacity (t/railcar)	92	---
Wood Pellets	Throughput (t)	1,300,000	1,000,000
	Railcars/Train	45	45
	Railcar Capacity (t/railcar)	92	92

PARAMETERS		2015 BASELINE	2020 FUTURE YEAR
Grains	Throughput (t)	---	2,000,000
	Railcars/Train	---	112
	Railcar Capacity (t/railcar)	---	100

As with on-site unit train emissions estimation presented in Section A-4, the same set of published fuel-based emission factors from the Railway Association of Canada's (RAC) Locomotive Emissions Monitoring (LEM) Program 2013, as shown in Tables A-6 and A-7, were used to estimate CAC and GHG supply chain emissions from unit trains transiting to and from the CN Lynn Creek Yard.

A.7.2 MARINE VESSELS

For marine vessels, the supply chain emissions include the anchoring operations in English Bay, and the underway emissions travelling to and from the mouth of English Bay to the Fibreco Port and are inclusive of releases from the main engines, auxiliary engines, and boilers. The marine vessel supply chain emissions are dependent on the number of ship calls, the time required to travel the 12-km distance between Fibreco and English Bay and anchoring duration.

The number of ship calls for the 2015 baseline and the 2020 future project year has been provided by Fibreco. To determine the underway travel time for the Fibreco vessels, a ratio, based on the total regional marine traffic underway time to berthing time[12], was applied to the total vessel berthing hours provided by Fibreco. The average vessel anchoring time was estimated and provided by PMV[17] for another project.

Based on the above activity information, the same emission factors, as shown in Section A-5, were applied in estimating emissions from the vessel main and auxiliary engines as well as the ship boiler during transit through Burrard Inlet and idling while at anchor in English Bay.

[17] Rigby, Christine, 2014, Private Communication regarding Vessel Anchoring Time, September 25.

Appendix B

DISPERSION MODELLING METHODOLOGY

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FIGURES

B MODELLING METHODOLOGY

B.1 MODEL SELECTION

CALPUFF is a suite of numerical models (CALMET, CALPUFF, and CALPOST) that are used in series to determine the impact of emissions in the vicinity of a source or group of sources. Detailed three-dimensional meteorological fields are produced by the diagnostic computer model CALMET, based on inputs such as: surface, marine and upper air meteorological data, digital land use data and terrain data, and prognostic meteorological data. The three-dimensional fields produced by CALMET are used by CALPUFF, a three-dimensional, multi-species, non-steady-state Gaussian puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport. Finally CALPOST, a statistical processing program, is used to summarize and tabulate the pollutant concentrations calculated by CALPUFF.

B.2 WRF

Three-dimensional prognostic meteorological data from the Weather Research and Forecasting (WRF) Nonhydrostatic Mesoscale Model (NMM) was used as an “initial guess” field for the CALMET model. WRF-NMM prognostic data used for this dispersion modelling analysis was run by Exponent and provided as CALMET-ready for 2012. Exponent ran WRF-NMM in “analysis mode”, using historical data snapshots from the National Centers for Environmental Prediction (NCEP) North American Mesoscale (NAM) Model as initial and boundary conditions. This historical data includes all available observations, such as satellite, radar, balloon borne, surface, and tower observations. WRF-NMM was run with an approximately 145 km by 132 km domain encompassing the CALMET domain with 4 km grid resolution.

B.3 CALMET

CALMET Version 6.4.2 (140912), an updated version of the United States Environmental Protection Agency (US EPA) approved CALMET Version 5.8.4 (130731), was run to calculate meteorological fields for the modelled time period from January 1, 2012 through December 31, 2012.

Three-dimensional prognostic meteorological data from WRF-NMM was used in order to improve the performance of the CALMET model. In addition, meteorological input data was also used from 16 surface stations within the CALMET domain. The meteorological data and CALMET output for this modelling period were assessed following the Quality Assurance and Quality Control (QA/QC) procedures outlined in Section A-2, CALMET Quality Assurance and Control. A description of the CALMET methods and data sets follows.

B.3.1 CALMET MODELLING DOMAIN

The Universal Transverse Mercator (UTM, NAD 83) coordinate system was used for this model application. The CALMET domain is a 40 km by 40 km area, as shown in Figure B-1. The WRF domain incorporated into the CALMET modelling extends well beyond the CALMET domain. The CALMET model was run with a 200 m grid resolution. The modelling domain and grid resolution were chosen to encompass the main topographical features for generating the CALMET three-dimensional diagnostic meteorological fields. In the vertical axis, 11 atmospheric layers were chosen, the height of which are given in Table B-1.

Table B-1 Heights of CALMET Model Layers

VERTICAL LAYER NUMBER	HEIGHT AT TOP OF LAYER (M)
1	20
2	40
3	80
4	160
5	320
6	600
7	1,000
8	1,500
9	2,000
10	3,000
11	4,000

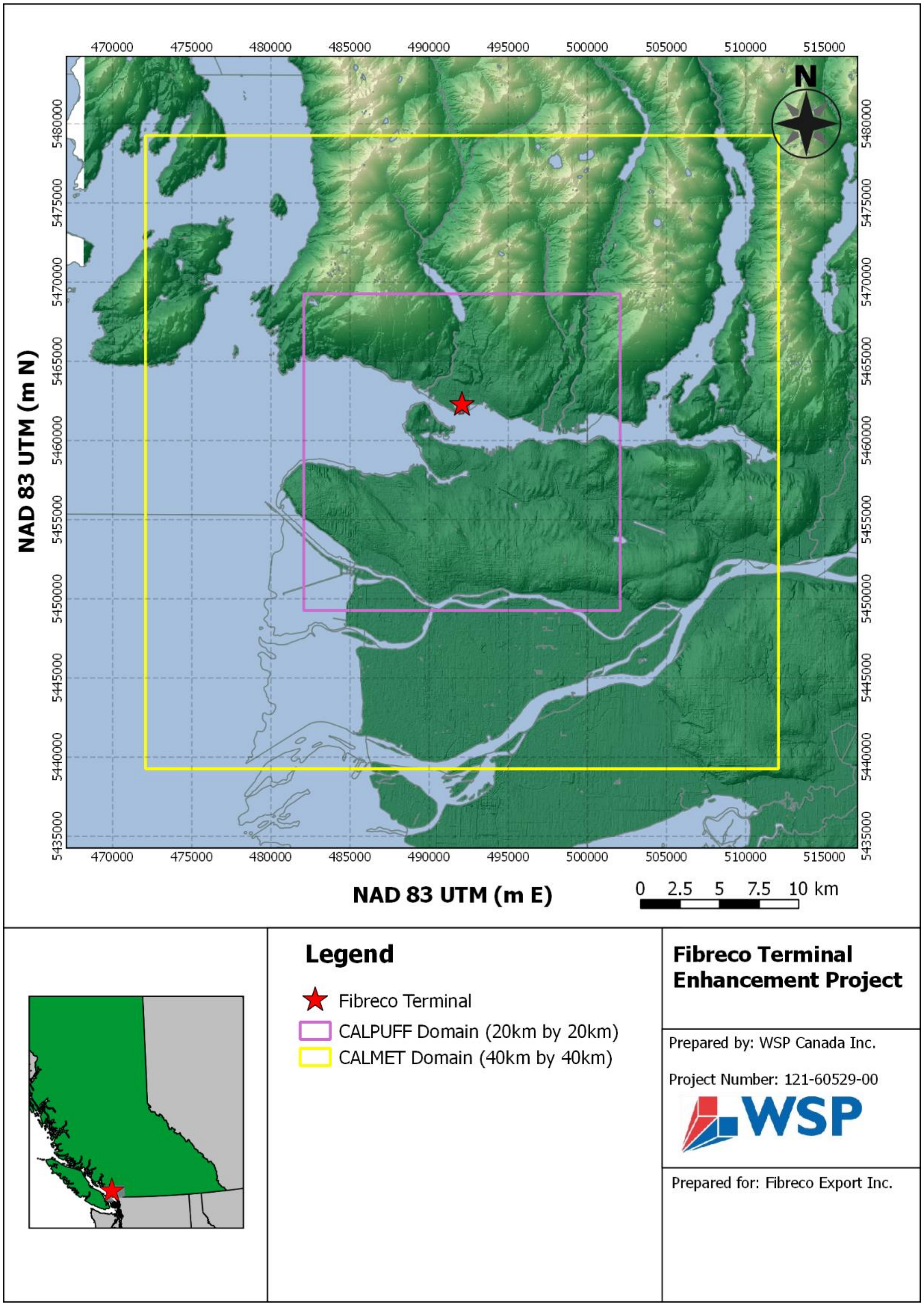


Figure B-1 CALMET and CALPUFF Modelling Domains

B.3.2 TERRAIN ELEVATION AND LAND USE DATA

Digital terrain and land use data covering the model domain was included in the CALMET input data set. Digital terrain files with a 1:50,000 scale were used to generate inputs for each CALMET grid point. Land use characteristics for each grid cell based on LandData BC data sets were used. The BC land use class codes were translated into the land use class codes used by CALMET according to the procedures in the BC Air Quality Modelling Guidelines (AQMG) (BC MOE, 2015). Plots of the digital terrain and land use data used in CALMET are shown in Figure B-2 and Figure B-3 below.

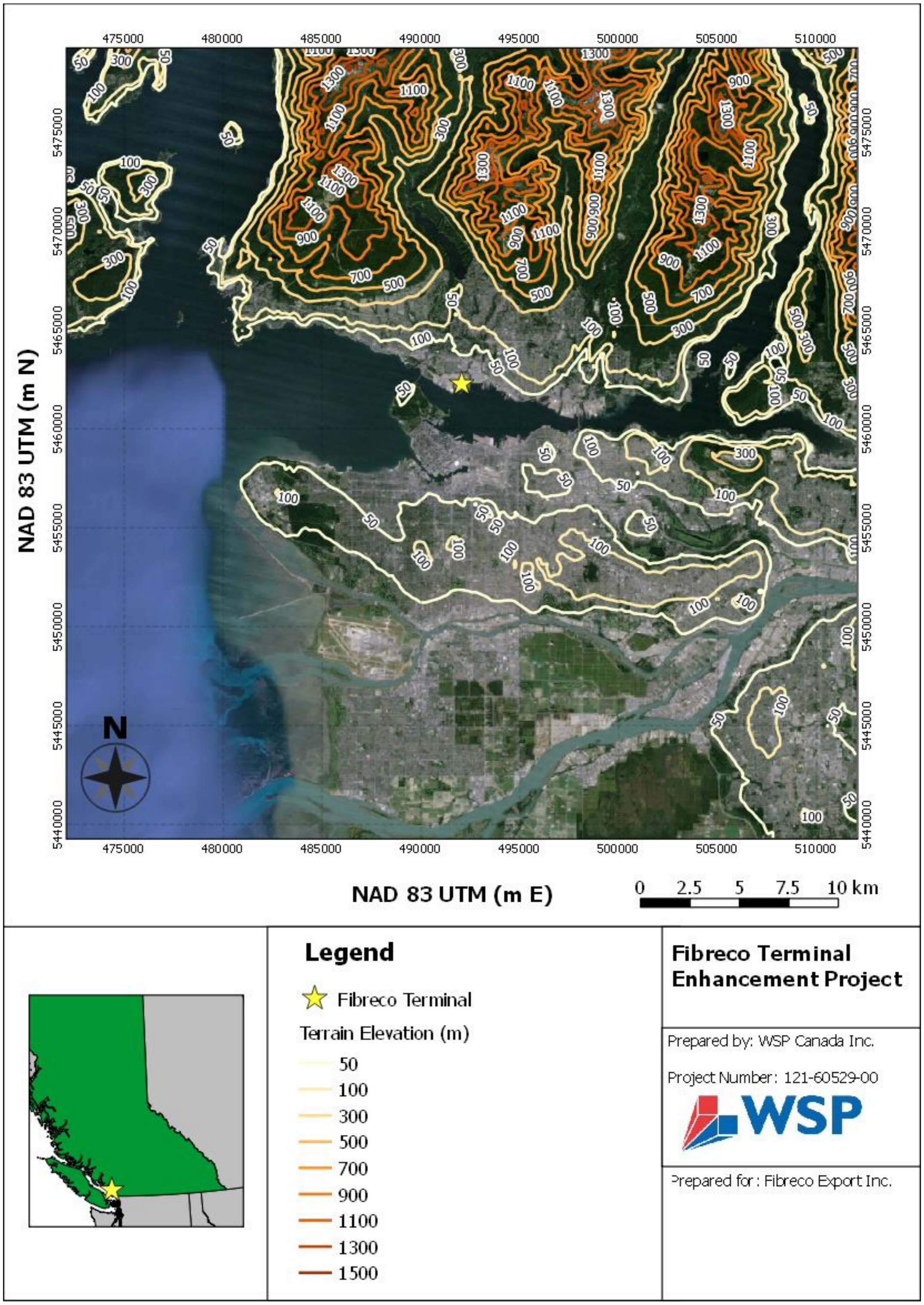


Figure B-2 Terrain Data Used in CALMET

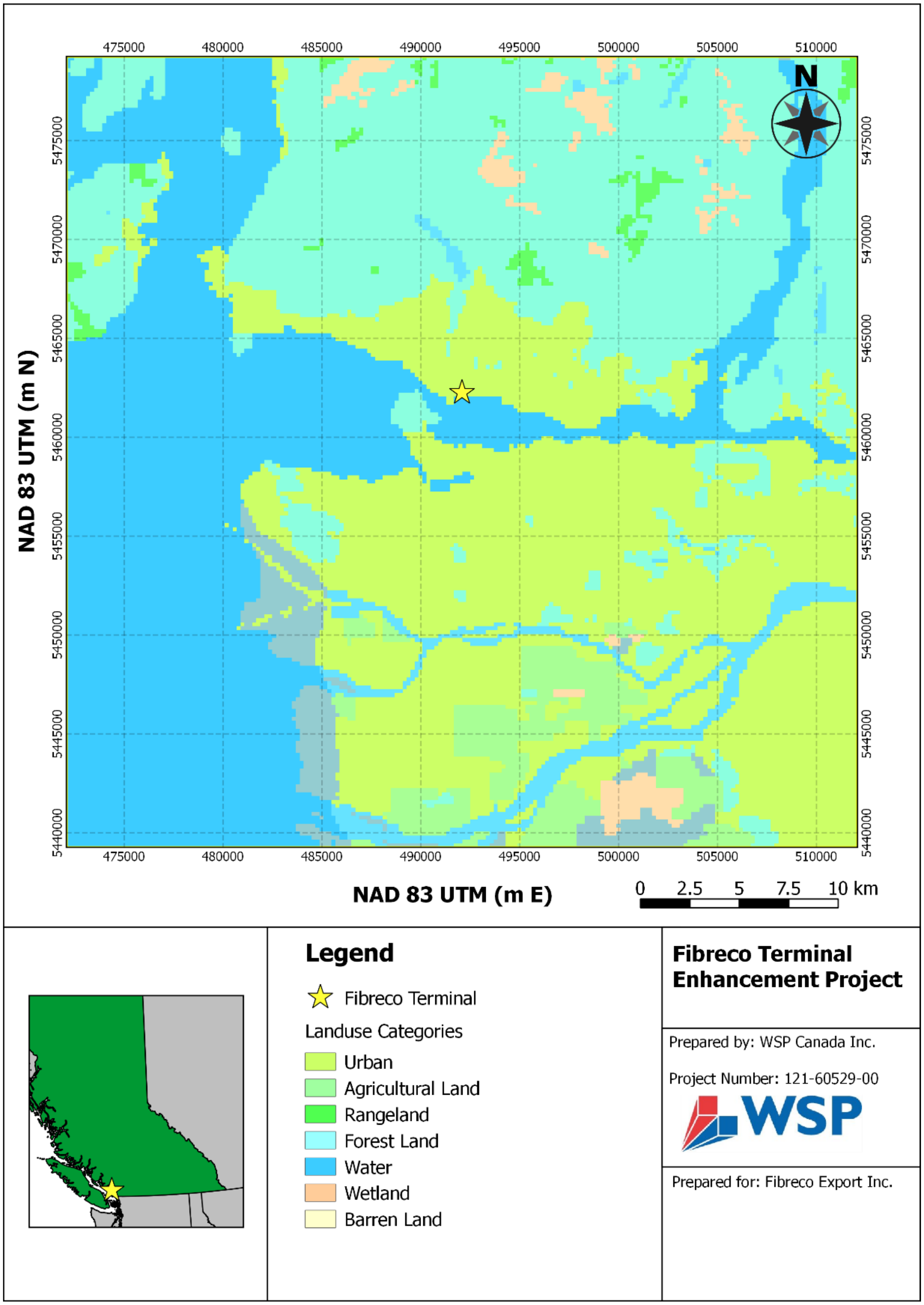


Figure B-3 Land Use Data Used in CALMET

B.3.3 METEOROLOGICAL DATA

Surface meteorological stations that record hourly data include those operated by Environment Canada (EC) and Metro Vancouver. Data from 16 surface stations, listed in Table B-2, were used as input to the CALMET model. Upper air data was not used as the prognostic data contains the necessary upper air information within the CALMET domain and no upper air station are located in or near the CALMET modelling domain.

CALMET requires a measured data value for every hour from at least one meteorological station in order to simulate the three-dimensional fields. Missing data procedures were implemented, when required, as per the AQMG.

As a supplement to the observational data, three-dimensional meteorological fields from the WRF prognostic model were used. The WRF prognostic data was used as input into CALMET as the “initial guess” field. The "initial guess" wind field is calculated by interpolating the winds to the fine CALMET scale and then adjusting them for terrain and land use effects. The wind fields are then adjusted based on the observed meteorological fields from the fourteen surface stations.

Table B-2 Surface Meteorological Stations Used for CALMET Input

SURFACE METEOROLOGICAL STATION	OPERATED BY
T02 Vancouver – Kitsilano	Metro Vancouver
T04 Burnaby -Kensington Park	Metro Vancouver
T06 North Vancouver – Second Narrows	Metro Vancouver
T9 Port Moody	Metro Vancouver
T13 North Delta	Metro Vancouver
T14 Burnaby Mountain	Metro Vancouver
T17 Richmond South	Metro Vancouver
T18 Burnaby South	Metro Vancouver
T22 Burnaby – Burmount	Metro Vancouver
T23 Burnaby - Capitol Hill	Metro Vancouver
T24 Burnaby North	Metro Vancouver
T26 North Vancouver – Mahon Park	Metro Vancouver
T31 Richmond – Airport	Metro Vancouver
T35 Horseshoe Bay	Metro Vancouver

SURFACE METEOROLOGICAL STATION	OPERATED BY
T38 Annacis Island	Metro Vancouver
Vancouver Airport	Environment Canada

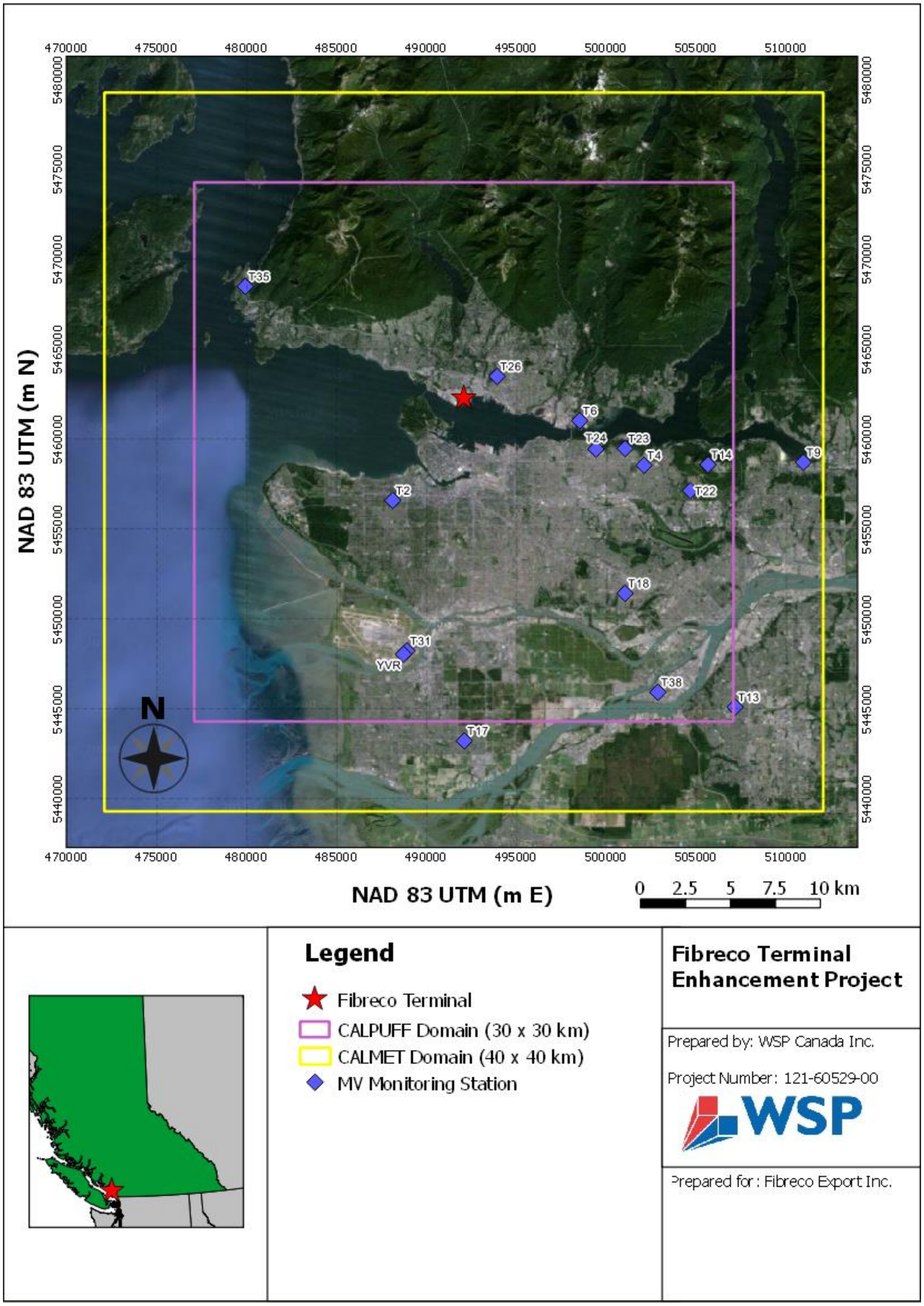


Figure B-4 Surface Meteorological Stations Used in CALMET

B.3.4 CALMET MODEL OPTIONS

The CALMET model has a number of user-specified input switches and options that determine how the model handles terrain effects, interpolation of observational input data, etc. The differences in the modelled and measured meteorological fields were examined, and this analysis was used to determine which model options were appropriate for modelling period.

Table B-3 outlines the CALMET options used in modelling. The 2015 AQMG default parameters were used whenever applicable.

Table B-3 Selected CALMET Model Options

CALMET MODEL OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
Wind field model selection variable	IWFCOD	1 (Yes)	✓
Compute Froude number adjustment effects?	IFRADJ	1 (Yes)	✓
Compute kinematic effects?	IKINE	0 (No)	✓
Use O'Brien procedure for adjustment of the vertical velocity?	IOBR	0 (No)	✓
Compute slope flows?	ISLOPE	1 (Yes)	✓
Extrapolate surface wind observations to upper layers?	IEXTRP	1	x
Extrapolate calm winds aloft?	ICALM	0 (No)	✓
Layer-dependent biases	BIAS	0, 1, 1, 1, 1, 1, 1, 1, 1, 1	No default
Minimum distance between upper air station and surface station for which extrapolation of surface winds will be allowed	RMIN2	-1 (Set to -1 for IEXTRP = +/- 4)	✓
Gridded prognostic wind field model output fields	IPROG	14 (Yes, use wind fields from MM5/3D.dat file as initial guess field)	✓
Use varying radius of influence?	LVARY	F (No, if stations outside RMAX1 are definitely not wanted)	✓
Maximum radius of influence over land of the surface layer	RMAX1	4 km	No default
Maximum radius of influence over land aloft	RMAX2	20 km	No default
Maximum radius of influence over water	RMAX2	50 km	No default
Minimum radius of influence used in the wind field interpolation	RMIN	0.1	✓
Radius of influence of terrain features	TERRAD	10 km	No default
Distance from a surface station at which the station observations and 1st guess field are equally weighted	R1	1.105 km	No default
Distance from an upper air station at which the observations and 1st guess field are equally	R2	5 km	No default

CALMET MODEL OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
weighted			
Relative weighting of the prognostic wind field data	RPROG	0	No default
Maximum acceptable divergence in the divergence minimum procedure.	DIVLIM	$5*10^{-6}$	✓
Maximum number of iterations in the divergence minimum procedure.	NITER	50	✓
Number of passes in the smoothing procedure	NSMTH	2, 4, 4, 4, 4, 4, 4, 4, 4	✓
Maximum number of stations used in each layer for the interpolation of data to a grid point	NINTR2	99	✓
Critical Froude number	CRITFN	1	✓
Empirical factor controlling the influence of kinematic effects	ALPHA	0.1	✓
Multiplicative scaling factor for extrapolation of surface observations to upper layers	FEXTR2	Unused	✓
Number of barriers to interpolation of the wind fields	NBAR	Unused	✓
X and Y coordinates of barriers	XBBAR, YBBAR, XEBAR, YEBAR	Unused	✓
Diagnostic module surface temperature option	IDIOPT1	0 (Compute internally from hourly surface observations or prognostic fields)	✓
Diagnostic module domain-averaged lapse rate option	IDIOPT2	0 (Compute internally from (at least) twice-daily upper air observations or prognostic fields	✓
Diagnostic module upper air station to use for lapse rate to use	IUPT	Unused	✓
Depth through which the domain-scale lapse rate is computed	ZUPT	200	✓
Initial guess field wind components	IDIOPT3	0	✓
Upper air station to use for domain-scale winds	IUPWND	Unused	✓
Bottom and top of layer through which the initial guess winds are computed	ZUPWND	1,1000	✓

B.4 CALPUFF

CALPUFF Version 7.2.1 (Level 150618), an updated version of the US EPA approved CALPUFF Version 5.8.5 (Level 151214), was run for the modelled time period from January 1, 2012 through December 31, 2012. The CALPUFF model was used to simulate dispersion of emissions from the various permitted emission sources at Fibreco, based on the meteorological wind fields developed by CALMET.

B.4.1 CALPUFF MODEL OPTIONS

Table B-4 outlines dispersion options used in the CALPUFF modelling. Unless otherwise stated in Table B-4, the applicable default regulatory options recommended in the 2015 AQMG were used as those were the regulatory options in effect at the time the modelling plan was developed.

Table B-4 Selected CALPUFF Model Options

OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
Vertical distribution used in the near field	MGAUSS	1 (Gaussian)	✓
Terrain adjustment method	MCTADJ	3 (Partial plume path adjustment)	✓
Subgrid-Scale complex terrain flag	MCTSG	0 (Not Modelled)	✓
Near-field puffs modelled as elongated?	MSLUG	0 (No)	✓
Transitional Plume Rise modelled?	MTRANS	1 (Yes)	✓
Method used to simulate building downwash?	MBDW	2 (Prime)	✓
Stack-tip downwash?	MTIP	1 (Yes)	✓
Vertical wind shear modelled above stack top?	MSHEAR	0 (No)	✓
Puff splitting allowed?	MSPLIT	0 (No)	✓
Chemical Transformation Scheme?	MCHEM	0 (Not Modelled)	
Aqueous phase transformation flag (only used in MCHEM =1 or 3)	MAQCHEM	Unused	✓
Wet removal modelled?	MWET	0 (No)	✓
Dry deposition modelled?	MDRY	0 (No)	✓
Method used to compute dispersion coefficients	MDISP	2 (Dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological	✓

OPTION	PARAMETER	OPTION SELECTED	AQMG DEFAULT
		variables (u*, w*, L, etc.)	
Sigma measurements used?	MTURBVW	Unused	✓
Back-up method used to compute dispersion when measured turbulence data are missing	MDISP2	Unused	✓
PG sigma y,z adjusted for roughness	MROUGH	0 (Yes)	✓
Partial plume penetration of elevated inversion?	MPARTL	1 (Yes)	✓
Strength of temperature inversion provided in PROFILE.DAT extended records?	MTINV	0 (No)	✓
Probability Distribution Function used for dispersion under convective conditions?	MPDF	1 (Yes)	✓
Sub-grid TIBL module used for shore line?	MSGTIBL	Unused	✓
Boundary conditions (concentration) modelled?	MBCON	0 (No)	✓
Configure for FOG Model output?	MFOG	0 (No)	✓
Test options specified to see if they conform to regulatory values?	MREG	0 (No)	✓

B.4.2 MODEL DOMAIN AND RECEPTORS

A 20 km x 20 km subset of the CALMET domain was used for the CALPUFF modelling (Figure B-5).

Receptor grid spacing (Figure 6-2) was agreed in the modelling plan to follow the BC Ministry of Environment's Guidelines for Air Quality Dispersion Modelling in British Columbia as follows:

- 20 m receptor spacing along the facility boundary
- 50 m spacing within 500 m of the facility boundary
- 250 m spacing within 2 km of the facility boundary
- 500 m spacing within 5 km of the facility boundary
- 1000 m spacing beyond 5 km of the facility boundary

All receptors were located at breathing (smelling) height (1.5 meter above the ground).

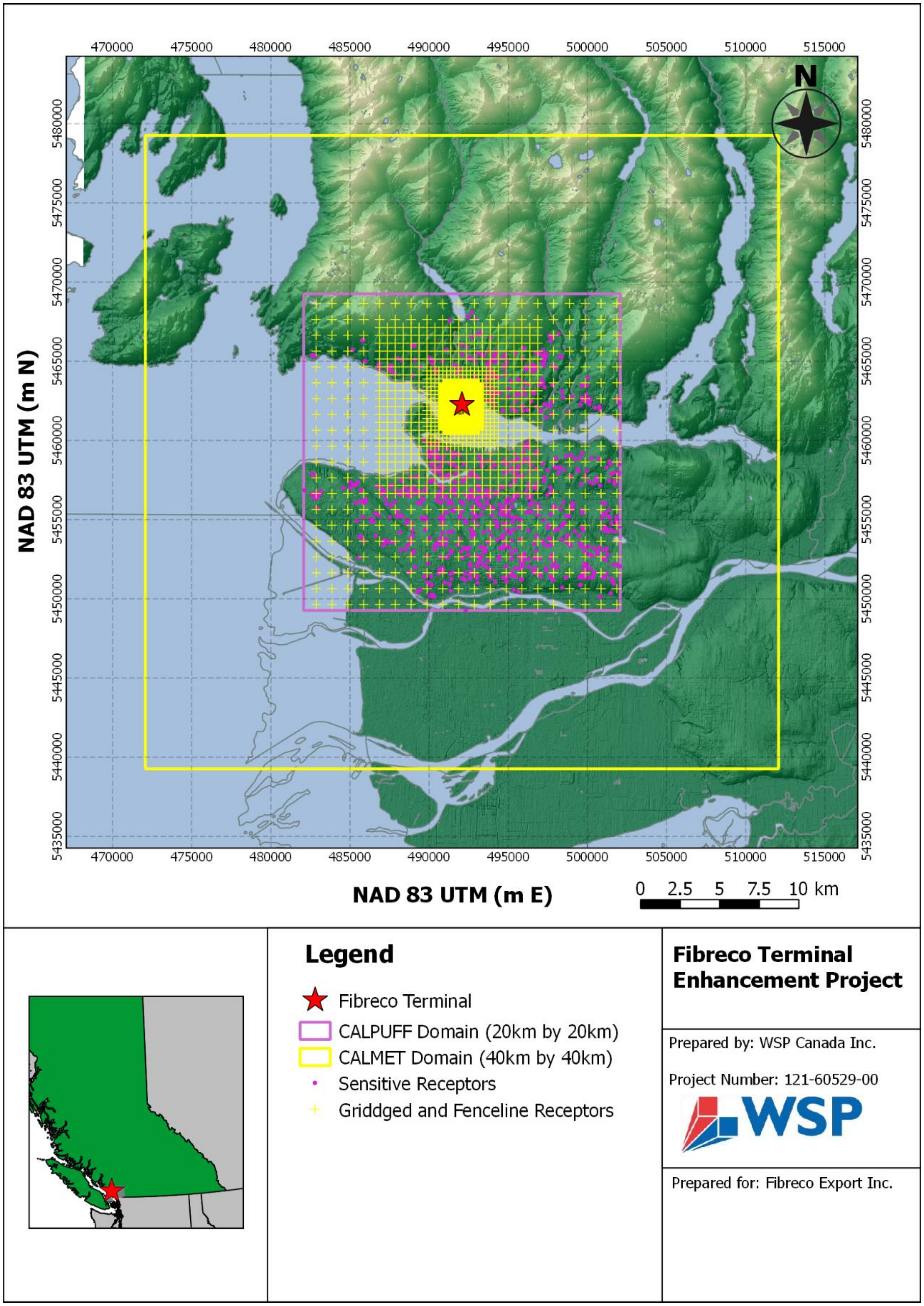


Figure B-5 CALPUFF Receptor Grid – Gridded and Sensitive Receptors

Figure B-6 CALPUFF Receptor Grid – Fenceline, Gridded and Sensitive Receptors

B.4.3 BUILDING DOWNWASH

Buildings or other solid structures, such as ships at berth, may impact air pollution plume flows in the vicinity of a source due to the formation of turbulent eddies on the downwind side of the building. On the downwind side of a structure, a recirculating cavity of air forms and it does not mix with other air efficiently. This cavity has the potential to reduce plume rise and impact dispersion. The flow that is affected by the obstruction is known as the “wake”.

The CALPUFF model accounts for building downwash with enhanced plume dispersion coefficients due to the turbulent wake and reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment on the wake. Building downwash was considered in this assessment using the US EPA Building Profile Input Program (BPIP-PRIME).

B.4.4 NO TO NO_2 CONVERSION

AAQOs refer to NO_2 (not NO_x), and the CALPUFF model as applied does not account for NO_x to NO_2 conversion. In accordance with the preferred conversion method in the AQMG, if 100% NO_x conversion leads to exceedances of the AAQO, the Ambient Ratio Method (ARM) should be implemented to convert predicted NO_x concentrations into NO_2 concentrations. The AR method utilizes representative hourly NO_x and NO_2 monitoring data to characterize the NO_2/NO_x ratio given the ambient NO_x concentration. The method then applies this ratio to the model predicted NO_x concentrations with the NO_x background included.

Ambient air quality data from Metro Vancouver station T6 (Second Narrows) was used to calculate the ratio of NO_2/NO_x. For the 1-hour averaging period, an exponential equation of the form $y = ax^b$ was fit to the upper envelope of observed NO_2/NO_x versus NO_x, where *a* and *b* are empirically determined constants. The resulting equation was used to determine the ratio of NO_2/NO_x for NO_x values where the corresponding NO_2/NO_x ratio is less than 1. To account for the background NO_2 concentrations, a background NO_x concentration was added to the model predicted NO_x concentrations before applying the AR method. For cases where the NO_2/NO_x ratio is less than 1, a 100% conversion from NO_x to NO_2 is assumed. Figure B-7 illustrates the dependence of NO_2/NO_x ratio on ambient NO_x air quality.

The ARM method was not developed for the annual averaging period due to the limited number of data points (years) available to develop a relationship. An alternative method considered was the Ozone Limiting Method (OLM), however the annual concentrations are too low for the OLM method to reduce the concentrations, thus 100% conversion was applied (i.e. all NO_x is assumed to be NO_2).

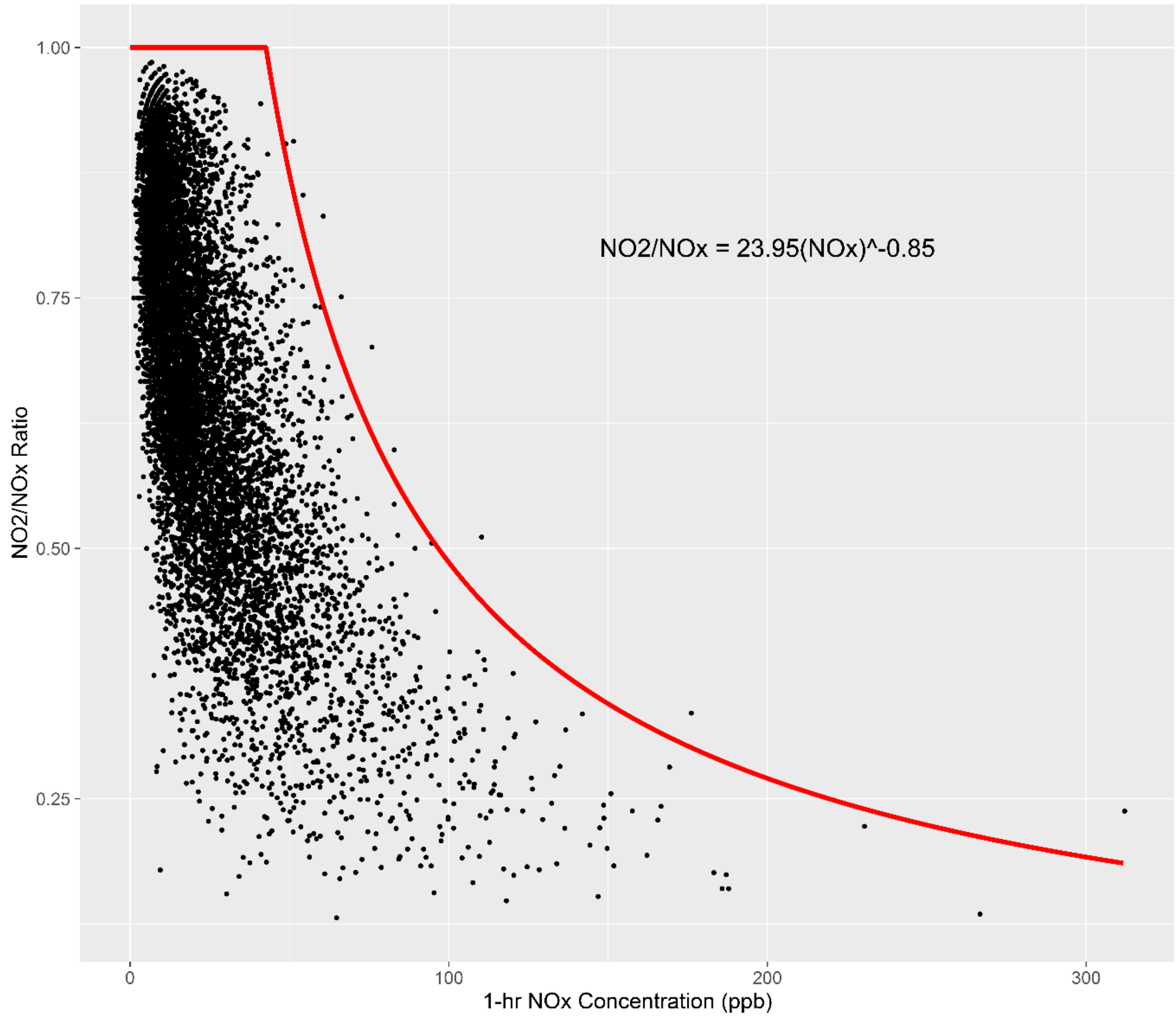


Figure B-7 NO_2/NO_x Ratio versus 1-hour Average NO_x Observations from Metro Vancouver Station T6 (Second Narrows)

B.4.5 CALPUFF SOURCE CONFIGURATION PARAMETERS

This section details the modelling parameters and emission rates used for the point, area and volume sources.

B.4.5.1 POINT SOURCES

Table B-5 Point Source Parameters and Modelled Emission Rates (Basecase)

Parameter		Metric	Transfer Tower #15 DC	Transfer Tower #18 DC	Transfer Tower #19 DC	Baghouse #2	Pellet Shed Baghouse	Rail + Nonroad Sources (8)	Tugs	Marine
Stack Orientation			H	V	V	V	V	V	V	V
Stack Location (UTM NAD 83)		(mE)	491988	492108	492106	492127	492109	Equidistant in Yard Area	492027	491899
		(mN)	5461745	5462257	5462403	5462306	5462273		5461717	5461694
Base Elevation		(m)	13	11	11.5	11	11.5	8.1	0	0
Stack Height		(m)	16.5	16.5	16.5	3.0	4.6	4.5	6	30.5
Stack Diameter		(m)	0.4	0.4	0.4	0.9	1.2	0.56	0.9	1.9
Stack Exit Velocity		(m/s)	12.7	9.1	9.1	6.1	20.2	4.8	25	25
Stack Exhaust Gas Temperature		(K)	250	250	250	250	250	385	573	573
Hourly Emission Rate		(g/s)								
CO								6.285E-01	3.739E-01	7.650E-01
NO_x								3.981E+00	2.337E+00	6.433E+00
SO_x								1.908E-03	1.472E-03	2.002E-01
Daily Emission Rate		(g/s)								
CO								2.314E-01	3.116E-02	2.804E-01
NO_x								1.469E+00	1.948E-01	2.072E+00
SO_x								7.189E-04	1.227E-04	1.077E-01
TPM			4.89E-03	9.77E-03	9.77E-03	1.47E-02	9.77E-03	3.298E-02	6.898E-03	5.764E-02
PM_{10}			1.79E-03	3.58E-03	3.58E-03	5.38E-03	3.58E-03	3.298E-02	6.622E-03	5.534E-02
$PM_{2.5}$			4.54E-04	9.08E-04	9.08E-04	1.36E-03	9.08E-04	3.199E-02	6.346E-03	5.091E-02
Annual Emission Rate		(g/s)								
CO								1.925E-02	7.526E-03	1.619E-01
NO_x								1.296E-01	4.704E-02	1.192E+00

Parameter	Metric	Transfer Tower #15 DC	Transfer Tower #18 DC	Transfer Tower #19 DC	Baghouse #2	Pellet Shed Baghouse	Rail + Nonroad Sources (8)	Tugs	Marine
SO_x							1.030E-04	2.963E-05	6.277E-02
TPM		1.46E-03	2.33E-03	2.33E-03	3.02E-03	6.03E-04	2.618E-03	1.666E-03	3.334E-02
PM_{10}		5.35E-04	8.56E-04	8.56E-04	1.11E-03	2.21E-04	2.618E-03	1.599E-03	3.201E-02
$PM_{2.5}$		1.35E-04	2.17E-04	2.17E-04	2.80E-04	5.60E-05	2.540E-03	1.533E-03	2.945E-02

Table B-6 Point Source Parameters and Modelled Emission Rates (Project)

Parameter	Metric	Transfer Tower #15 DC	Transfer Tower #18 DC	Transfer Tower #19 DC	Baghouse #2	Pellet Shed Baghouse	Rail + Nonroad Sources (8)	Tugs	Marine	Grain / Pellet Silo DC's (56)	Rail Unload DC	Grain / Pellet Material Transfer DC's
Stack Orientation		H	V	V	V	V	V	V	V			
Stack Location (UTM NAD 83)	(mE)	491988	492108	492106	492127	492109	Equidistant in Yard Area	492027	491899	varies	491986	varies
	(mN)	5461745	5462257	5462403	5462306	5462273		5461717	5461694		5462158	
Base Elevation	(m)	13	11	11.5	11	11.5	8.1	0	0	varies	8.5	varies
Stack Height	(m)	16.5	16.5	16.5	3.0	4.6	4.5	6	30.5	34.5	6	1.5 – 47.5
Stack Diameter	(m)	0.4	0.4	0.4	1.2	1.2	0.56	0.9	1.9	0.4	0.8	0.4
Stack Exit Volumetric Flow	(m^3/s)	1.7	1.2	1.2		23.6						
Stack Exit Velocity	(m/s)	12.7	9.1	9.1	20.2	20.2	4.8	25	25	12.7	20.3	10.9 – 12.7
-Stack Exhaust Gas Temperature	(K)	250	250	250	250	250	385	573	573	250	250	250
Hourly Emission Rate	(g/s)											
CO							6.285E-01	3.739E-01	7.650E-01			
NO_x							3.981E+00	2.337E+00	6.433E+00			
SO_x							1.908E-03	1.472E-03	2.002E-01			
Daily Emission Rate	(g/s)											
CO							2.314E-01	3.116E-02	2.804E-01			

Parameter	Metric	Transfer Tower #15 DC	Transfer Tower #18 DC	Transfer Tower #19 DC	Baghouse #2	Pellet Shed Baghouse	Rail + Nonroad Sources (8)	Tugs	Marine	Grain / Pellet Silo DC's (56)	Rail Unload DC	Grain / Pellet Material Transfer DC's
NO_x							1.469E+00	1.948E-01	2.072E+00			
SO_x							7.189E-04	1.227E-04	1.077E-01			
TPM		4.89E-03	9.77E-03	9.77E-03	1.47E-02	9.77E-03	3.298E-02	6.898E-03	5.764E-02	1.13E-03	3.33E-02	2.1E-03 – 1.3E-02
PM_{10}		1.79E-03	3.58E-03	3.58E-03	5.38E-03	3.58E-03	3.298E-02	6.622E-03	5.534E-02	4.14E-04	8.13E-03	7.6E-04 – 4.9E-03
$PM_{2.5}$		4.54E-04	9.08E-04	9.08E-04	1.36E-03	9.08E-04	3.199E-02	6.346E-03	5.091E-02	1.05E-04	1.35E-03	1.9E-04 – 1.2E-03
Annual Emission Rate	(g/s)											
CO							1.925E-02	7.526E-03	1.619E-01			
NO_x							1.296E-01	4.704E-02	1.192E+00			
SO_x							1.030E-04	2.963E-05	6.277E-02			
TPM		1.46E-03	2.33E-03	2.33E-03	3.02E-03	6.03E-04	2.618E-03	1.666E-03	3.334E-02	3.17E-04	2.09E-02	3.5E-04 – 2.6E-03
PM_{10}		5.35E-04	8.56E-04	8.56E-04	1.11E-03	2.21E-04	2.618E-03	1.599E-03	3.201E-02	1.16E-04	5.09E-03	1.2E-04 – 9.6E-04
$PM_{2.5}$		1.35E-04	2.17E-04	2.17E-04	2.80E-04	5.60E-05	2.540E-03	1.533E-03	2.945E-02	2.94E-05	8.48E-04	3.3E-05 – 2.4E-04

B.4.5.2 AREA SOURCES

Table B-7 Area Source Parameters and Modelled Emission Rates (Basecase)

PARAMETER	METRIC	STOCKPILE FIR	STOCKPILE SPF
Area Orientation		Polygon	Polygon
Base Elevation	(m)	11	11
Release Height	(m)	20.7	20.7
Initial Sigma Zo	(m)	9.6	9.6
DAILY EMISSION RATE	$g/s/m^2$		
TPM		4.76E-07	4.76E-07
PM_{10}		4.04E-07	4.04E-07
$PM_{2.5}$		6.18E-08	6.18E-08
ANNUAL EMISSION RATE	$g/s/m^2$		
TPM		1.43E-07	1.43E-07
PM_{10}		1.22E-07	1.22E-07
$PM_{2.5}$		1.86E-08	1.86E-08

B.4.5.3 VOLUME SOURCES

Table B-8 Volume Source Parameters and Modelled Emission Rates (Basecase)

PARAMETER	METRIC	TRANSFER 3/2	TRANSFER 4/3	TRANSFER 21/22	BARGE LOAD	PILE TRANSFER 16	PILE TRANSFER 19	RAIL UNLOAD	SHIP LOAD TRANSFER	SHIP LOADER
Source Location (UTM NAD 83)	(mE)	491987	492109	492055	491967	492047	492066	491986	492102	491997
	(mN)	5461753	5462227	5462088	5461919	5462104	5462358	5462158	5461782	5461712
Base Elevation	(m)	0	14	16	0	14	14	12	0	0
Effective Height	(m)	26	5.5	23.5	17	23.5	23.5	6	21.3	15.7
Initial Lateral Dimensions	(m)	0.35	0.35	0.35	0.4	0.3	0.3	2.1	0.3	1.7
Initial Vertical Dimensions	(m)	1.3	1.9	1.4	5.1	3.3	3.3	2.8	1.9	7.3
DAILY EMISSION RATE	(g/s)									
TPM		1.47E-01	1.98E-01	4.84E-02	5.46E-01	6.83E-02	6.83E-02	7.82E-01	1.47E-01	1.06E+01
PM_{10}		5.38E-02	7.27E-02	1.78E-02	1.37E-01	1.71E-02	1.71E-02	1.91E-01	5.38E-02	2.64E+00
$PM_{2.5}$		1.36E-02	1.84E-02	4.50E-03	1.88E-01	2.35E-02	2.35E-02	3.18E-02	1.36E-02	4.85E-01
ANNUAL EMISSION RATE	(g/s)									
TPM		3.92E-02	3.05E-02	1.27E-03	6.05E-03	6.34E-03	2.24E-03	2.26E-01	1.27E-03	2.09E+00
PM_{10}		1.44E-02	1.12E-02	4.65E-04	1.51E-03	1.59E-03	5.60E-04	5.50E-02	4.65E-04	5.23E-01
$PM_{2.5}$		3.64E-03	2.83E-03	1.18E-04	2.08E-03	2.18E-03	7.70E-04	9.16E-03	1.18E-04	9.59E-02

Table B-9 Volume Source Parameters and Modelled Emission Rates (Project)

PARAMETER		METRIC	SHIP LOADER
Source Location (UTM NAD 83)		(mE)	491997
		(mN)	5461712
Base Elevation		(m)	0
Effective Height		(m)	15.7
Initial Lateral Dimensions		(m)	1.7
Initial Vertical Dimensions		(m)	7.3
DAILY EMISSION RATE		(g/s)	
TPM			2.82E-01
PM_{10}			7.05E-02
$PM_{2.5}$			1.29E-02
ANNUAL EMISSION RATE		(g/s)	
TPM			6.26E-02
PM_{10}			1.57E-02
$PM_{2.5}$			2.87E-03

B.4.6 CALPUFF MODELLING RESULTS (CONTOUR PLOTS)

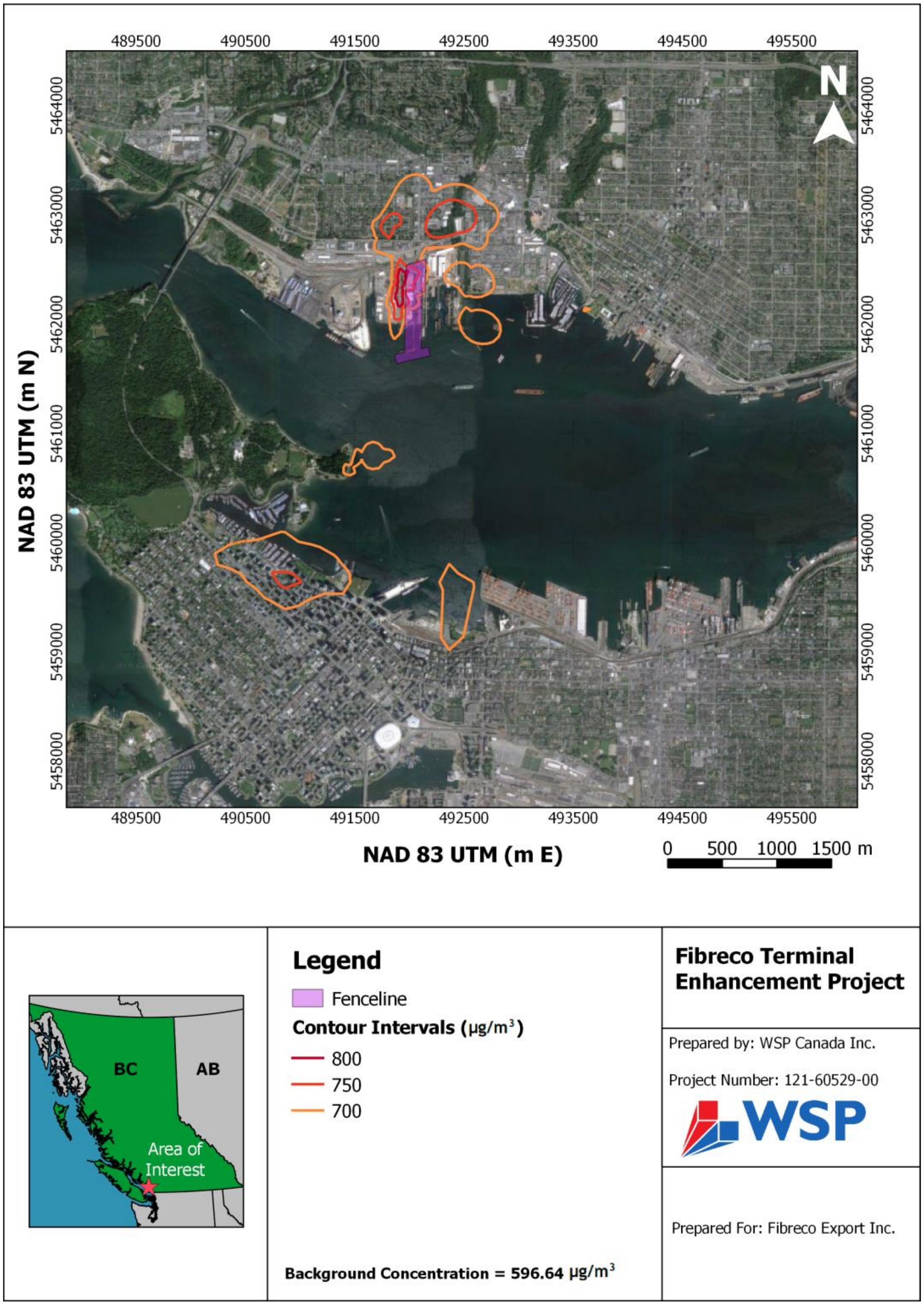


Figure B-8 Contour Plot of 1-hour Maximum Predicted CO Concentrations for Project

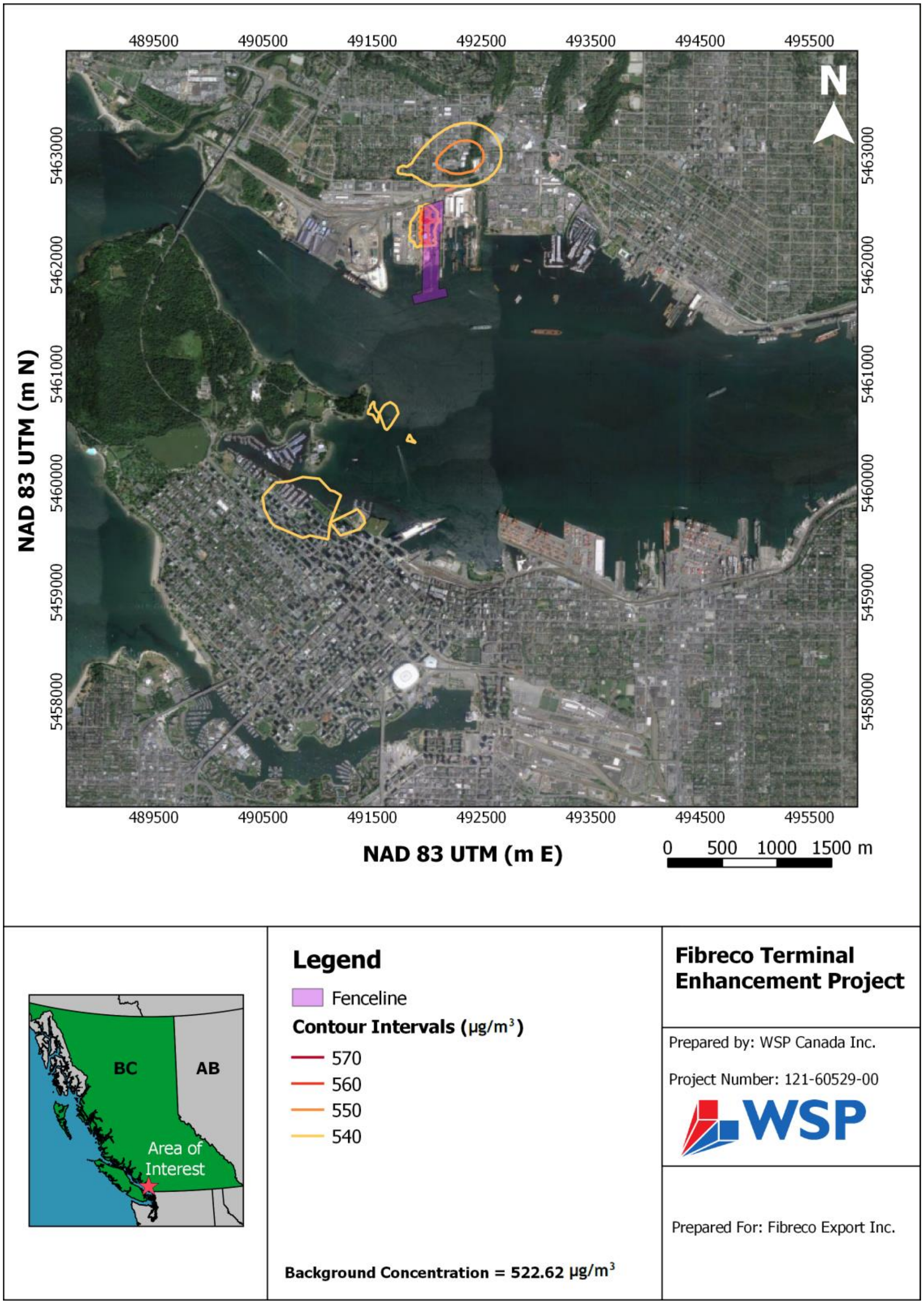


Figure B-9 Contour Plot of 8-hour Maximum Predicted CO Concentrations for Project

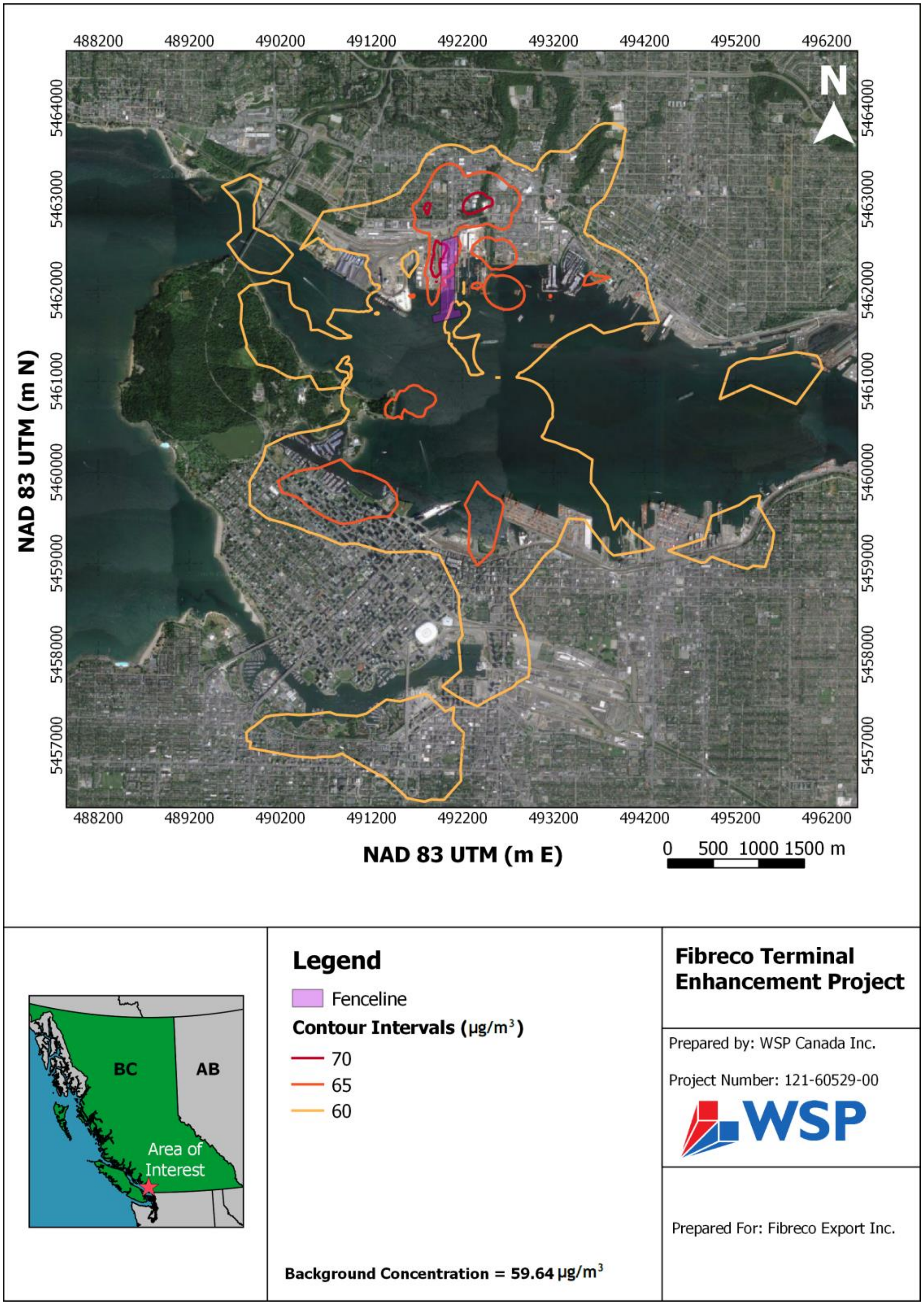


Figure B-10 Contour Plot of 1-hour Maximum Predicted NO_2 (ARM Method) Concentrations for Project

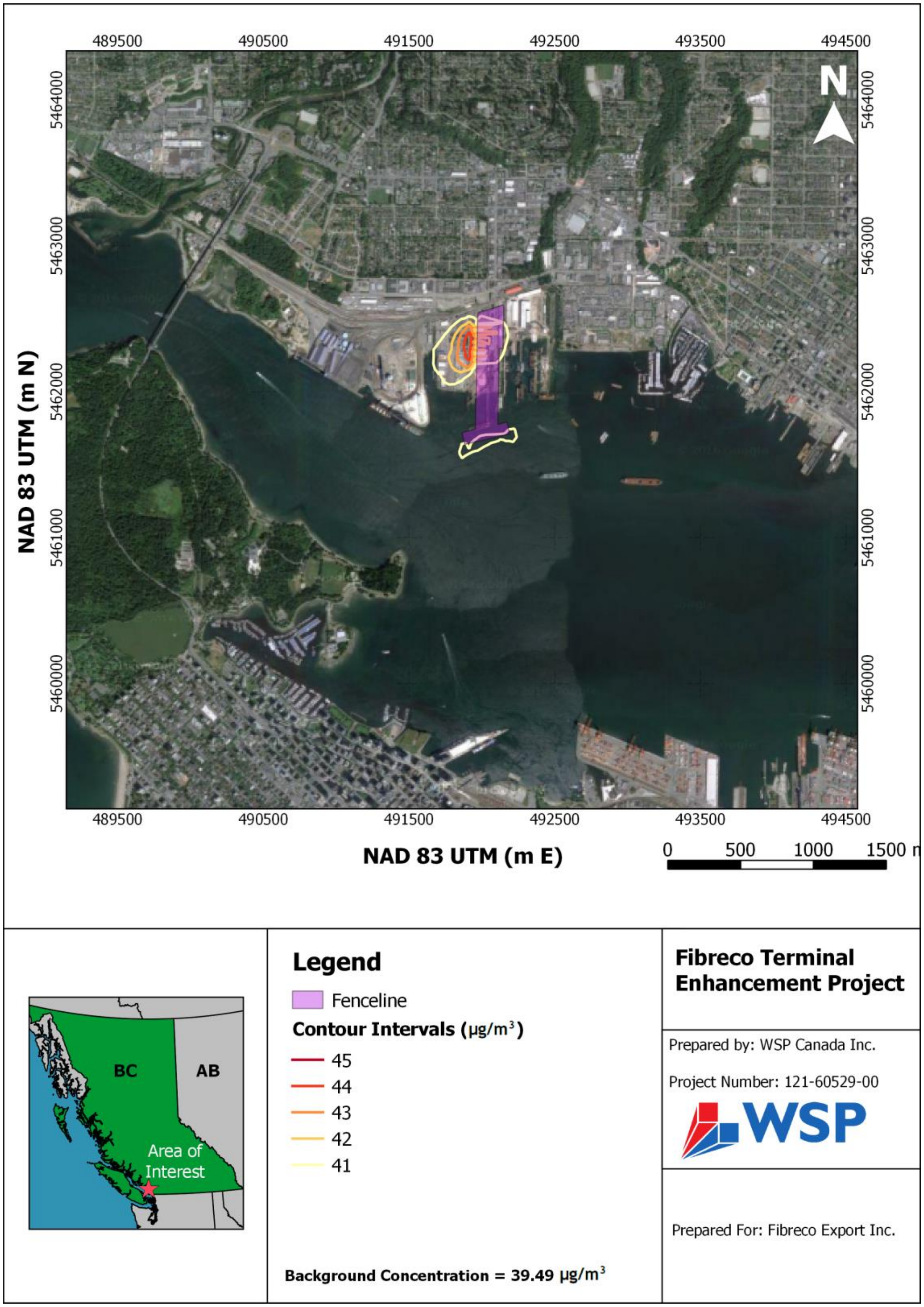


Figure B-11 Contour Plot of Annual Maximum Predicted NO_2 (100% NOx) Concentrations for Project

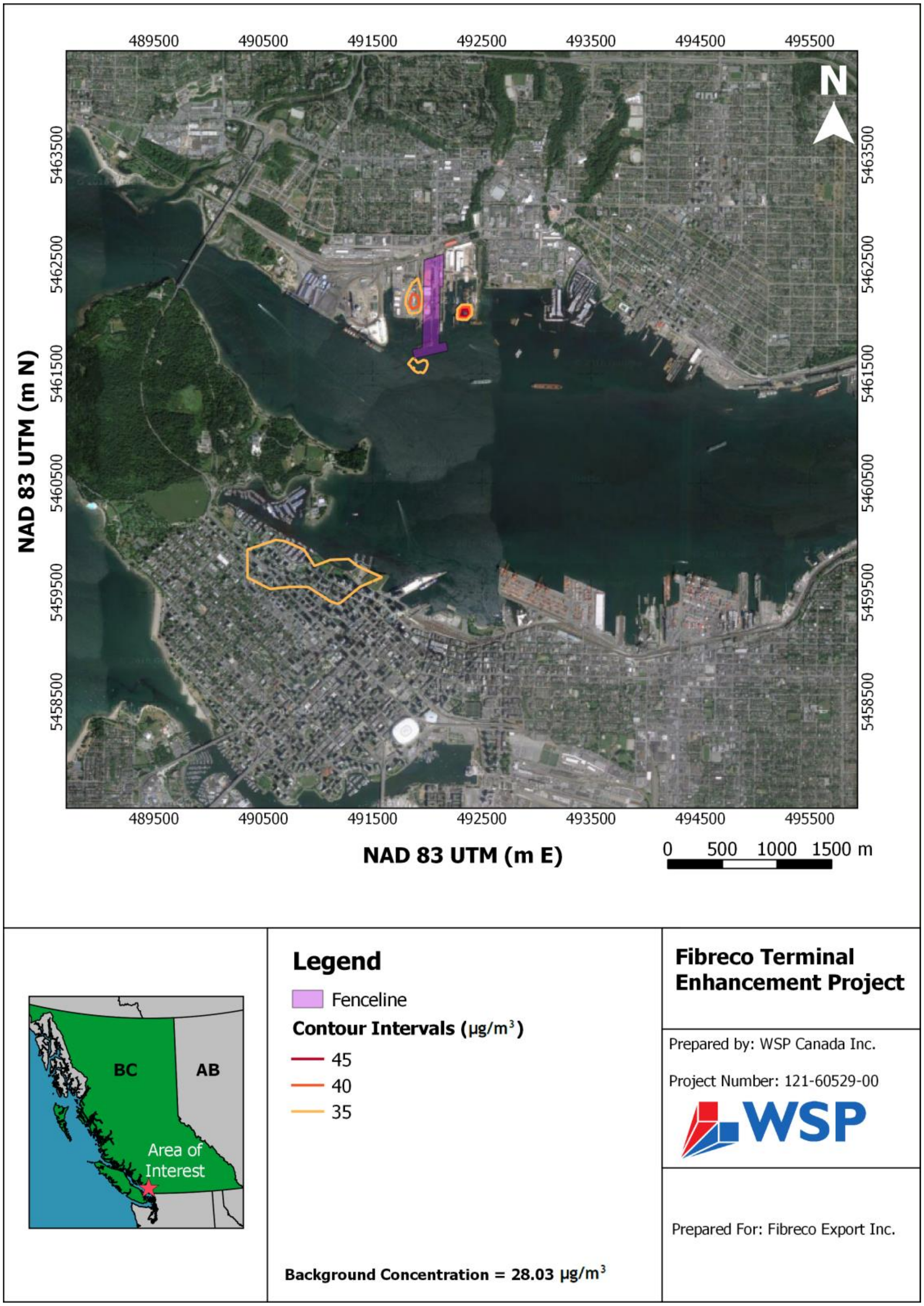


Figure B-12 Contour Plot of 1-hour Maximum Predicted SO_2 Concentrations for Project

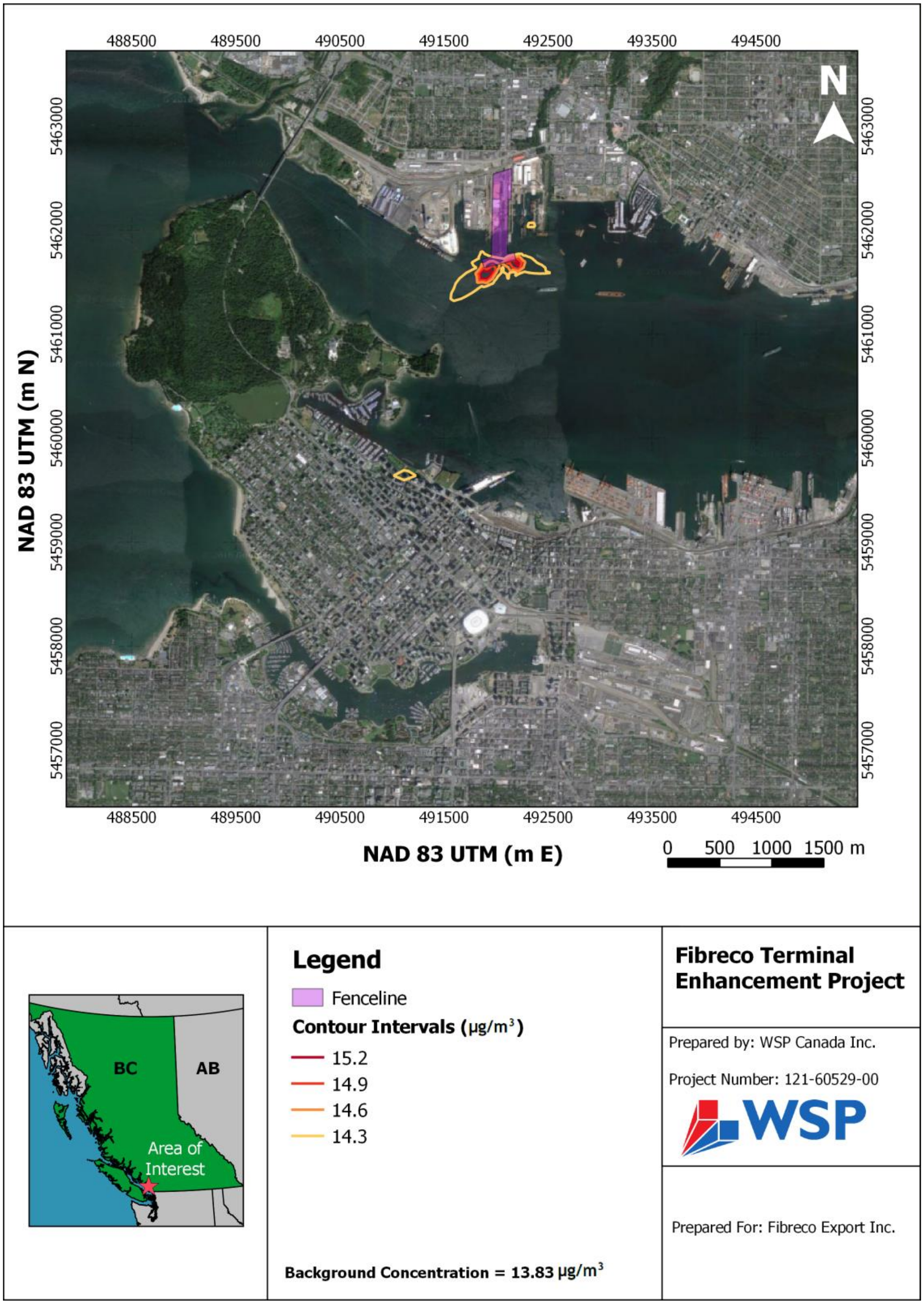


Figure B-13 Contour Plot of 24-hour Maximum Predicted SO_2 Concentrations for Project

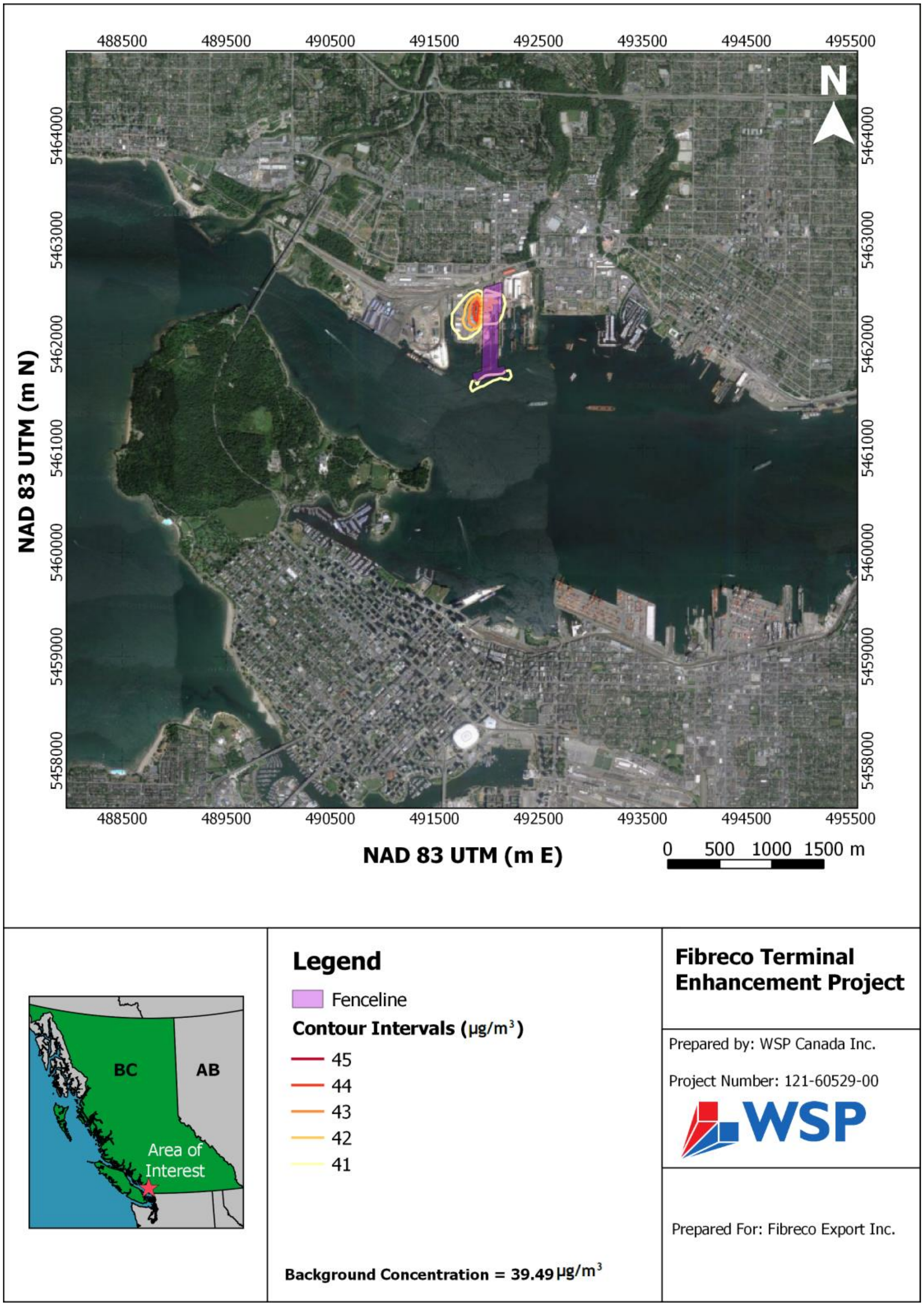


Figure B-14 Contour Plot of Annual Maximum Predicted SO_2 Concentrations for Project

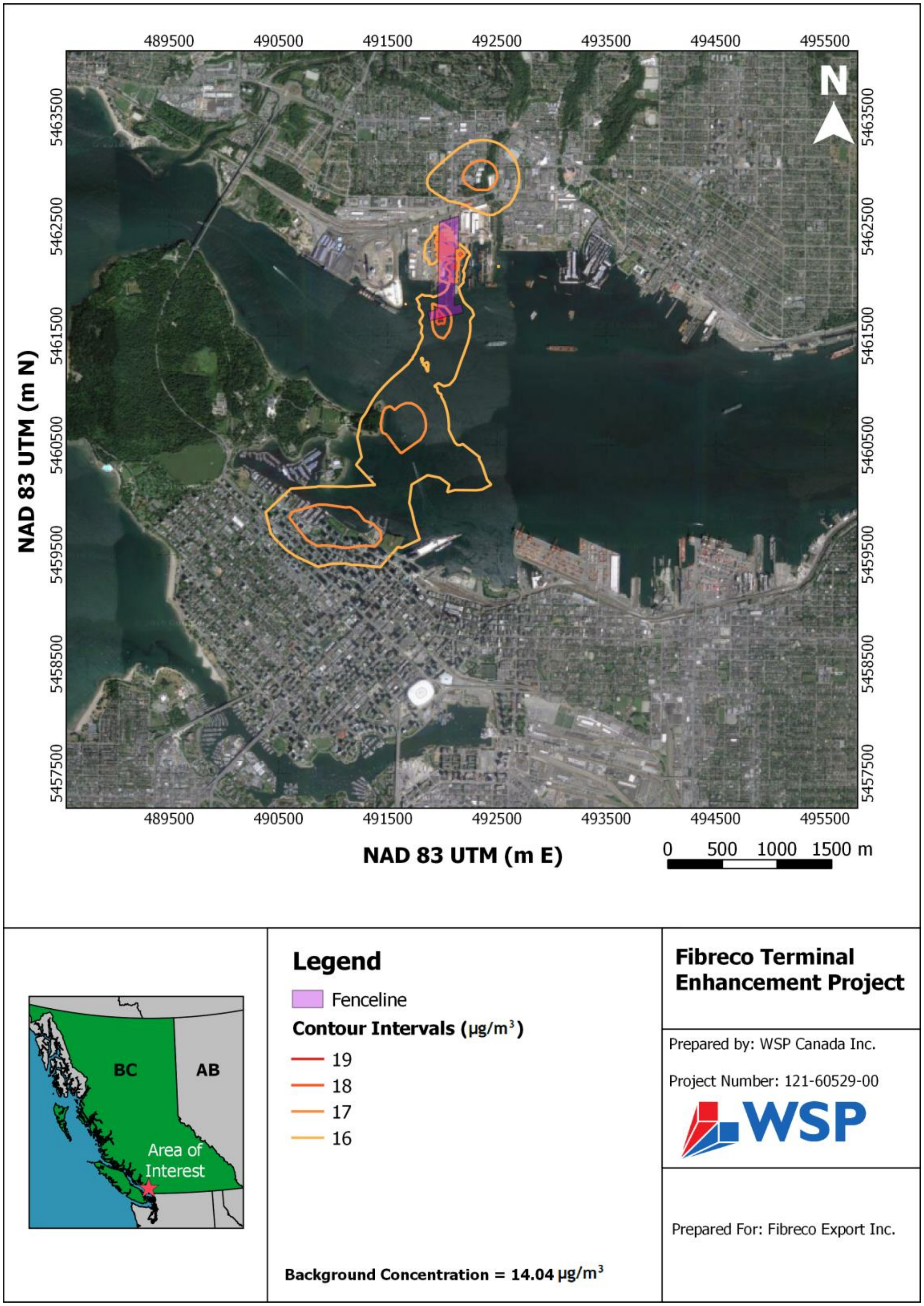


Figure B-15 Contour Plot of 24-hour Maximum Predicted $PM_{2.5}$ Concentrations for Project

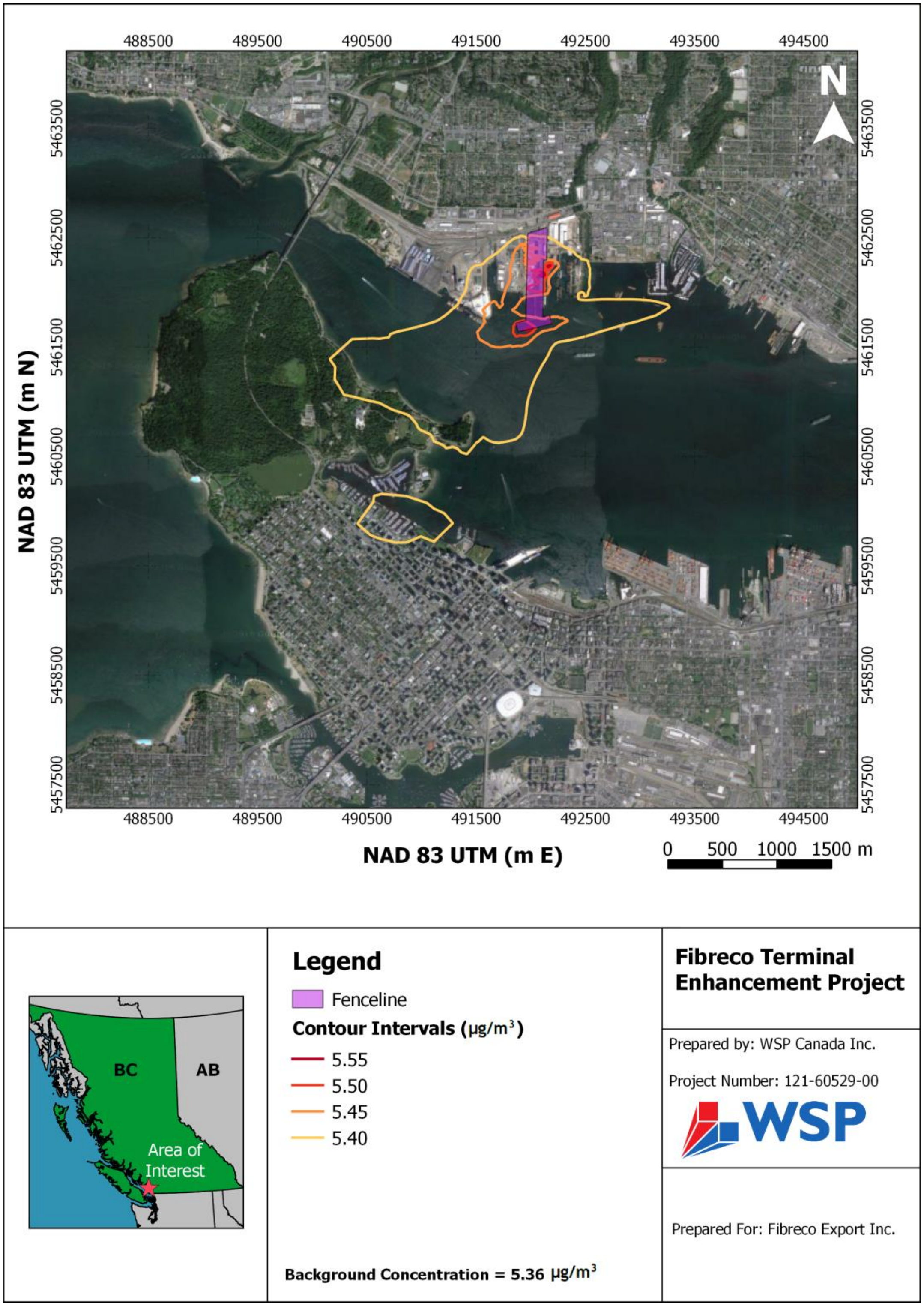


Figure B-16 Contour Plot of Annual Maximum Predicted $PM_{2.5}$ Concentrations for Project

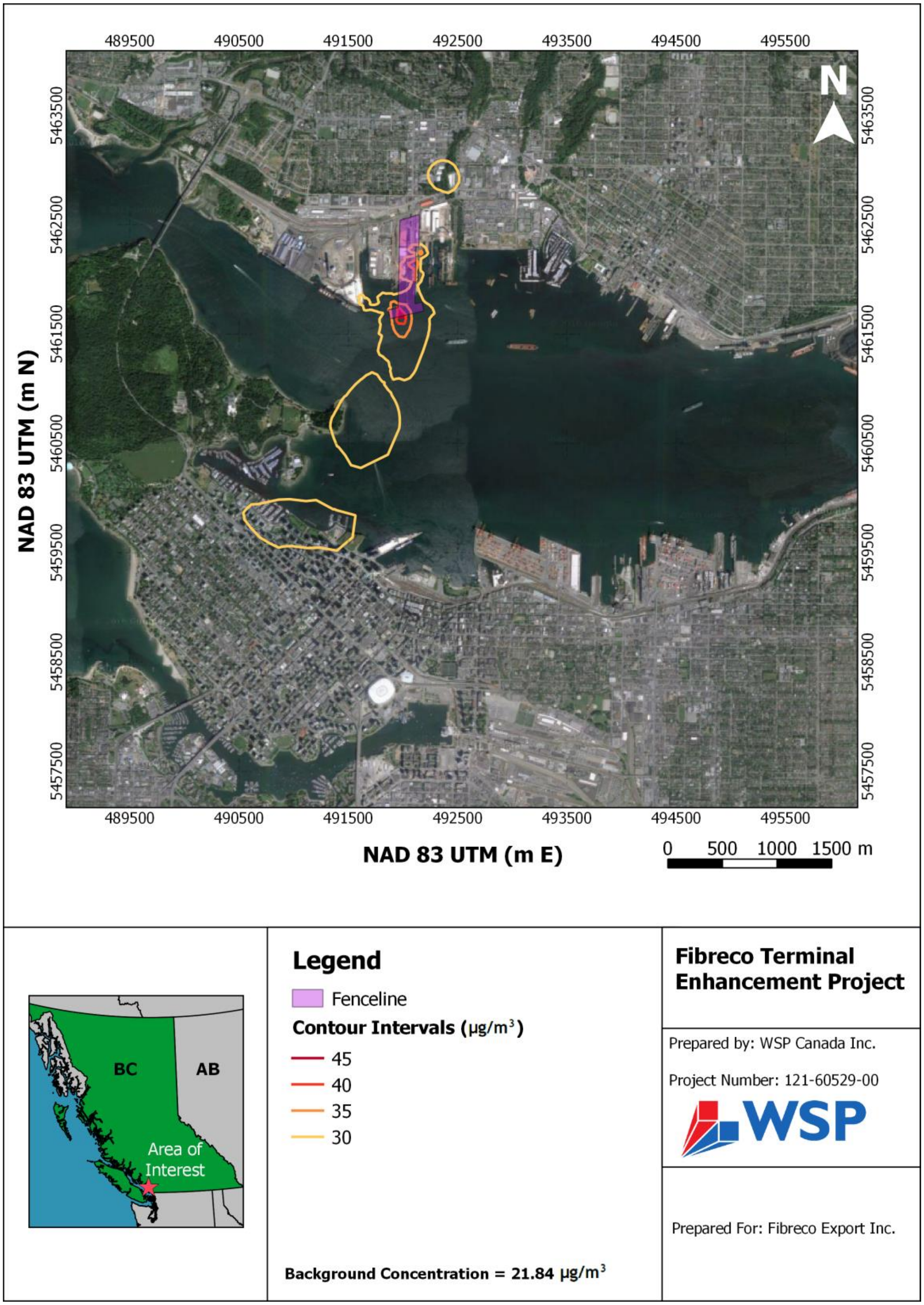


Figure B-17 Contour Plot of 24-hour Maximum Predicted PM_{10} Concentrations for Project

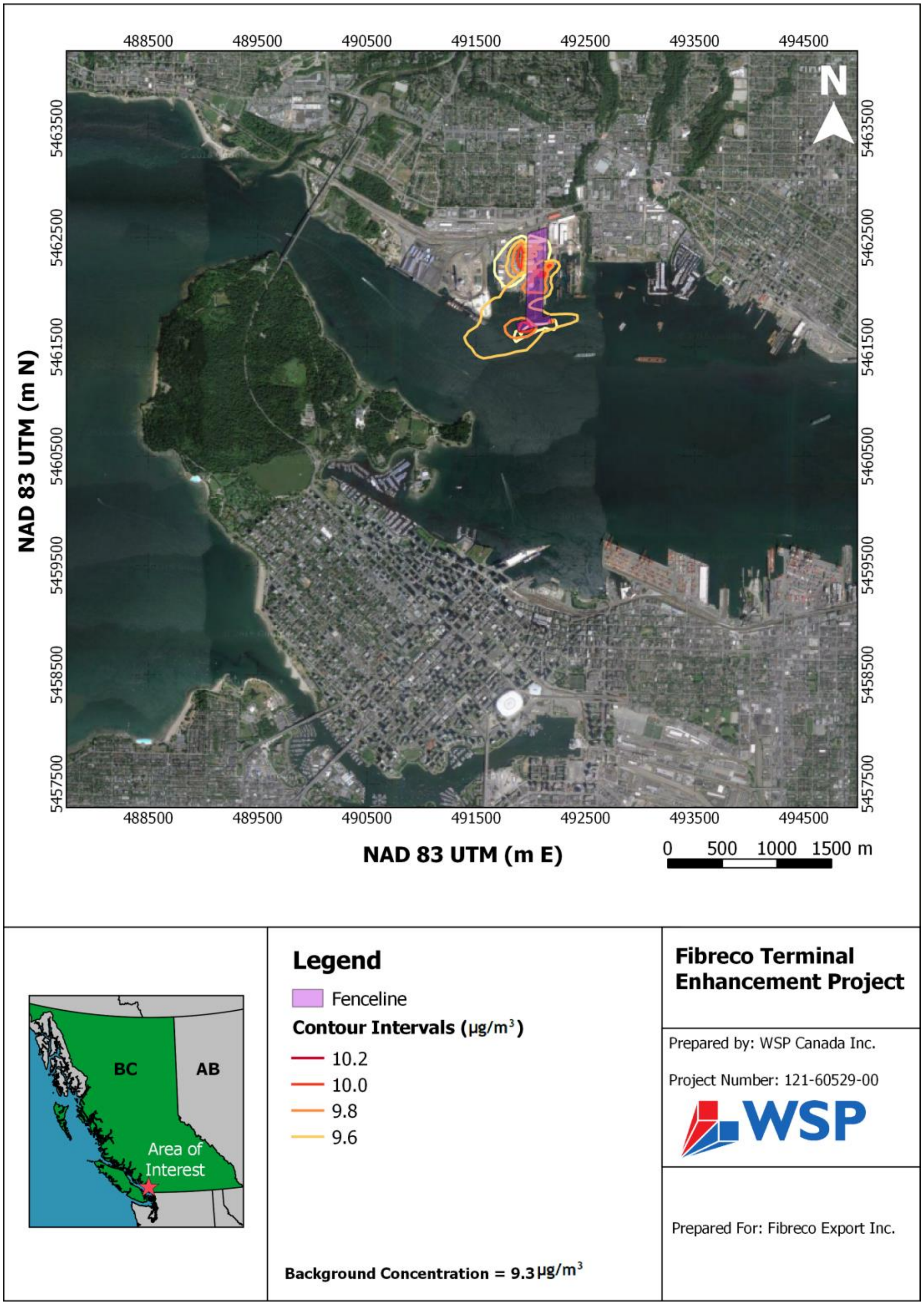


Figure B-18 Contour Plot of Annual Maximum Predicted PM_{10} Concentrations for Project

B.5 QUALITY MANAGEMENT

Metro Vancouver's latest dispersion modelling plan provides recommendations and guidance on QA/QC for CALMET / CALPUFF modelling. The sections below document the quality tests that were applied to the WCR updated modelling.

B.5.1 GEOPHYSICAL INPUT DATA

Plots of the topography (Figure B-2) and land use (Figure B-3) were provided earlier. The plots show that the topographical and land use information is representative of the modelling domain.

B.5.2 METEOROLOGICAL INPUT DATA

The annual and seasonal wind roses for each of the surface meteorological stations provided below generally correspond with expected wind flows in the region with each station's wind patterns also accounting for topographical effects on wind near the station.

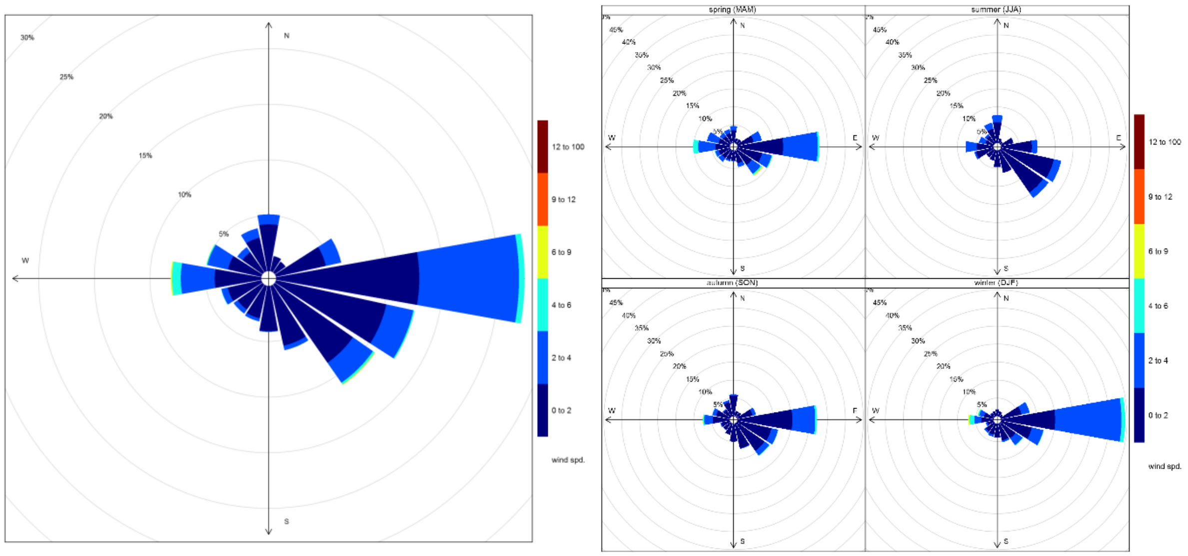


Figure B-19 Observed Wind Roses at T2 Vancouver – Kitsilano

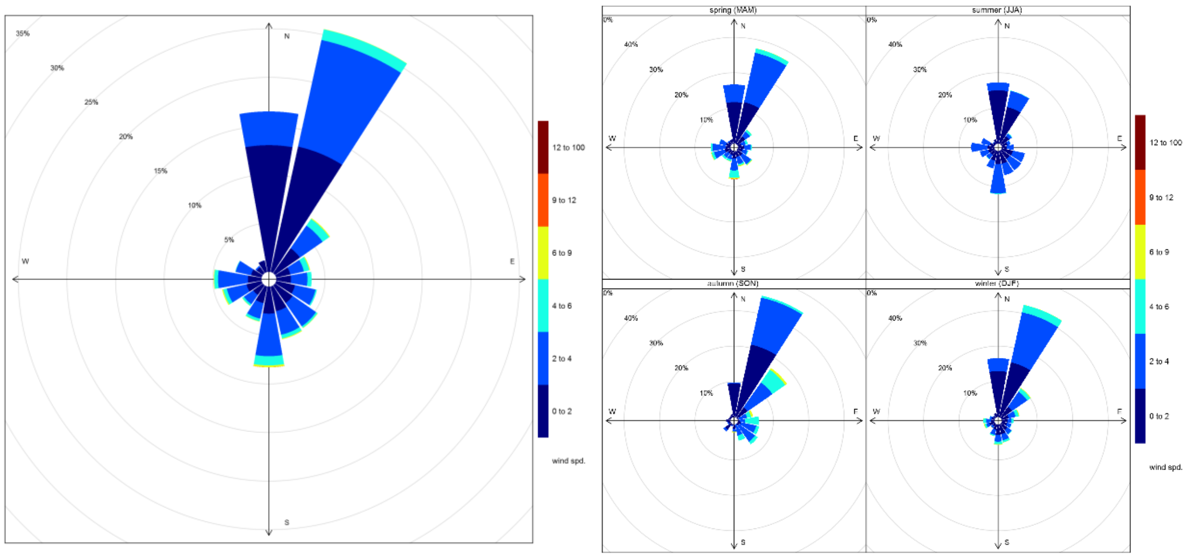


Figure B-20 Observed Wind Roses at T4 Burnaby – Kensington Park

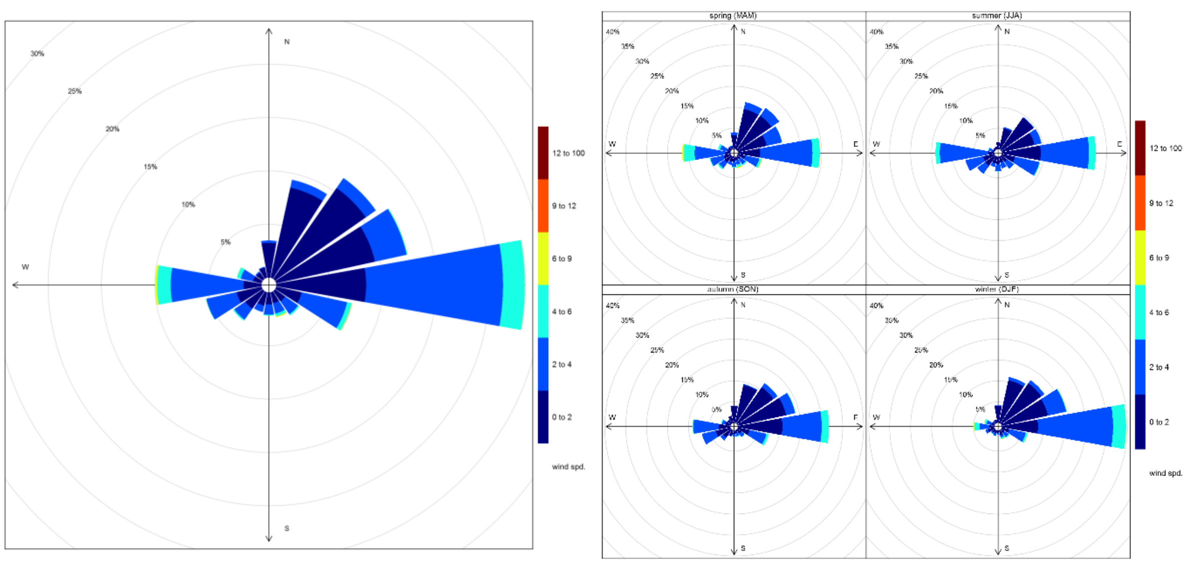


Figure B-21 Observed Wind Roses at T6 North Vancouver – Second Narrows

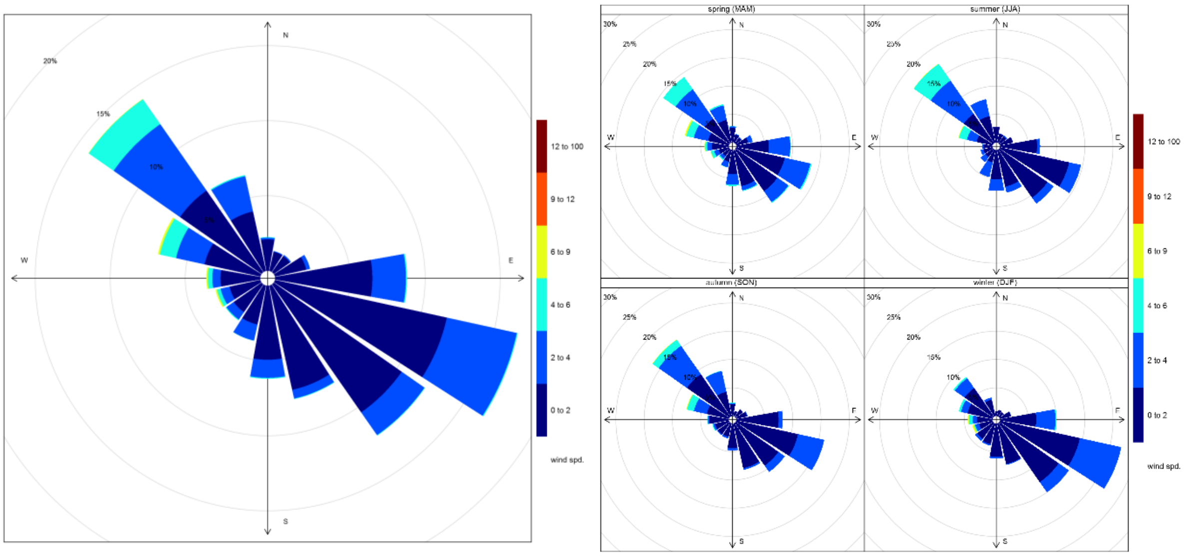


Figure B-22 Observed Wind Roses at T9 Port Moody

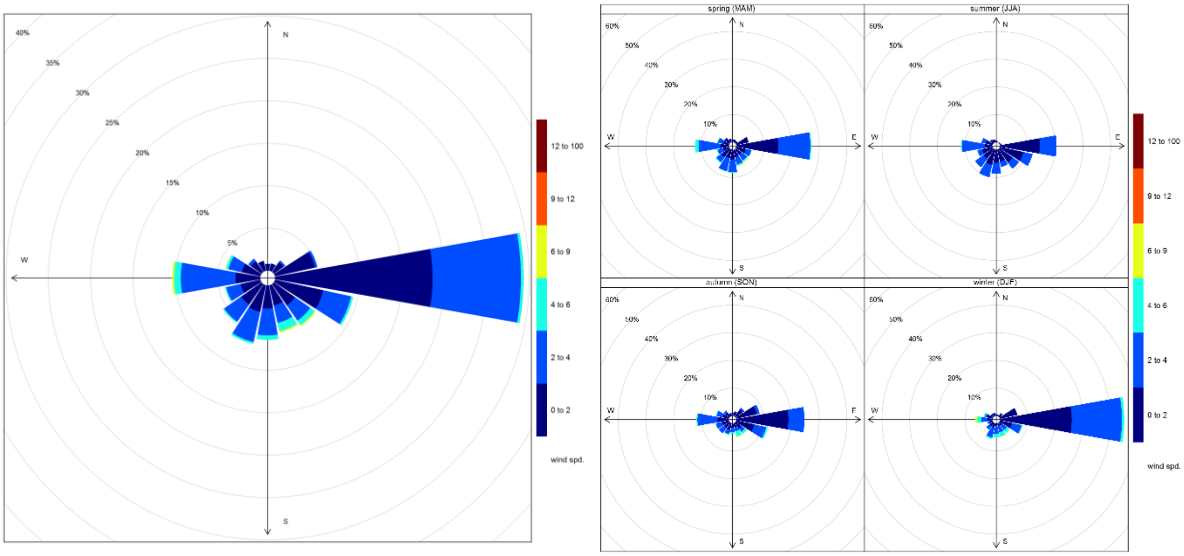


Figure B-23 Observed Wind Roses at T13 North Delta

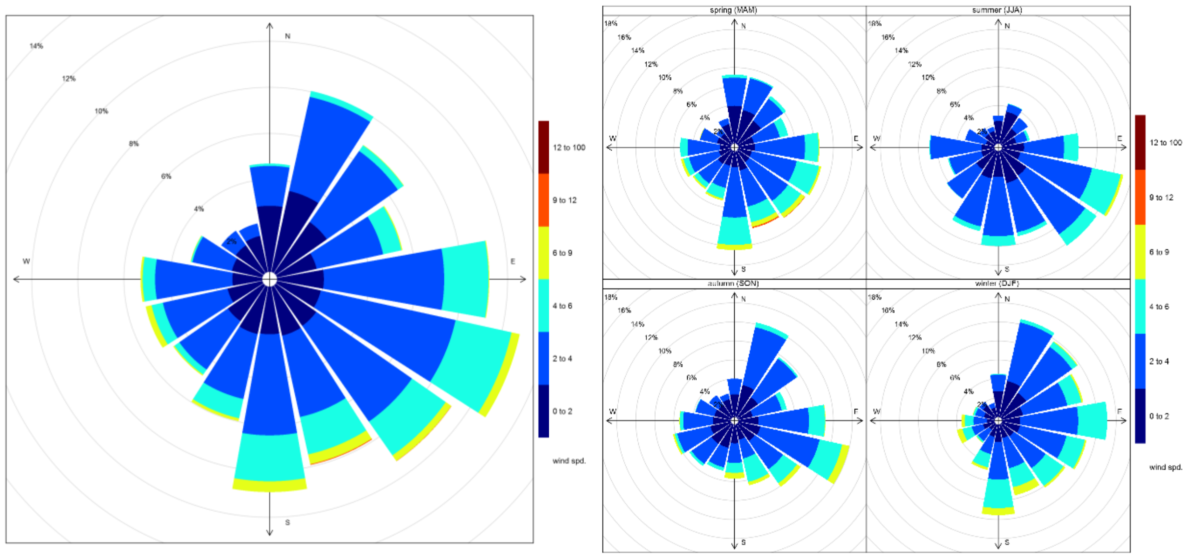


Figure B-24 Observed Wind Roses at T14 Burnaby Mountain

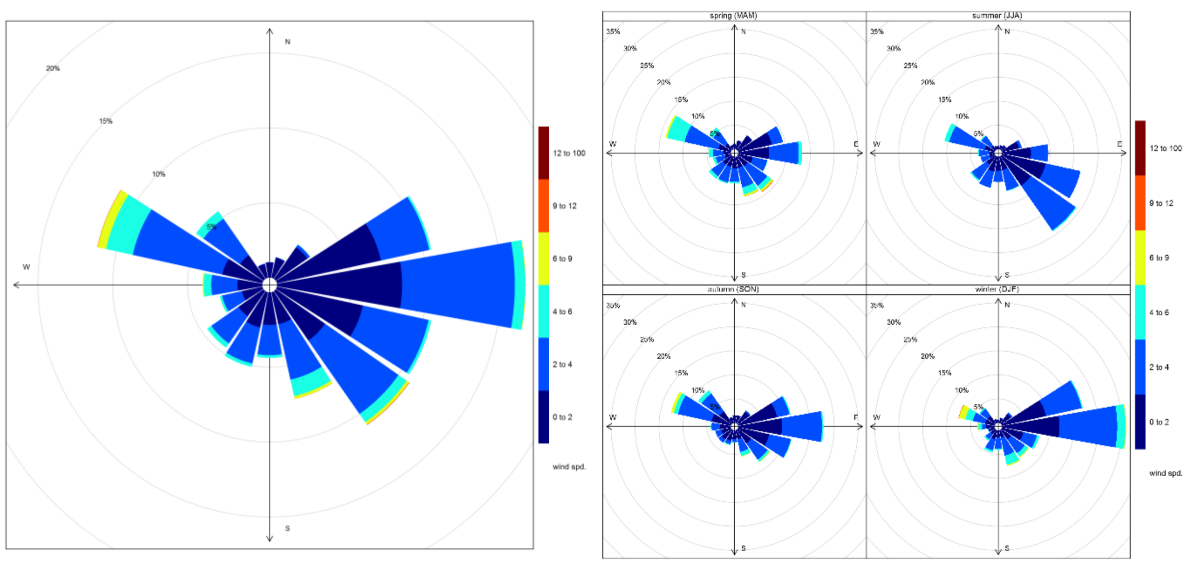


Figure B-25 Observed Wind Roses at T17 Richmond South

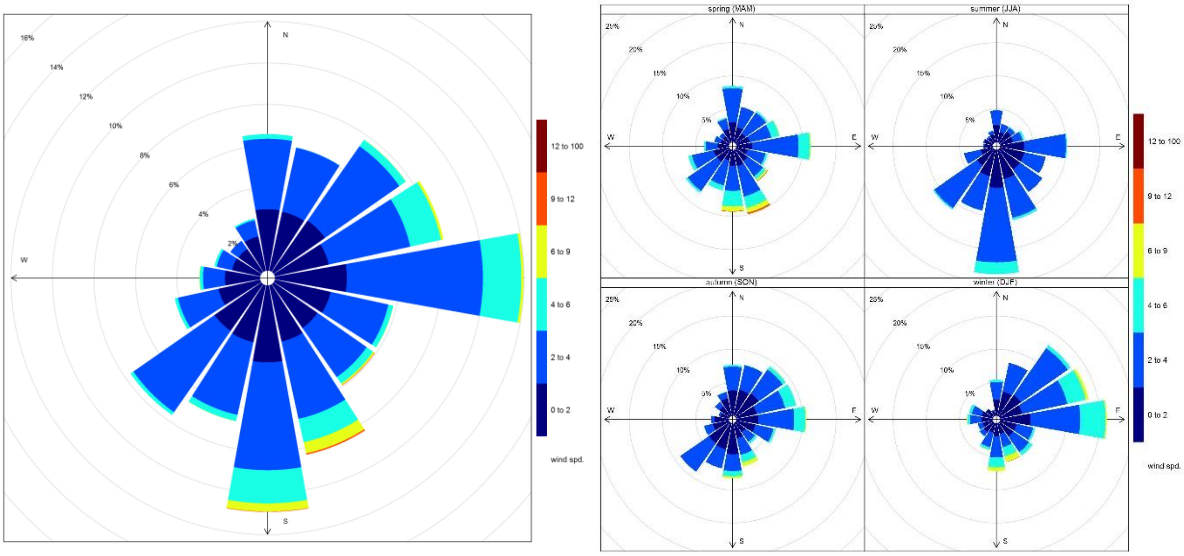


Figure B-26 Observed Wind Roses at T18 Burnaby South

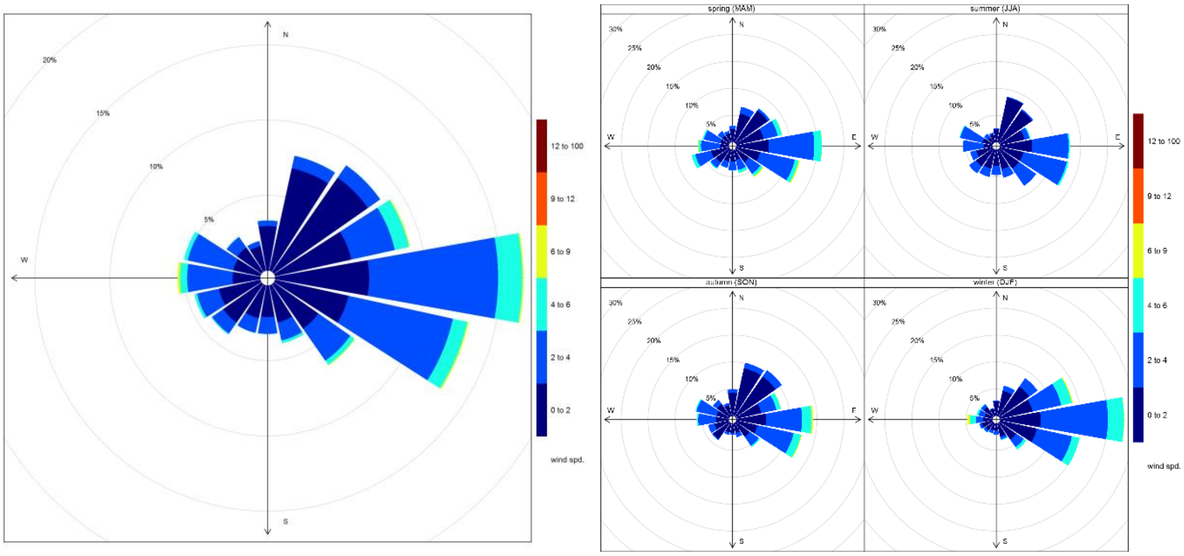


Figure B-27 Observed Wind Roses at T22 Burnaby – Burmount

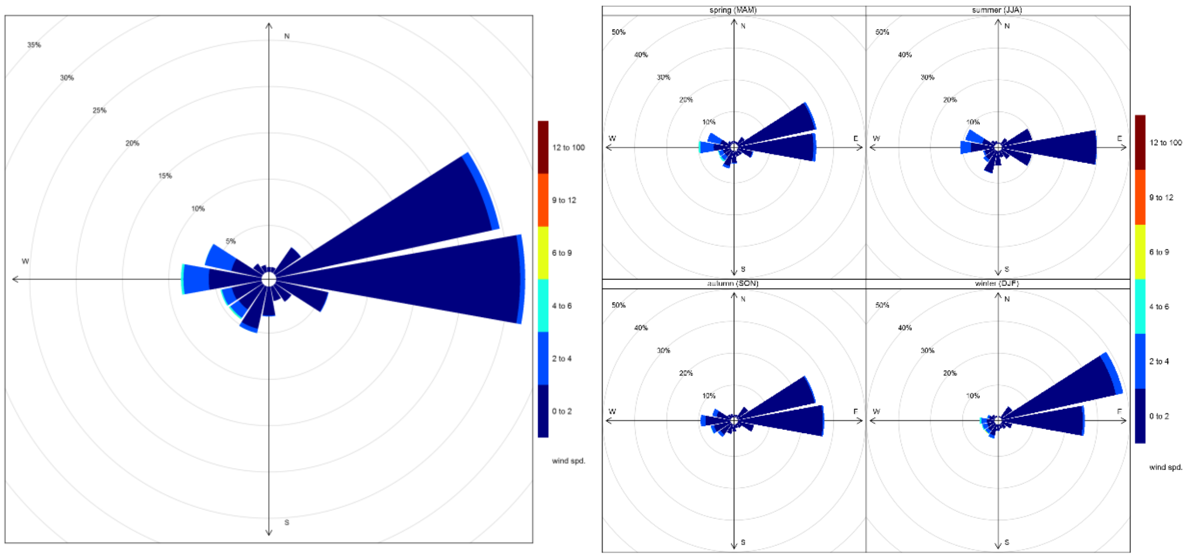


Figure B-28 Observed Wind Roses at T23 Burnaby – Capitol Hill

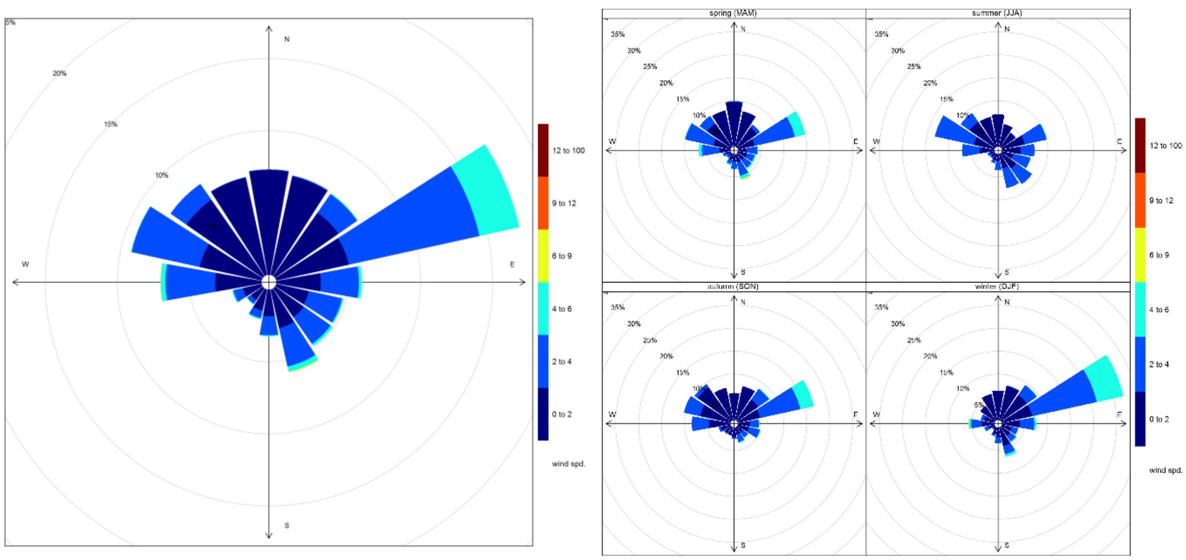


Figure B-29 Observed Wind Roses at T24 Burnaby North

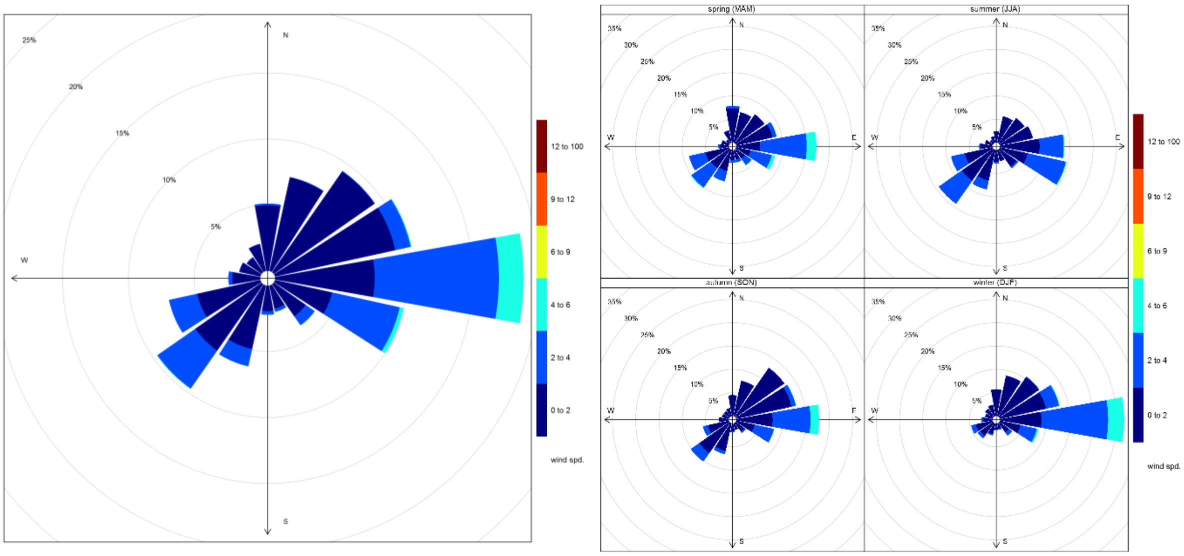


Figure B-30 Observed Wind Roses at T26 North Vancouver – Mahon Park

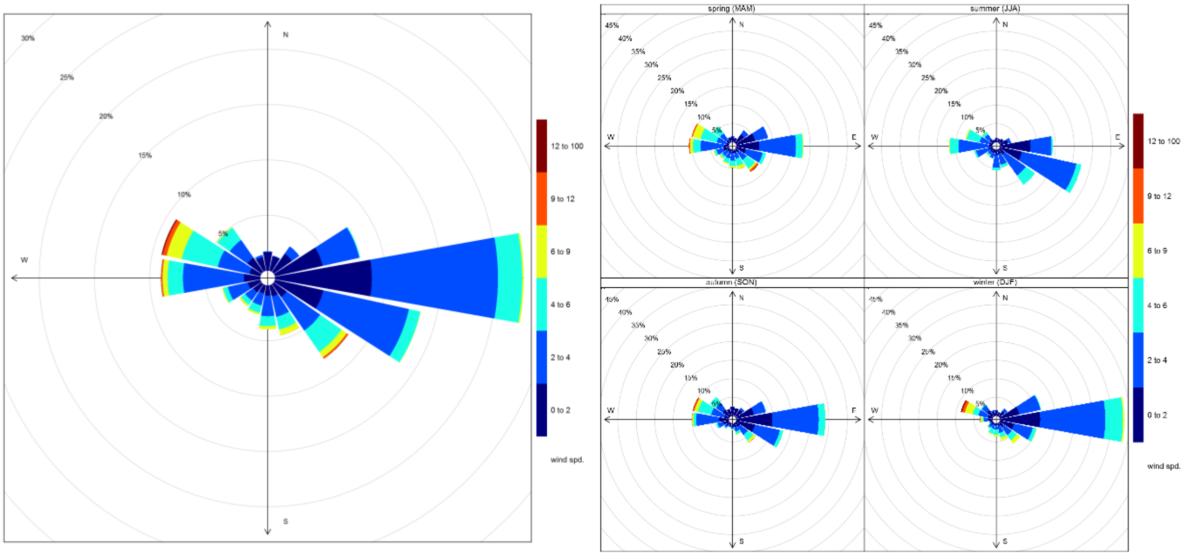


Figure B-31 Observed Wind Roses at T31 Richmond – Airport

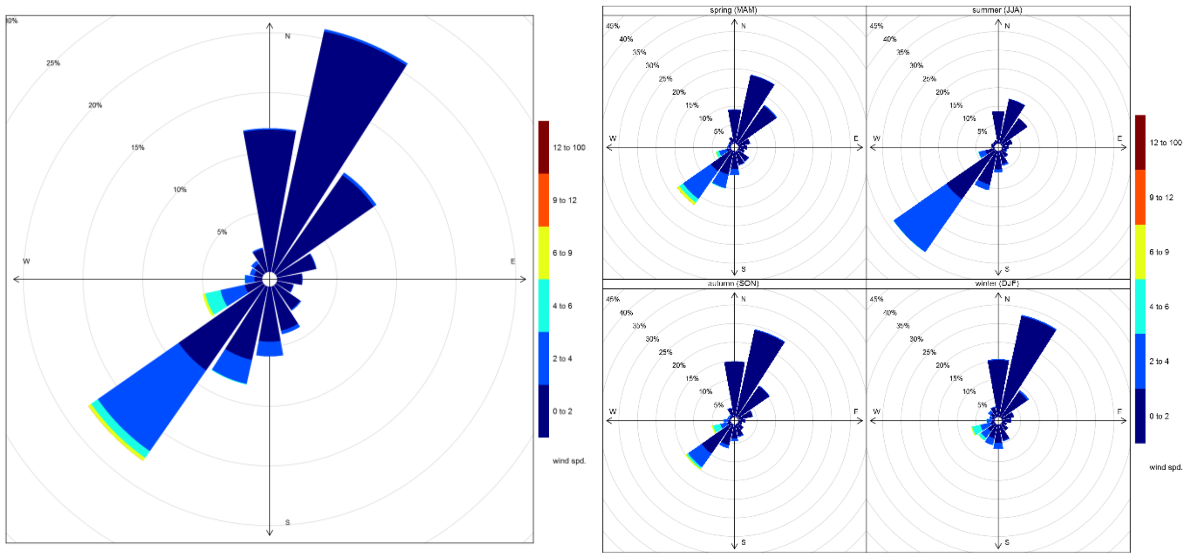


Figure B-32 Observed Wind Roses at T35 Horseshoe Bay

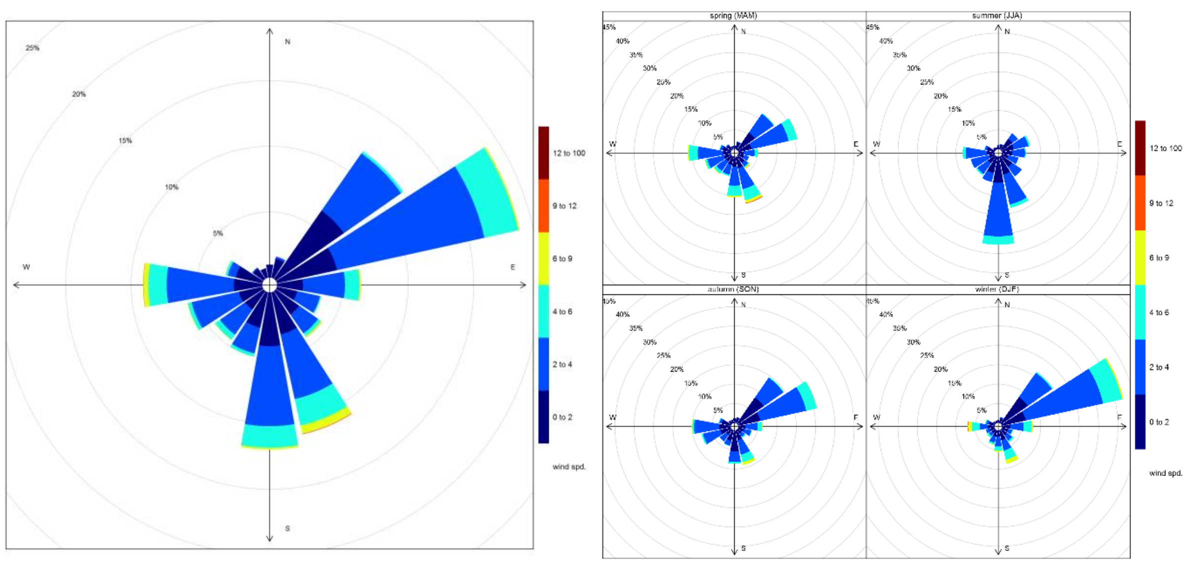


Figure B-33 Observed Wind Roses at T38 Annacis Island

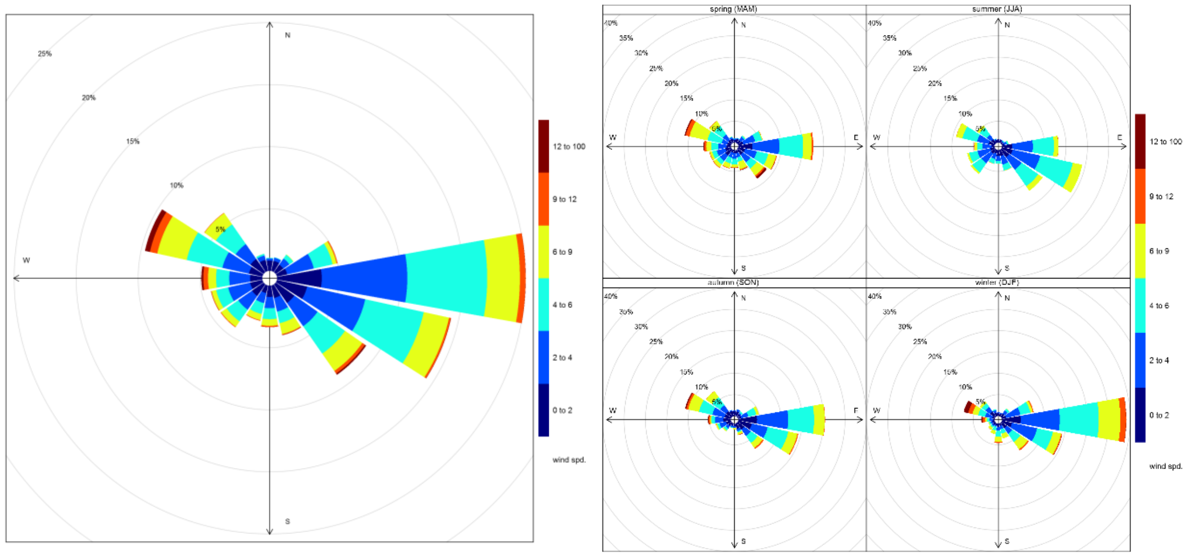


Figure B-34 Observed Wind Roses at Vancouver YVR Airport

B.5.3 WRF OUTPUT

B.5.3.1 WRF TEMPERATURES

The WRF output was evaluated at four grid points in the WRF data set labelled as Site, Burnaby, YVR, and Horseshoe Bay in Figure B-35. Hourly temperatures from these points were extracted and compared on a diurnal basis (Figure B-36). The diurnal patterns at each of the grid points is deemed reasonable, with the Burnaby grid point showing stronger diurnal variation in temperature. Given that this grid point is further inland than the other 3, it is reasonable for to see a stronger variation due to the lesser influence of sea breeze effects.

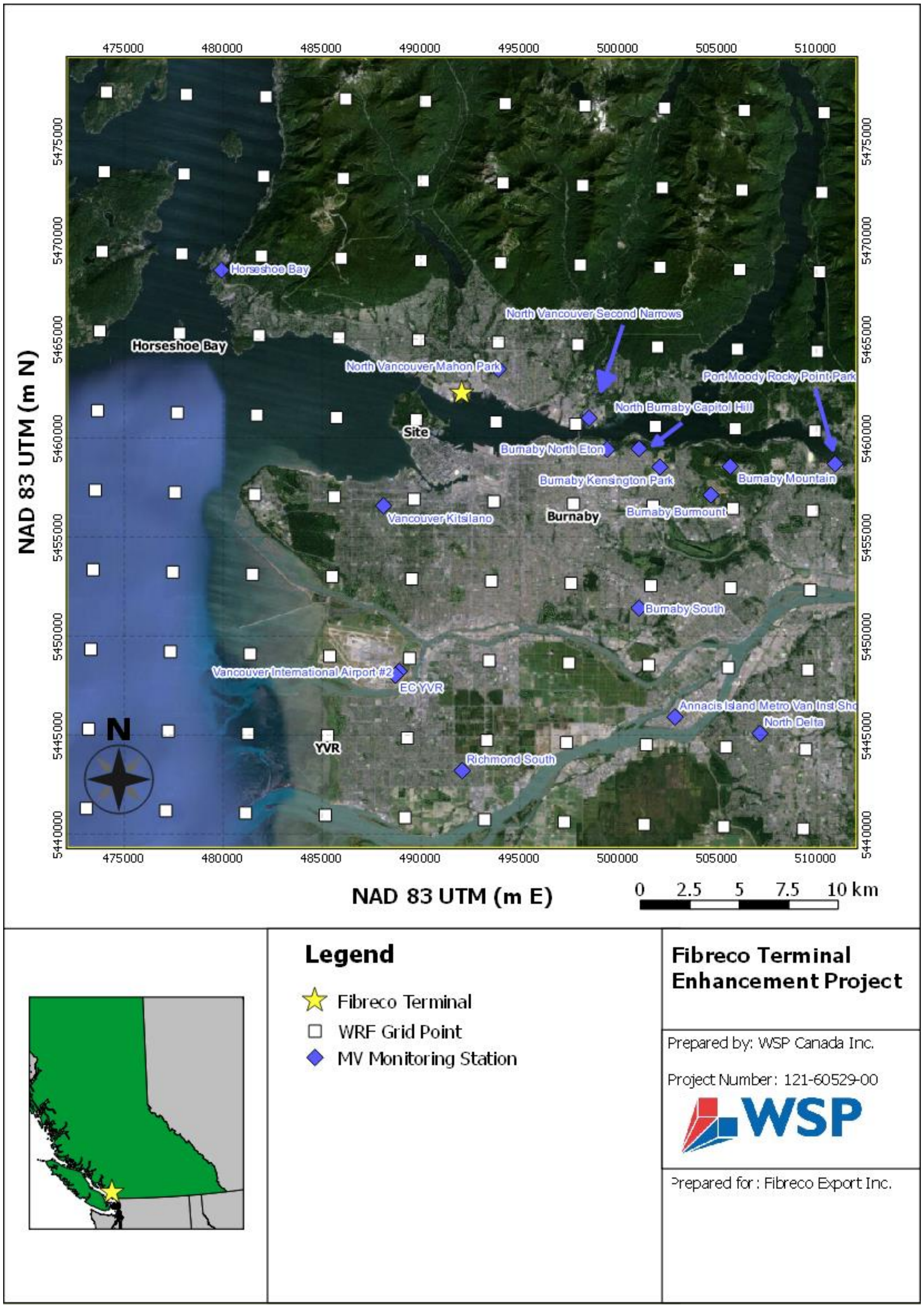


Figure B-35 WRF Grid Points

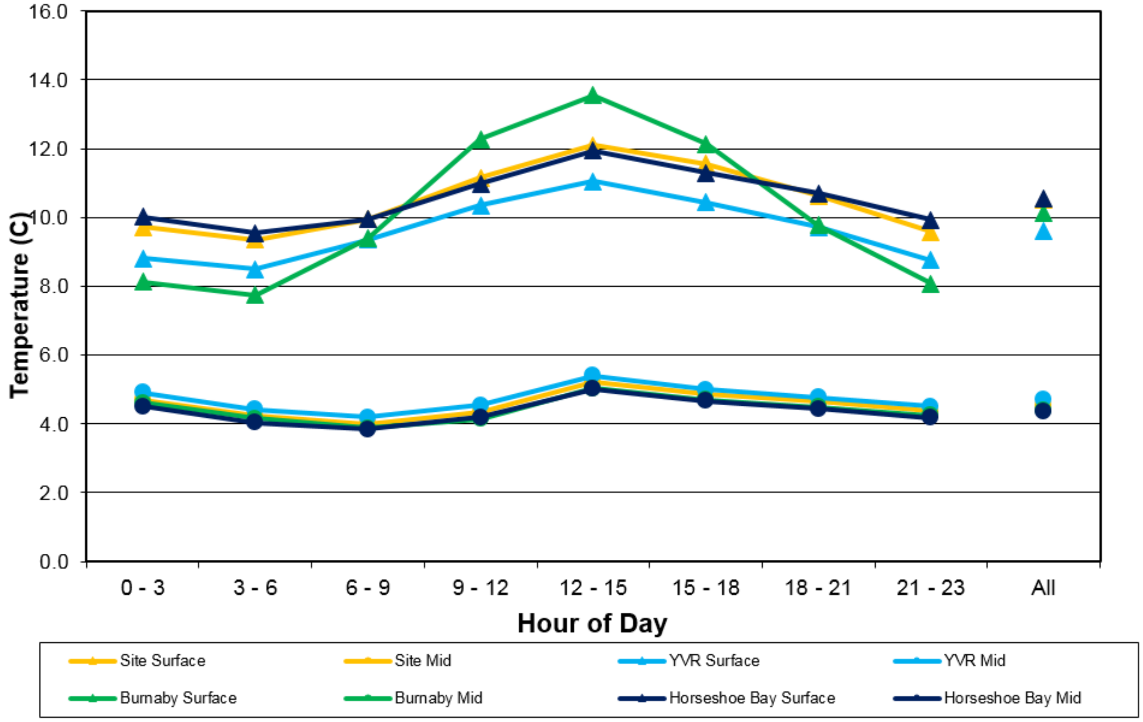
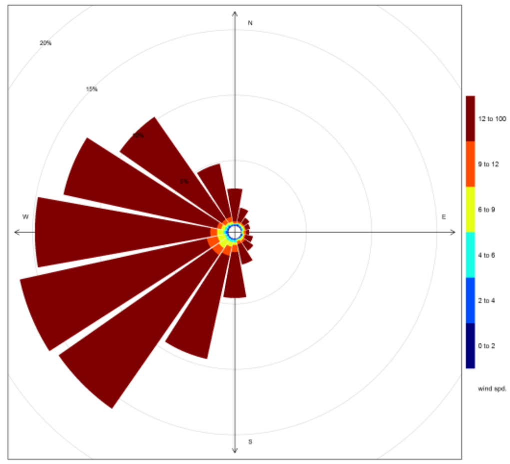
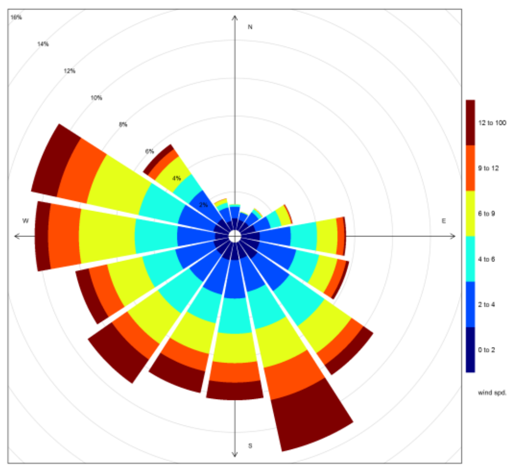


Figure B-36 Diurnal Temperature Plot at WRF Grid Points

B.5.3.2 WRF WIND ROSES

The following figures present the wind roses at the WRF extracted grid points at surface, mid and top levels of the domain. As expected, WRF captures the higher wind speeds in the layers aloft as well as a shift of winds primarily from the west, which is expected given the flow of the jet stream in those layers.


20%
15%
N
W
E
S
12 to 100
9 to 12
6 to 9
4 to 6
2 to 4
0 to 2
wind spd.


16%
14%
12%
10%
8%
6%
4%
2%
N
W
E
S
12 to 100
9 to 12
6 to 9
4 to 6
2 to 4
0 to 2
wind spd.

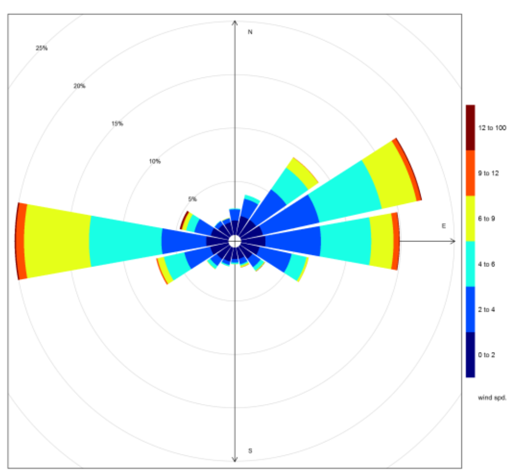
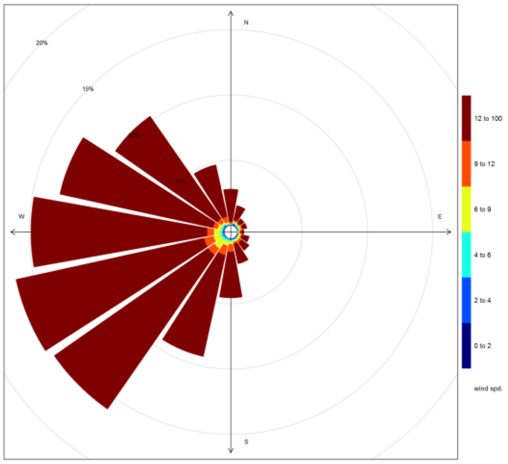
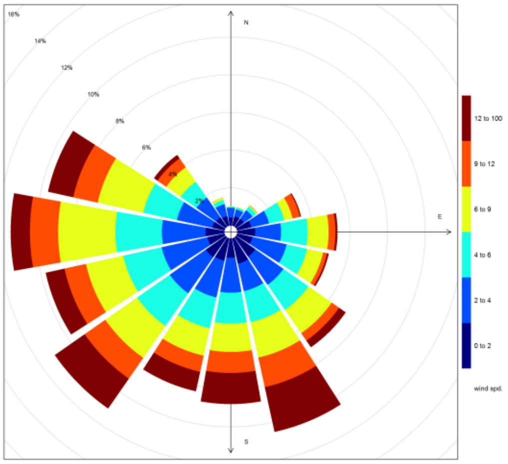

25%
20%
15%
10%
5%
N
E
S
12 to 100
9 to 12
6 to 9
4 to 6
2 to 4
0 to 2
wind spd.

Figure B-37 Annual Wind Rose at WRF extracted Site Grid Point (Top, Mid, Surface)





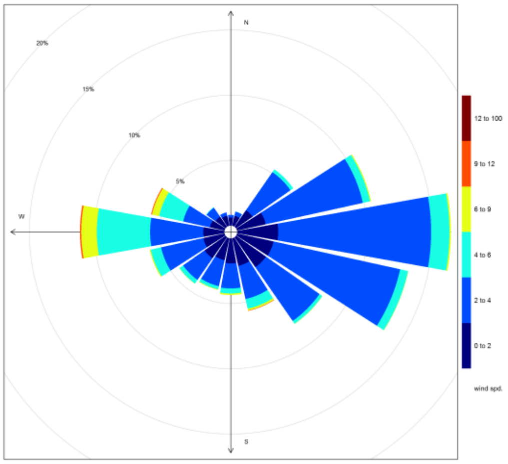
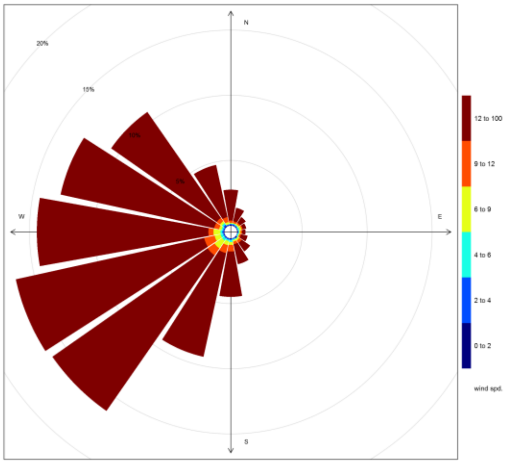
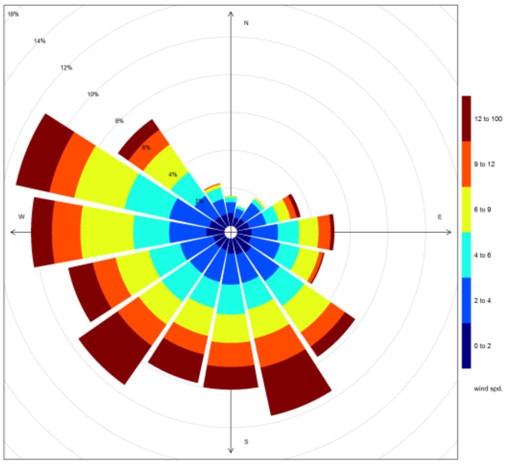


Figure B-38 Annual Wind Rose at WRF extracted Burnaby Grid Point (Top, Mid, Surface)





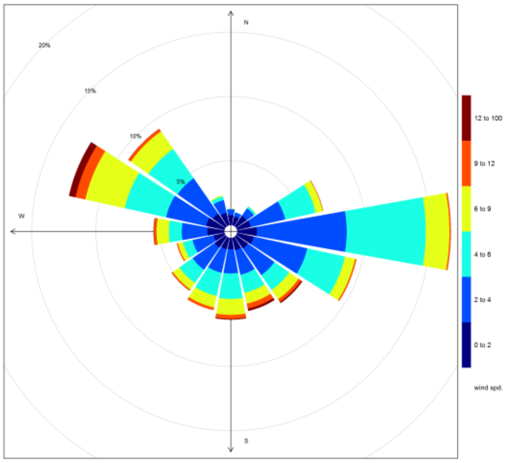
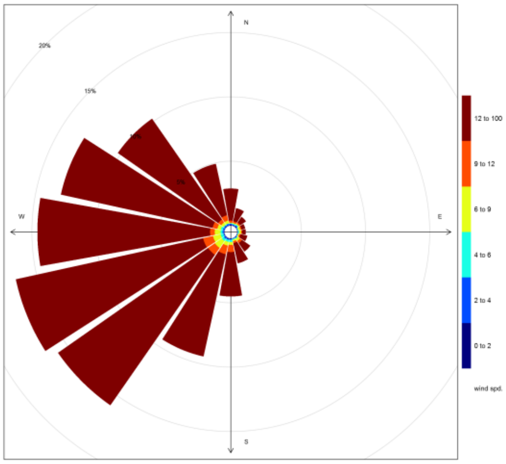
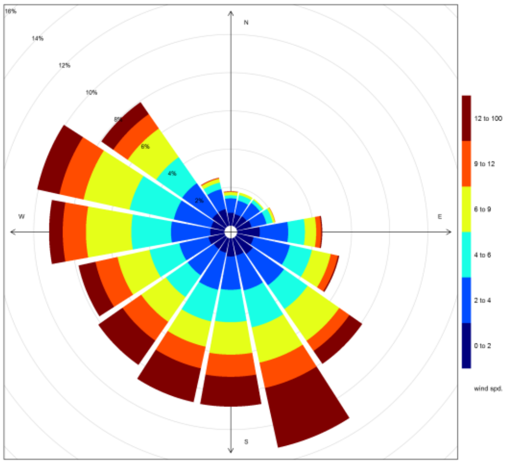


Figure B-39 Annual Wind Rose at WRF extracted YVR Grid Point (Top, Mid, Surface)





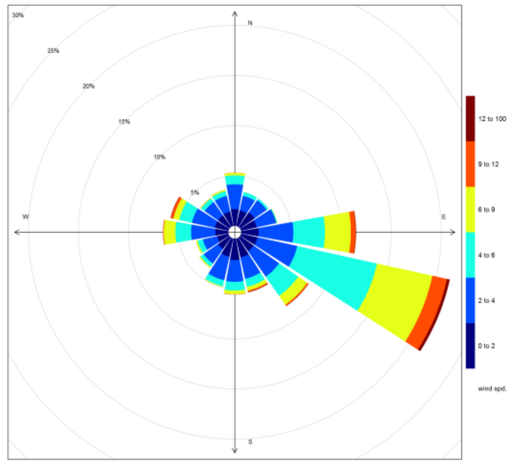


Figure B-40 Annual Wind Rose at WRF extracted Horseshoe Bay Grid Point (Top, Mid, Surface)

B.5.3.3 WRF WIND FIELDS

Representative WRF wind fields for two 24-hour periods are presented in this section. The 24-hour periods were chosen based on having light winds and stable conditions, with one of the periods during the summer season and the other during the winter season. Wind fields are presented at the surface, mid-level, and upper-level layers.

Wind field plots for the selected periods indicate that at the surface WRF is resolving the wind fields in the modelling domain reasonably well. The surface winds from WRF were further refined after the initial guess by using the surface meteorological data. WRF in the layers aloft has more uniform wind fields with higher wind speeds.

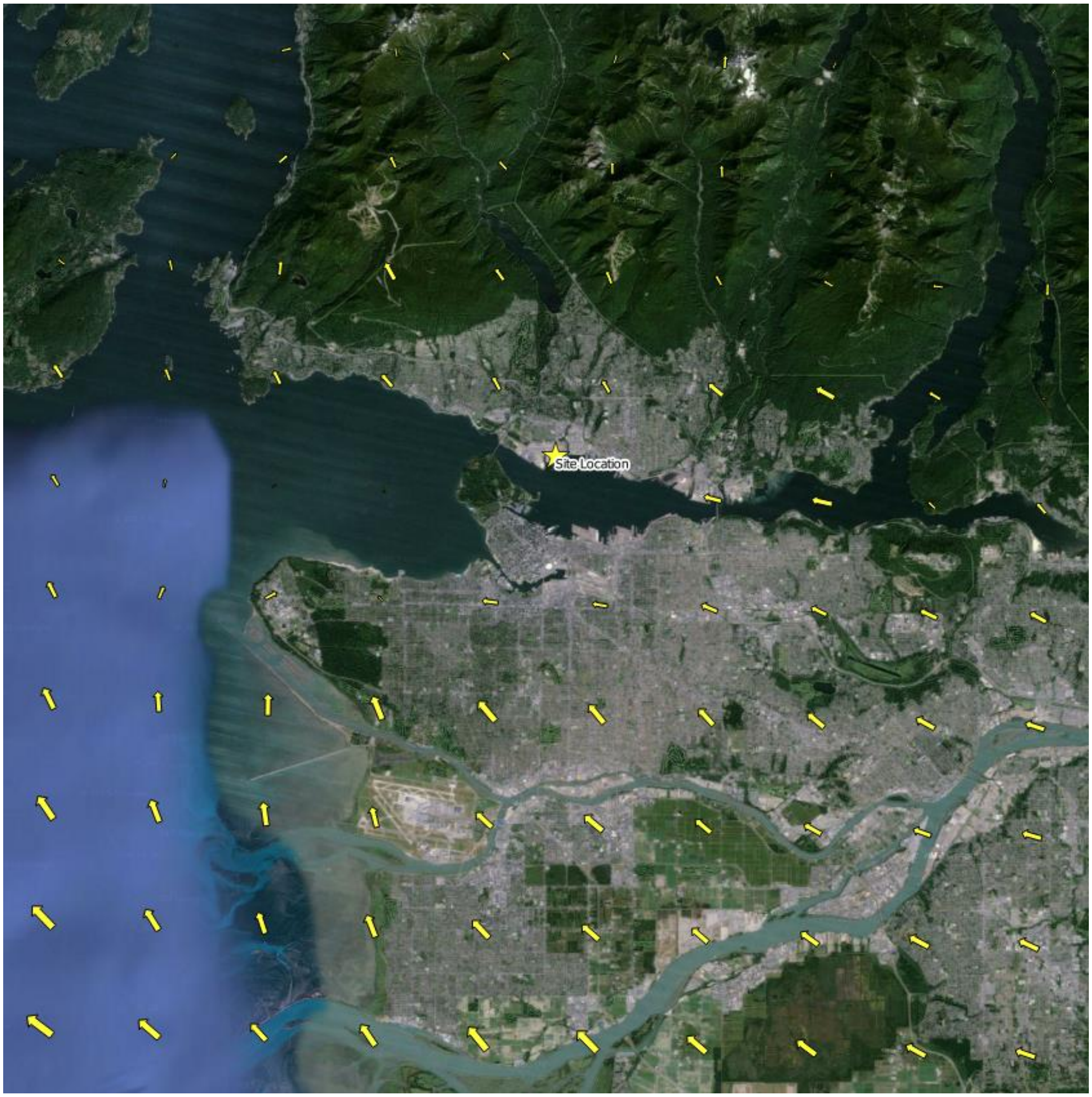


Figure B-41 WRF Wind Field Plots for the Surface Sigma Level on June 12th, 2012 at 00:00

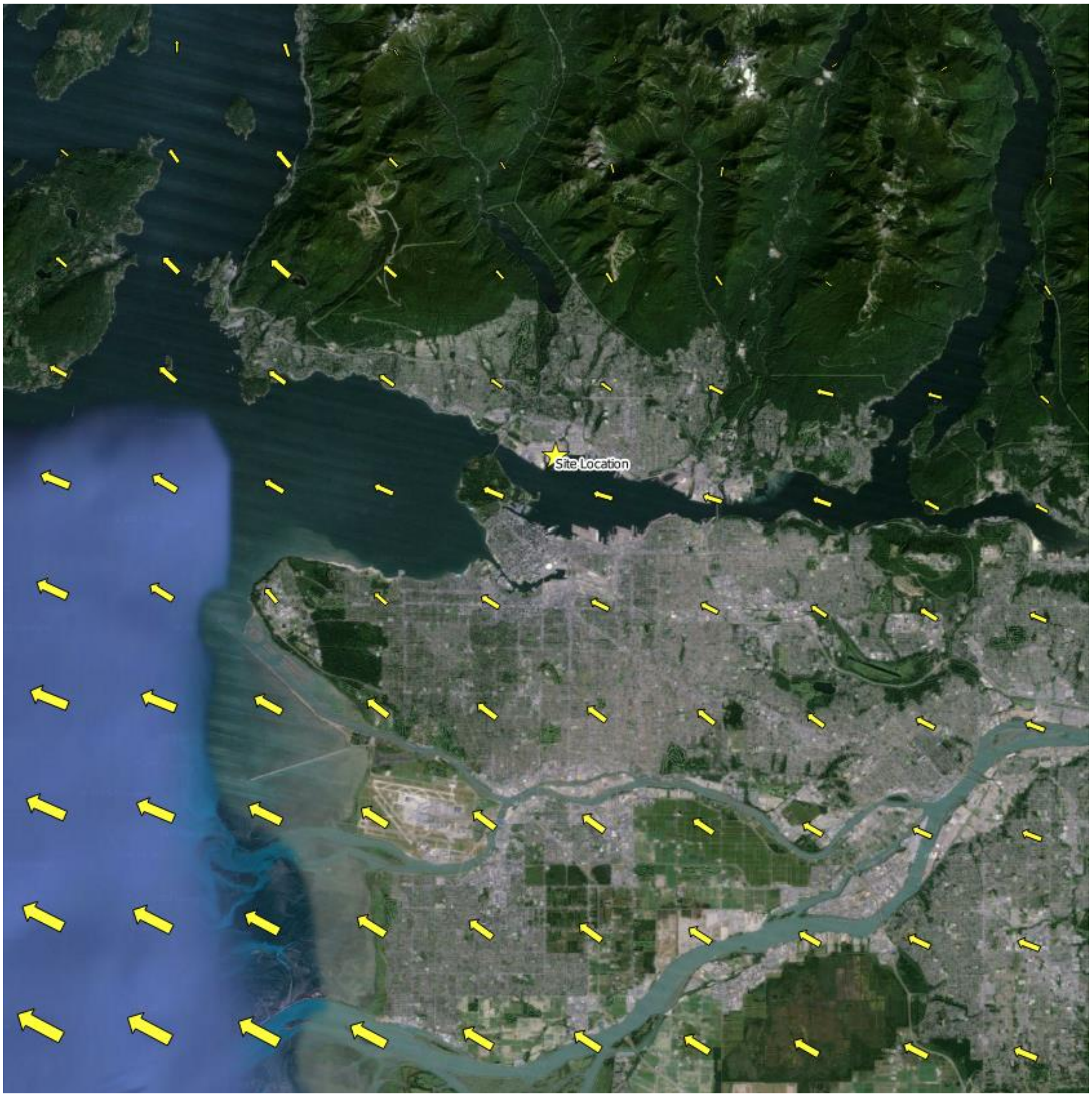


Figure B-42 WRF Wind Field Plots for the Mid Sigma Level on June 12th, 2012 at 00:00

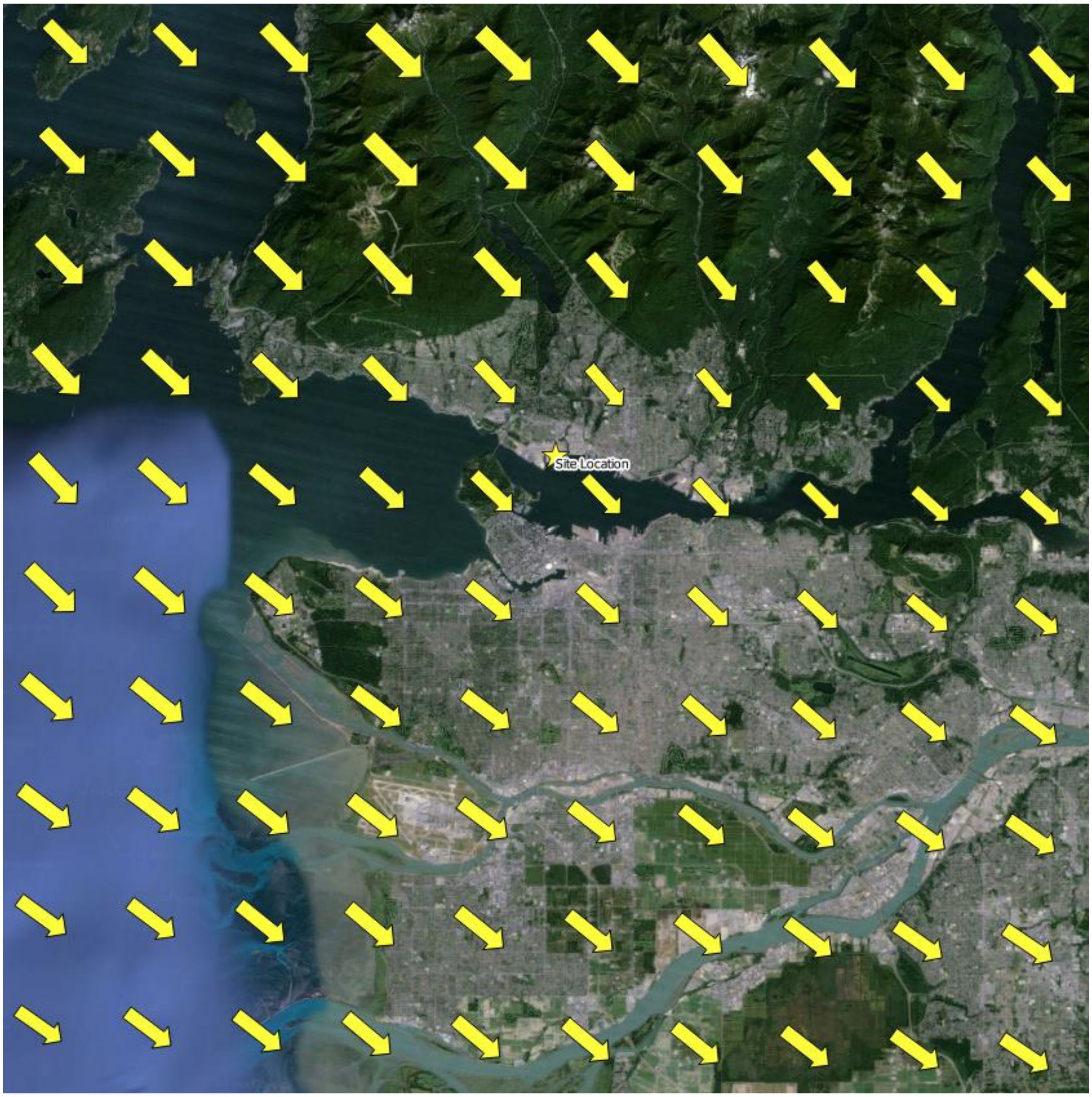


Figure B-43 WRF Wind Field Plots for the Top Sigma Level on June 12th, 2012 at 00:00

Figure B-44 WRF Wind Field Plots for the Surface Sigma Level on December 8th, at 16:00

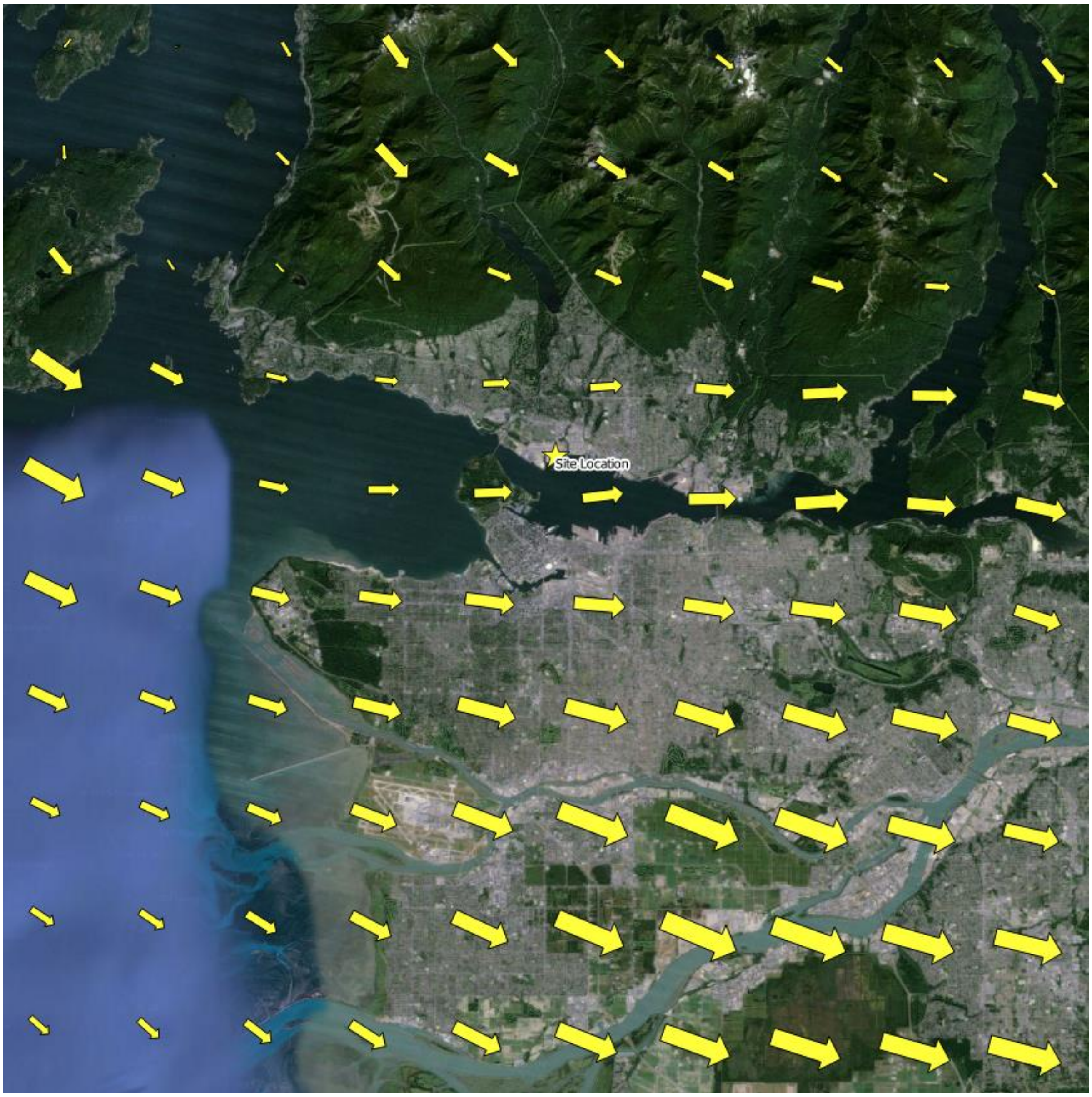


Figure B-45 WRF Wind Field Plots for the Mid Sigma Level on December 8th, at 16:00

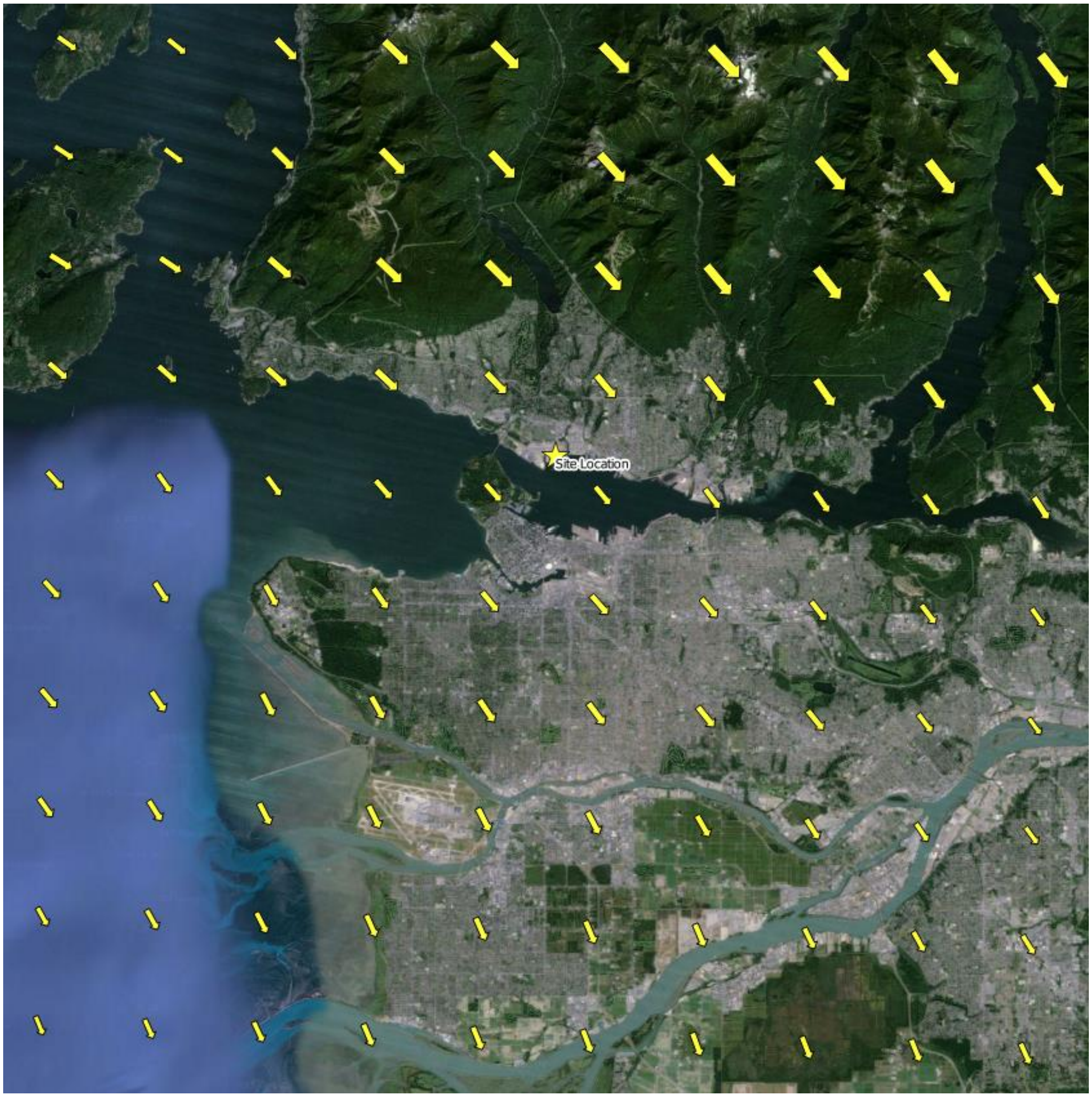


Figure B-46 WRF Wind Field Plots for the Top Sigma Level on December 8th, at 16:00

B.5.4 CALMET OUTPUT

B.5.4.1 TEMPERATURE

Figure B-47 shows the average monthly surface temperature at observed and CALMET extracted points. Figure B-48 shows the average hourly temperature (binned into intervals) at the same points. Both plots show good agreement between the predicted and observed values.

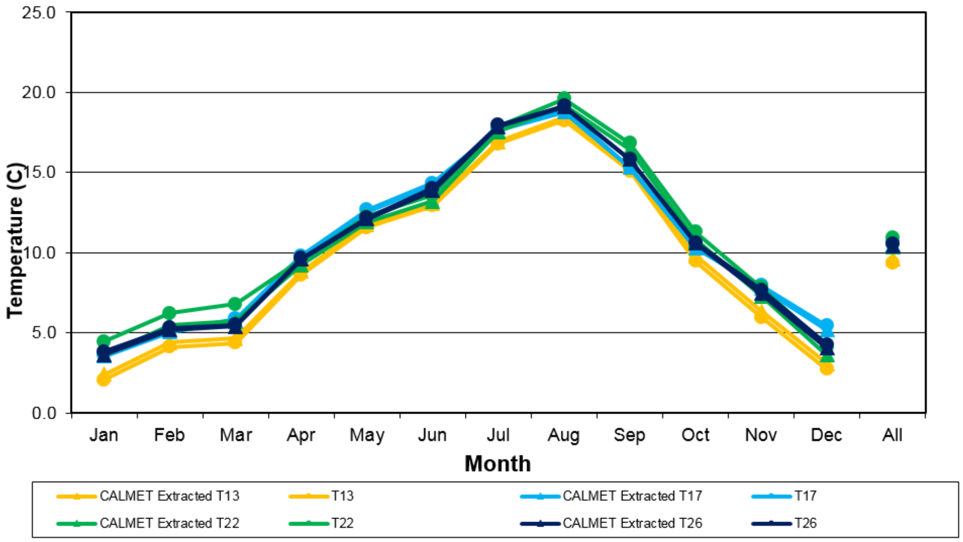


Figure B-47 Monthly Temperature Variation Observed at Meteorological Stations and Extracted Nearest Point from CALMET

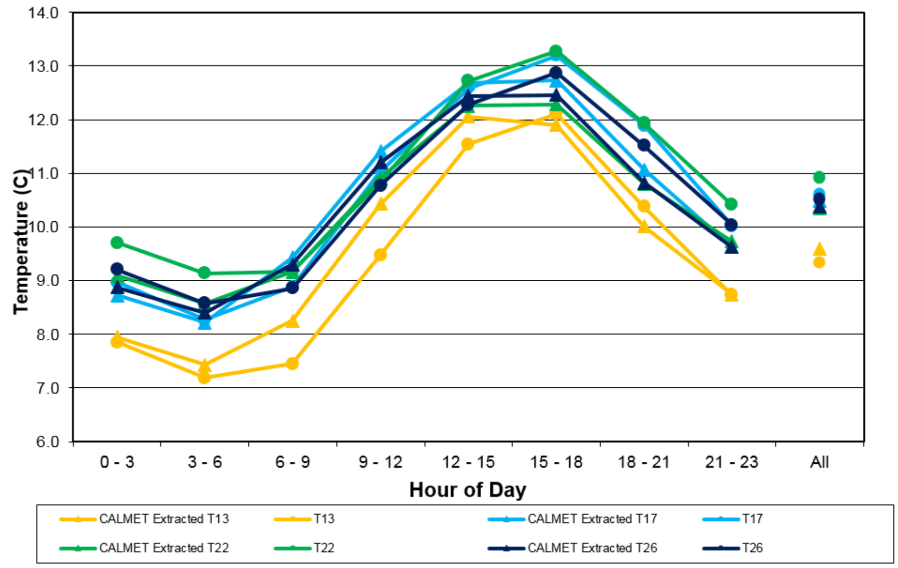


Figure B-48 Diurnal Variation Observed at Meteorological Stations and Extracted Nearest Point from CALMET

B.5.4.2 WIND SPEED

The frequency distribution of wind speed at the observed and CALMET extracted points CALMET are shown below in Figure B-38. The modelled wind speeds show good agreement with the observed data.

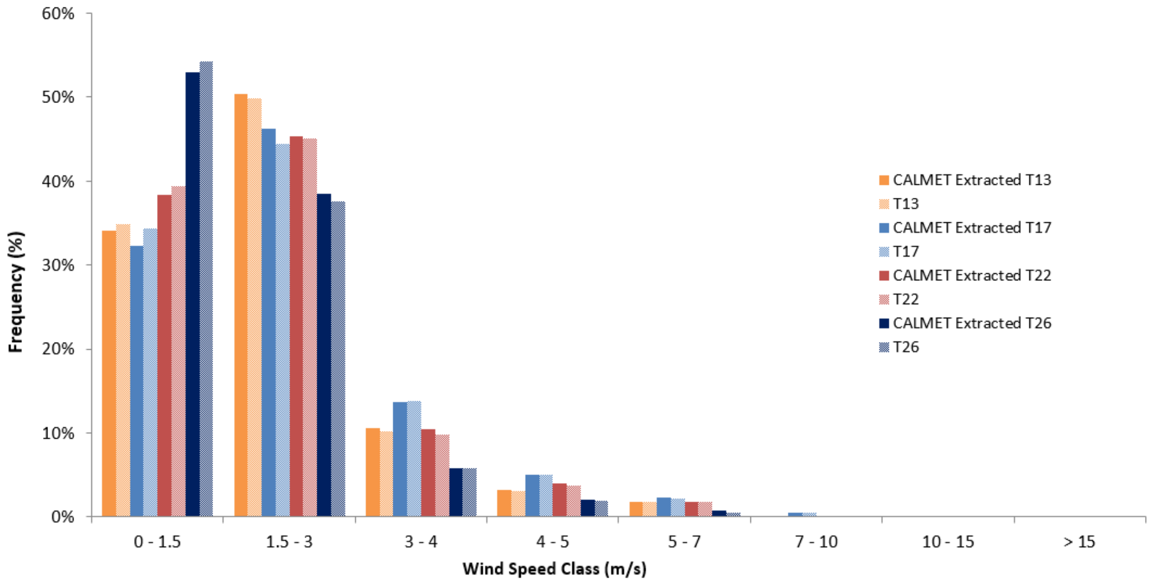


Figure B-49 Wind Speed Frequency Observed at Meteorological Stations and Extracted Nearest Point from CALMET

B.5.4.3 WIND ROSES

The following figures show wind roses extracted from CALMET at the nearest point to the selected referenced meteorological station. The wind roses show good agreement with the observed wind roses presented in section A.5.2.

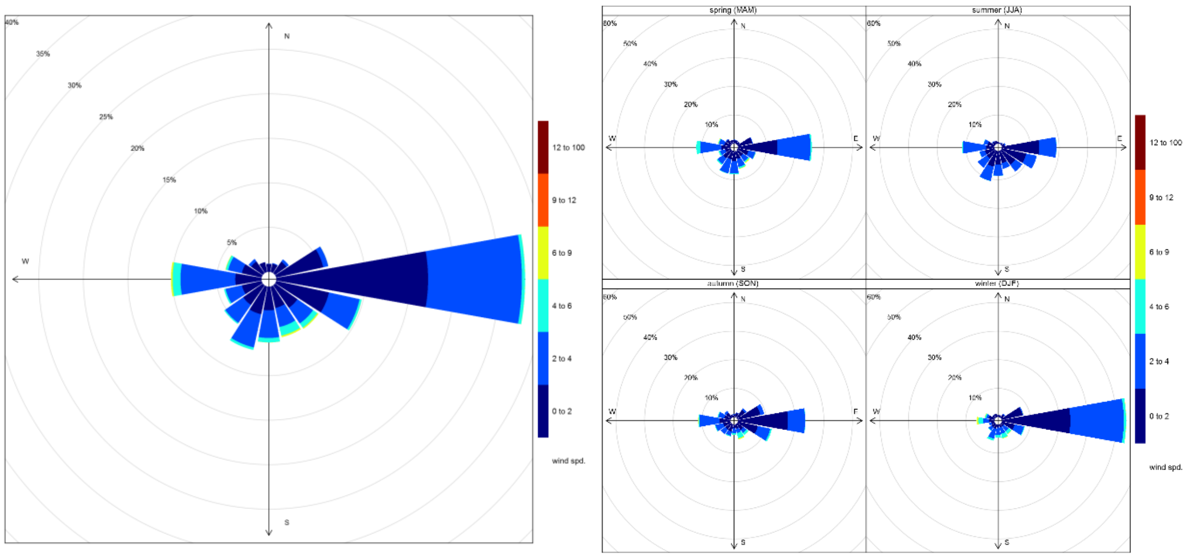


Figure B-50 CALMET Extracted Wind Roses near T13 North Delta

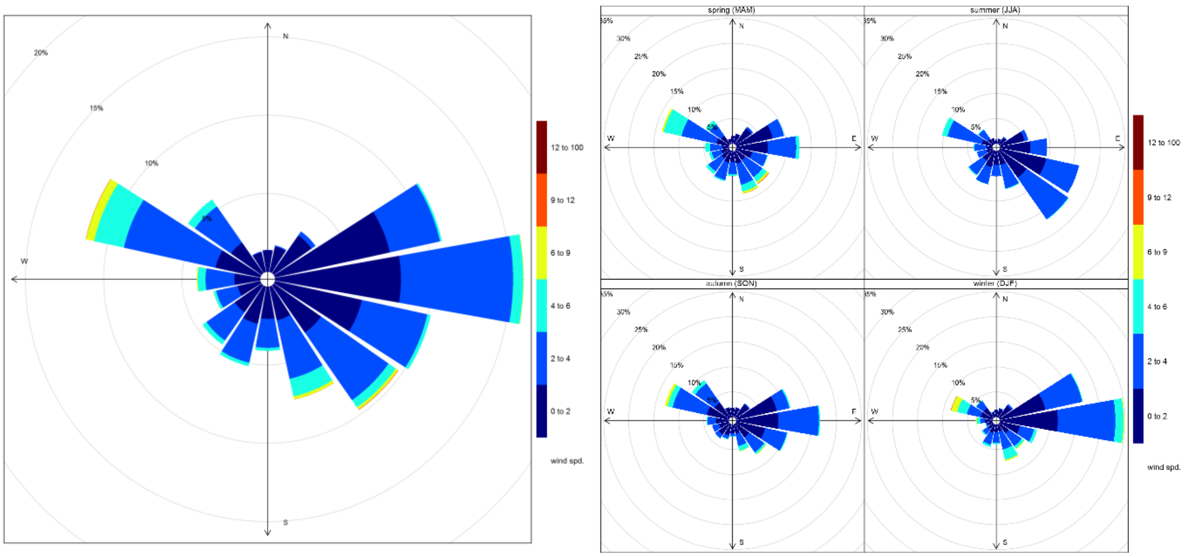


Figure B-51 CALMET Extracted Wind Roses near T17 Richmond South

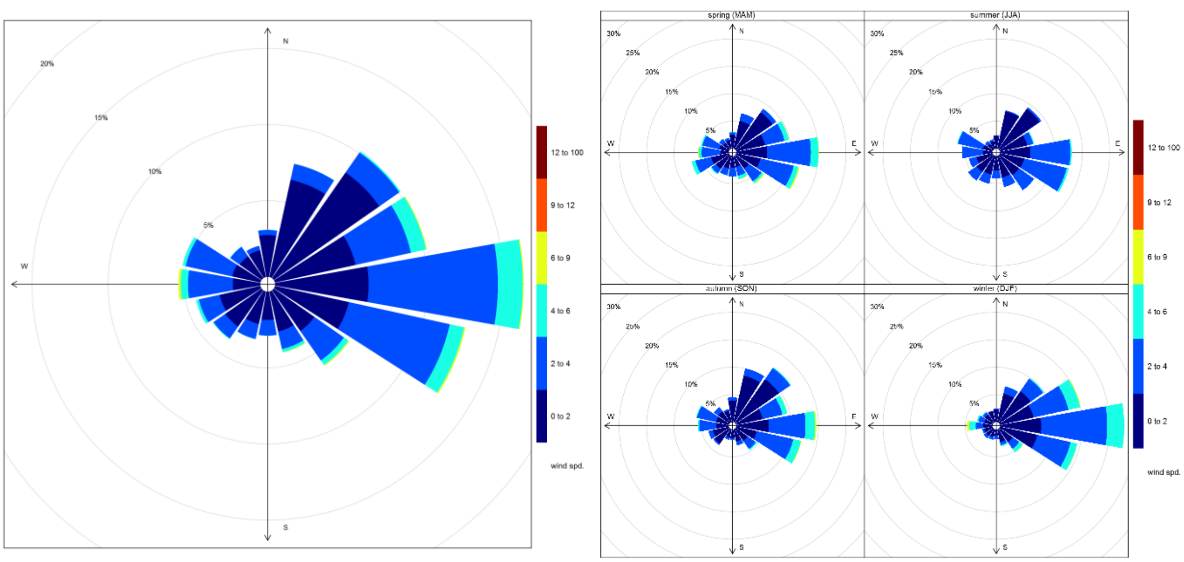
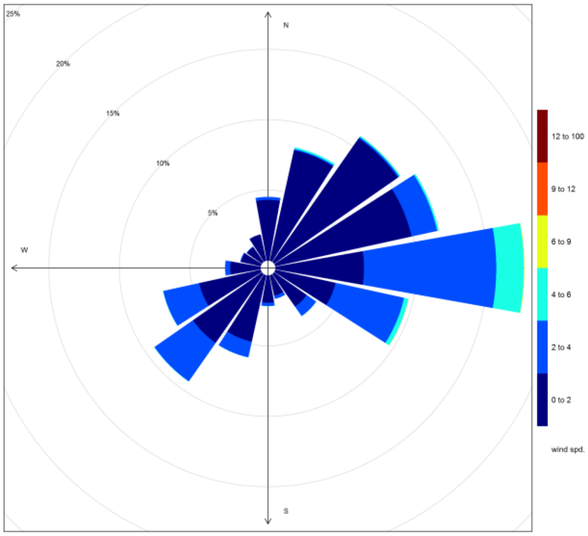


Figure B-52 CALMET Extracted Wind Roses near T22 Burnaby – Burmount



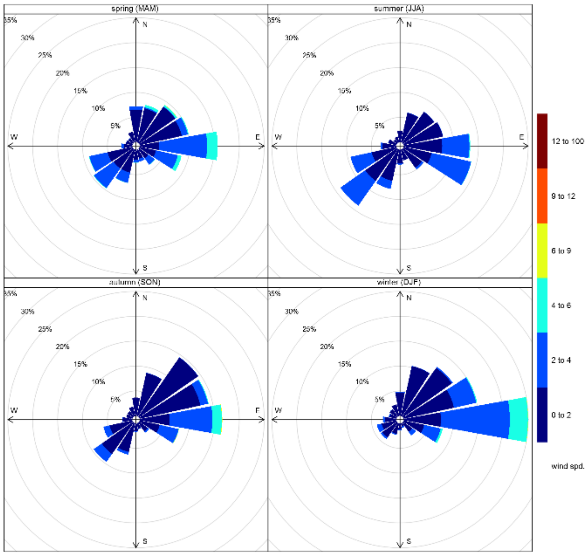


Figure B-53 CALMET Extracted Wind Roses near T26 North Vancouver – Mahon Park

B.5.4.4 CALMET WIND FIELDS

Representative CALMET wind fields for two 24-hour periods are presented in this section. The 24-hour periods were chosen based on having light winds and stable conditions, with one of the periods during the summer season and the other during the winter season. Wind fields are presented at the surface, mid-level, and upper-level layers.

Wind field plots for the selected periods indicate that at surface CALMET is resolving terrain effects and the introduction of the surface observations produces a reasonable wind field. CALMET winds in the layers aloft tend to be more uniform with higher wind speeds.

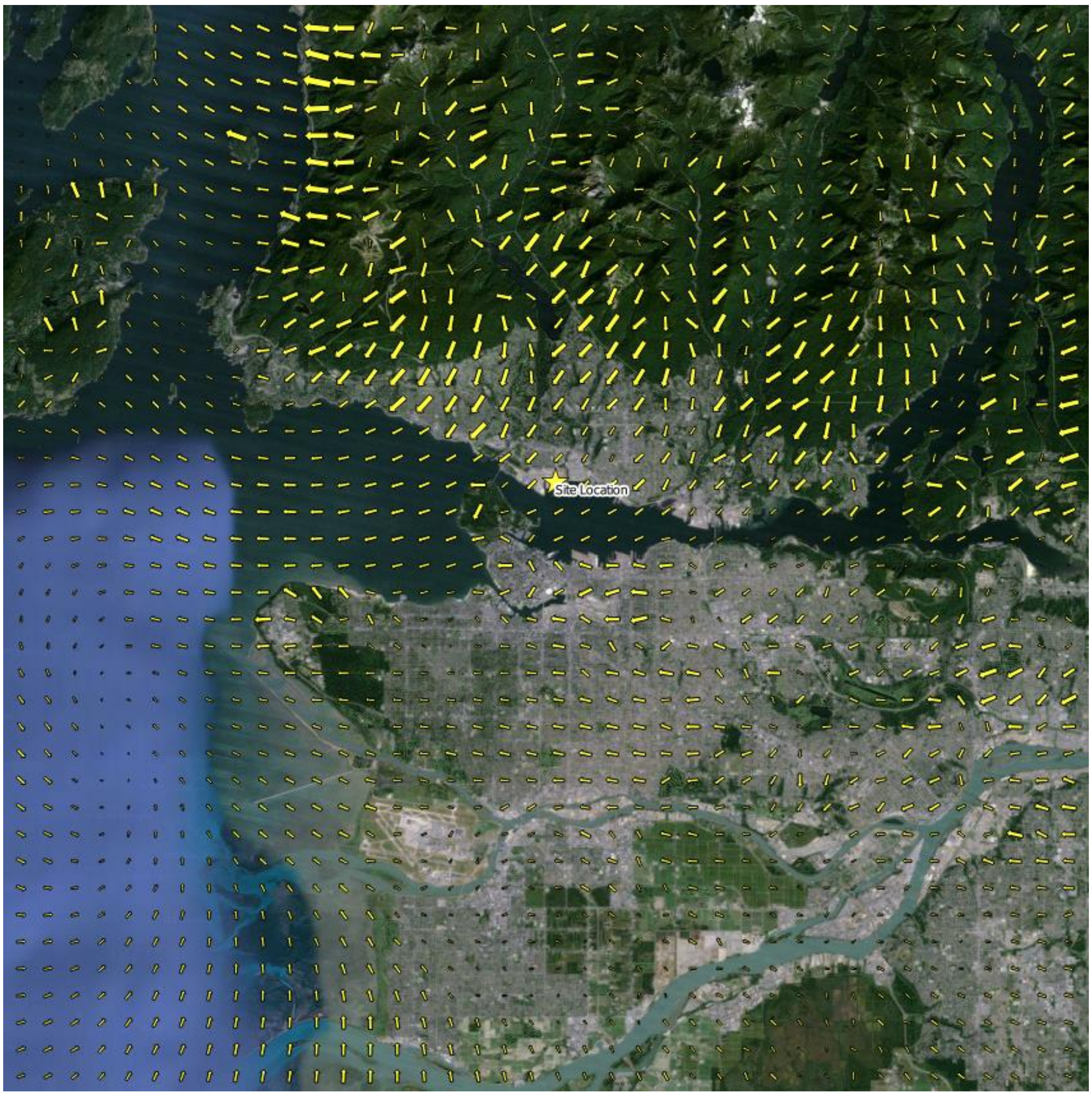


Figure B-54 CALMET Wind Field Plots for the Surface Level on June 12th, 2012 at 00:00

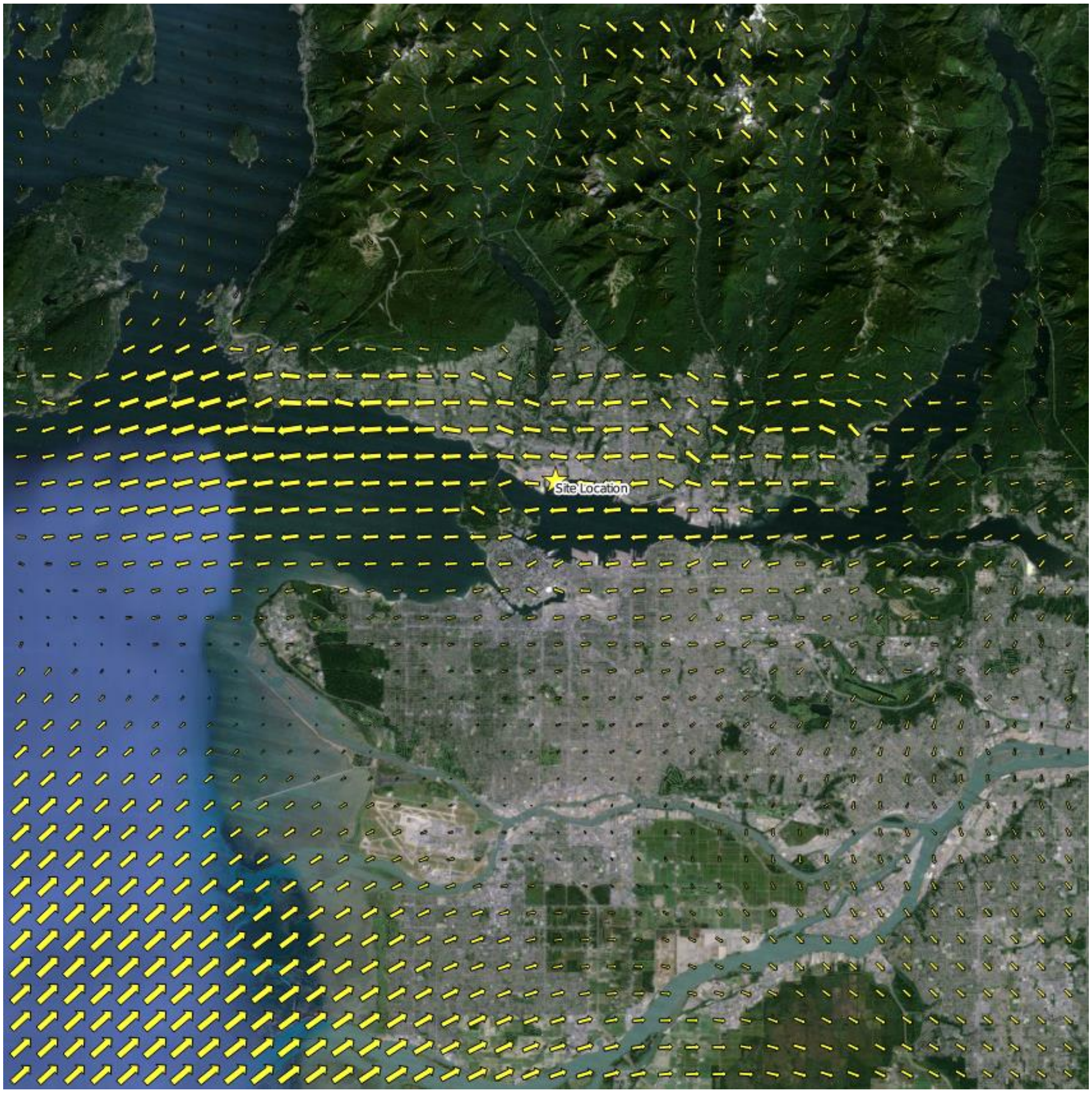


Figure B-55 CALMET Wind Field Plots for the Mid Level on June 12th, 2012 at 00:00

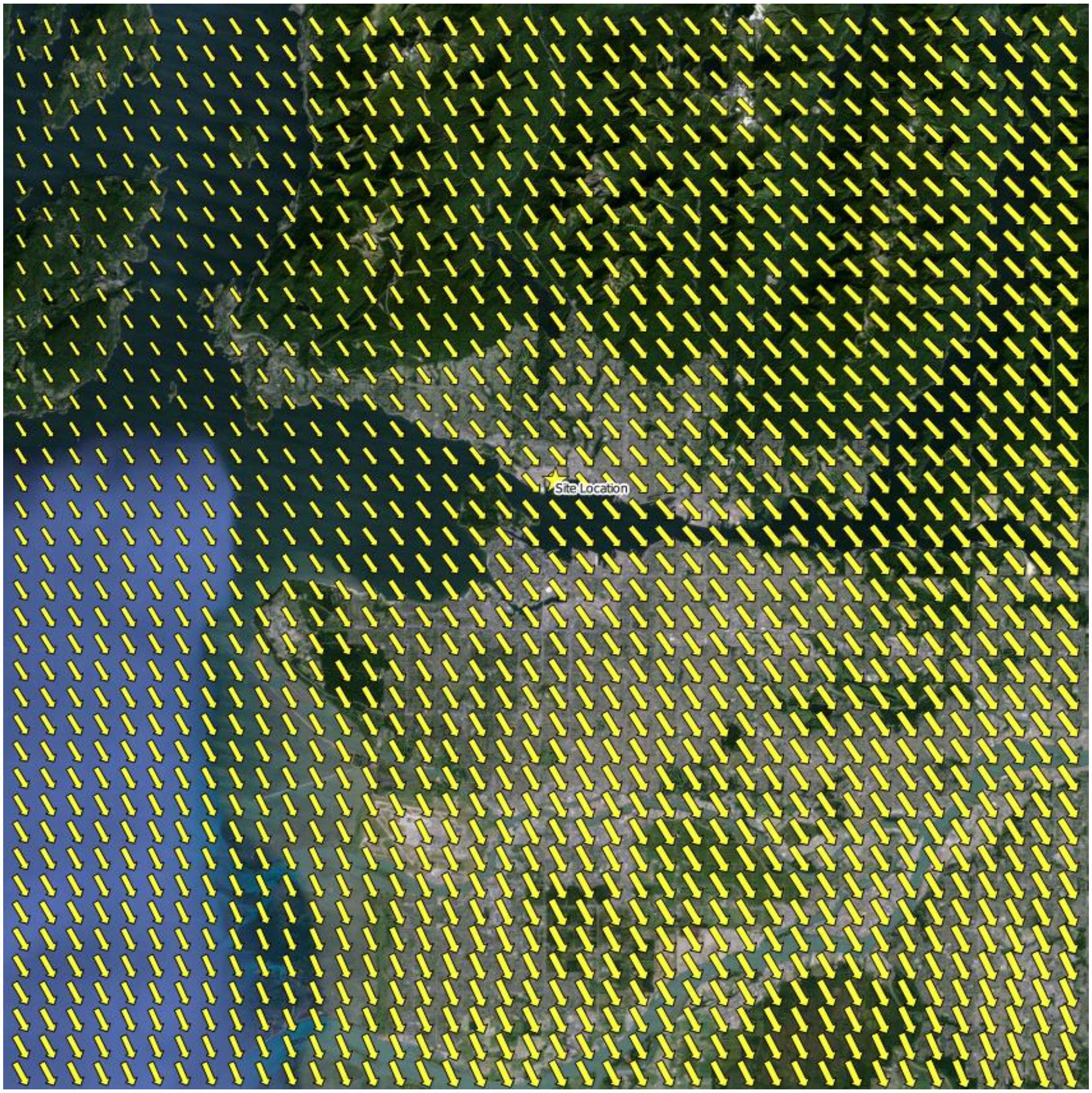


Figure B-56 CALMET Wind Field Plots for the Top Level on June 12th, 2012 at 00:00

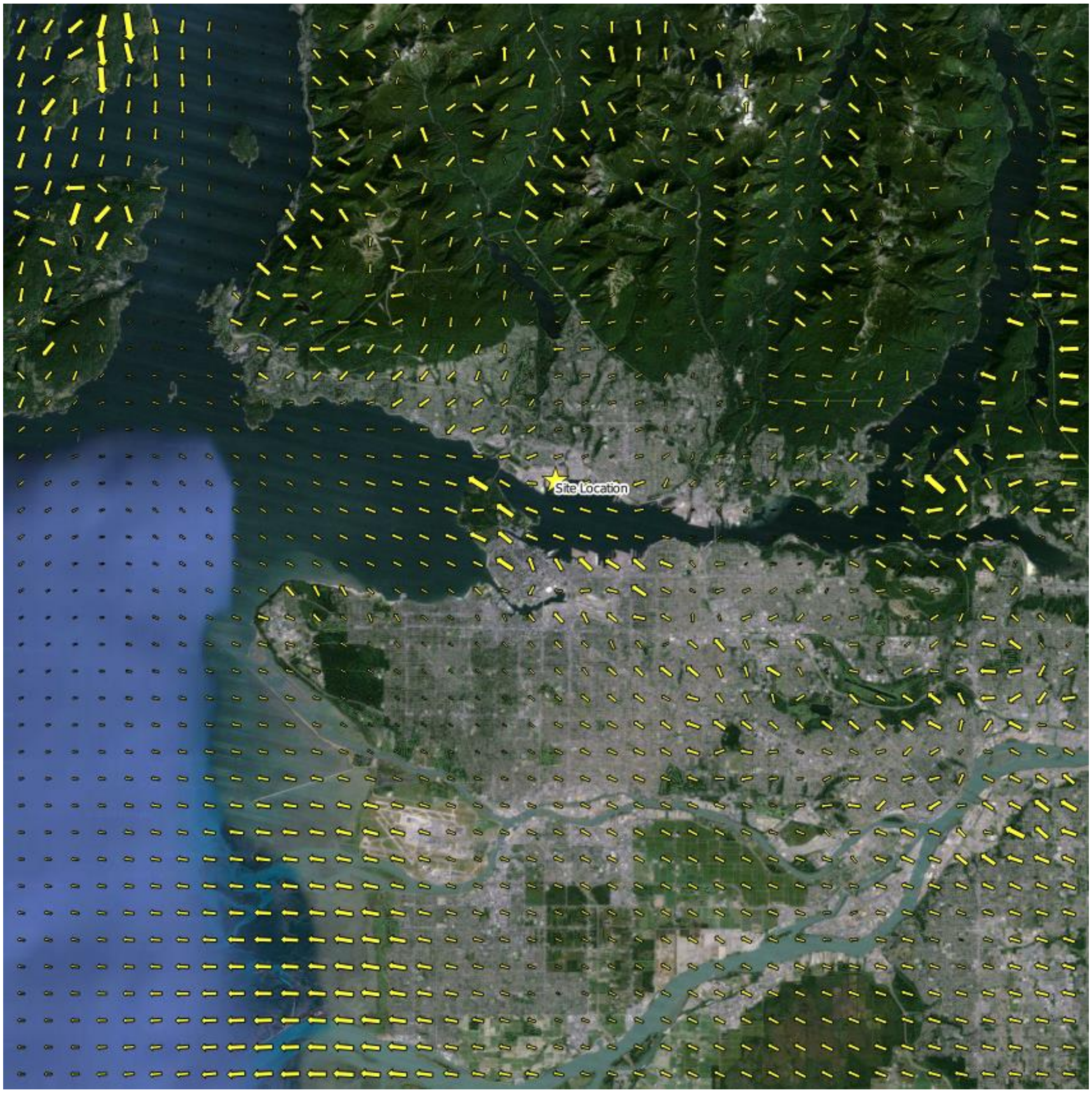


Figure B-57 CALMET Wind Field Plots for the Surface Level on December 8th, at 16:00

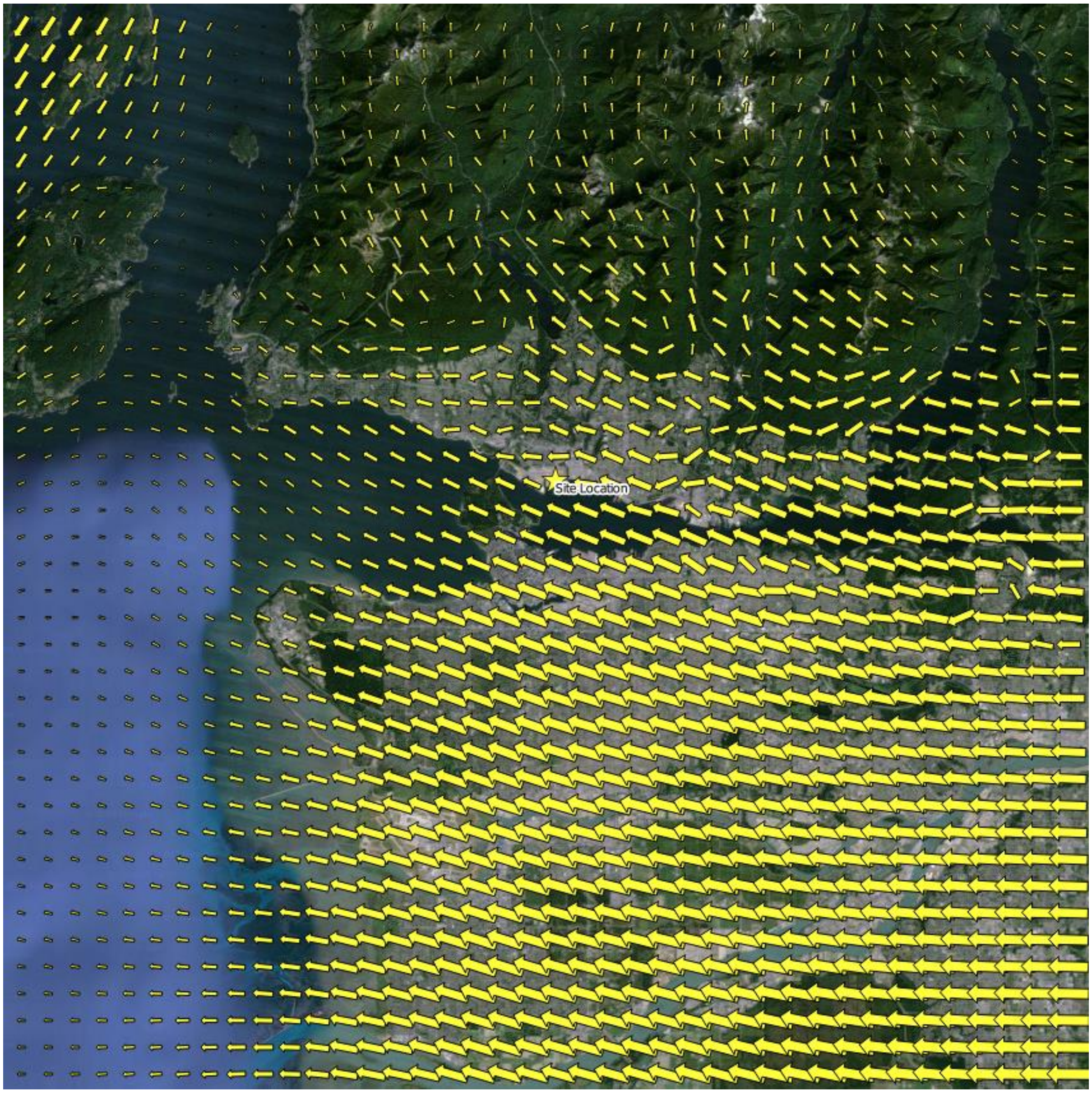


Figure B-58 CALMET Wind Field Plots for the Mid Level on December 8th, at 16:00

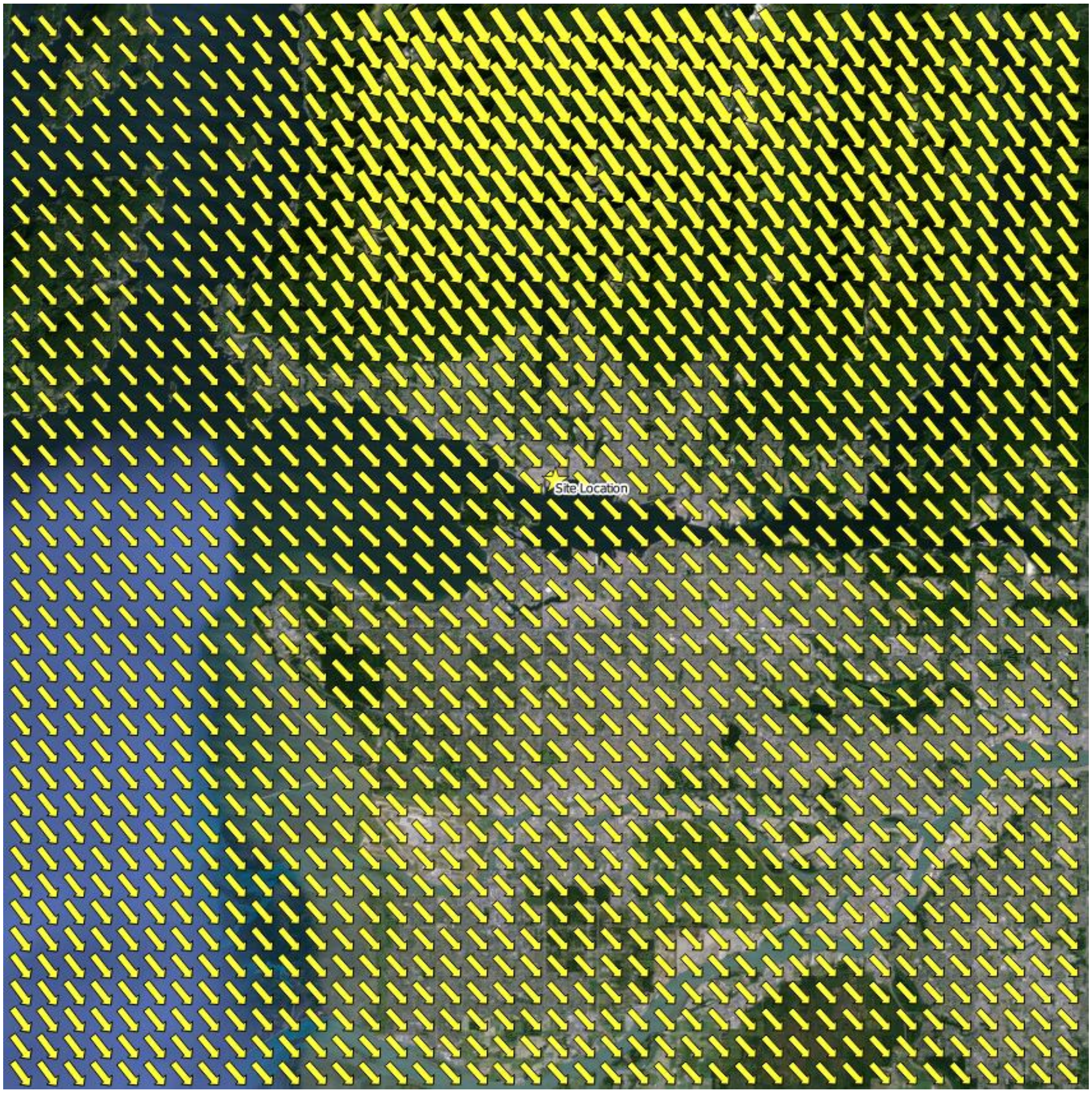


Figure B-59 CALMET Wind Field Plots for the Top Level on December 8th, at 16:00

B.5.4.5 STABILITY CLASSES

Model predicted stability classes are provided in Figure B-60. The distribution shows higher occurrences of stable (stability class 6) and neutral (stability class 4) conditions at site and near to the site. There are no observations of stability for comparison.

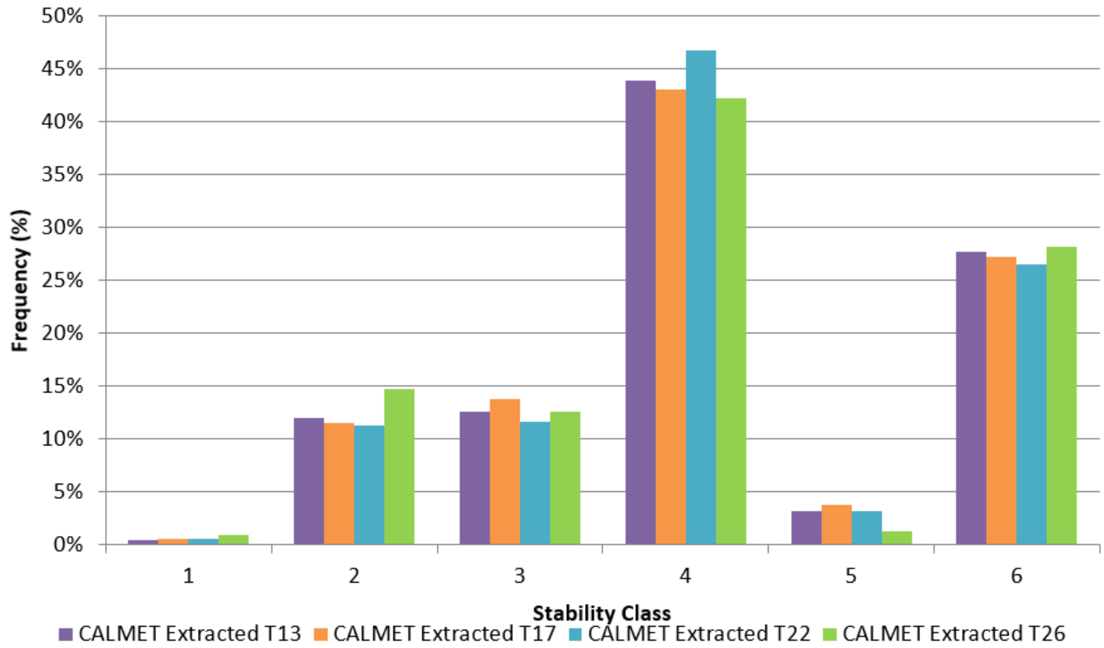


Figure B-60 Frequency Distribution of Stability Classes from CALMET Extracted Points

B.5.4.6 MIXING HEIGHTS

Predicted mixing heights statistics from CALMET are shown in Figure B-61 through Figure B-65 for select CALMET extracted points. Figure B-62 shows the diurnal mixing height variation, with the expected trend of higher mixing heights throughout the daytime compared to the nighttime. Plots in Figure B-63 and Figure B-64 show the diurnal growth and collapse of the mixing heights for selected days in the winter and summer. Figure B-65 shows the frequency distribution of all the mixing heights predicted by the CALMET model at the selected CALMET extract points.

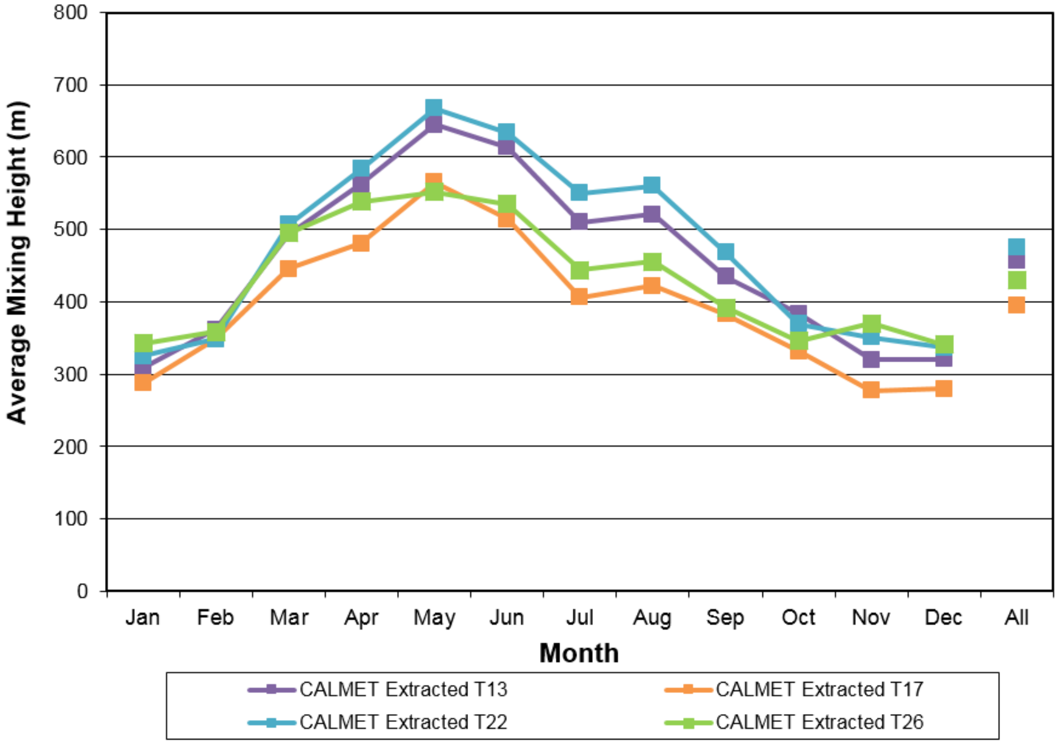


Figure B-61 CALMET Extracted Monthly Mixing Height Variation

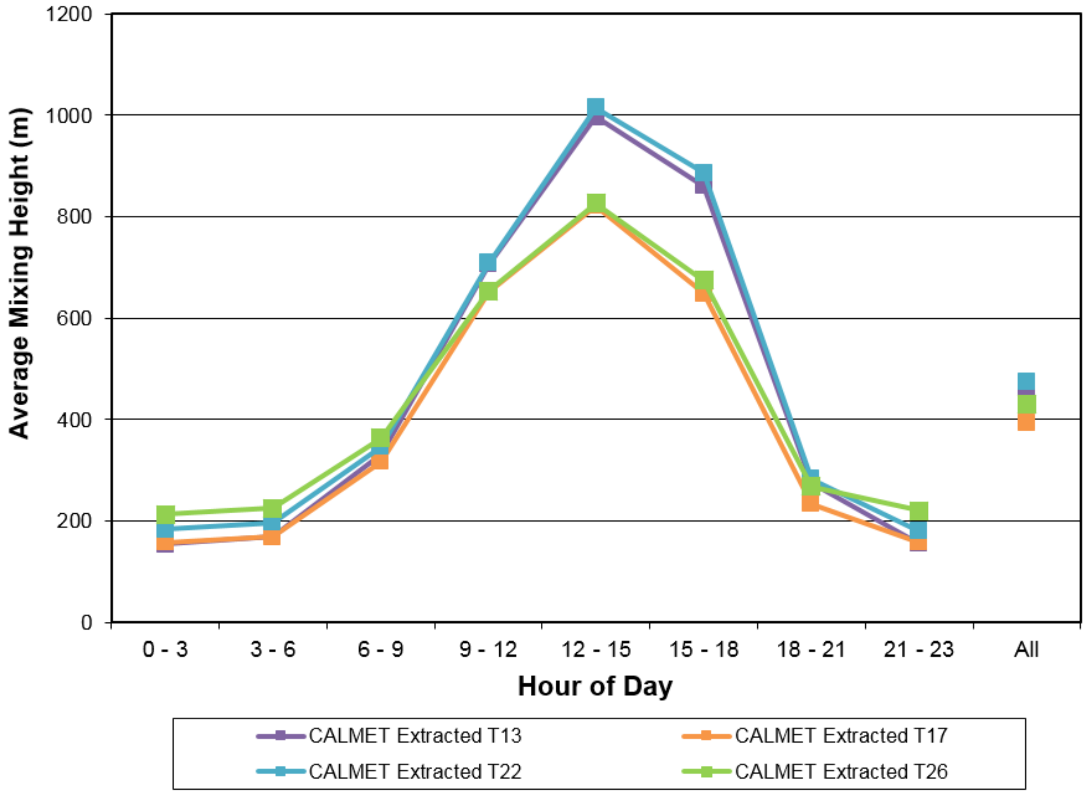


Figure B-62 CALMET Extracted Monthly Mixing Height Variation

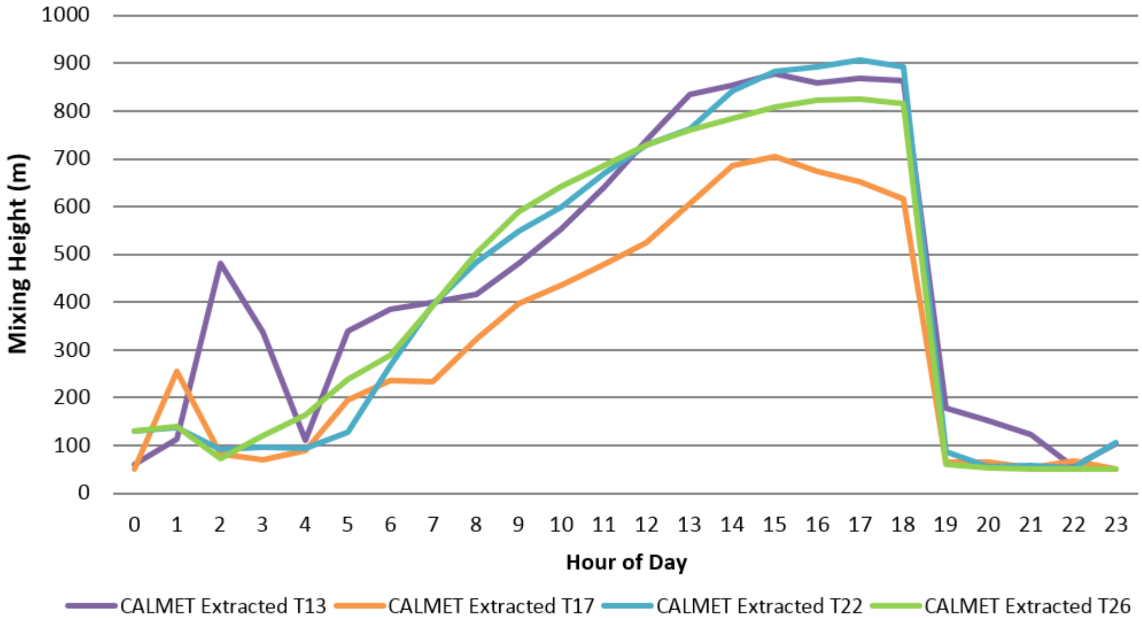


Figure B-63 CALMET Extracted Mixing Heights for June 12th, 2012

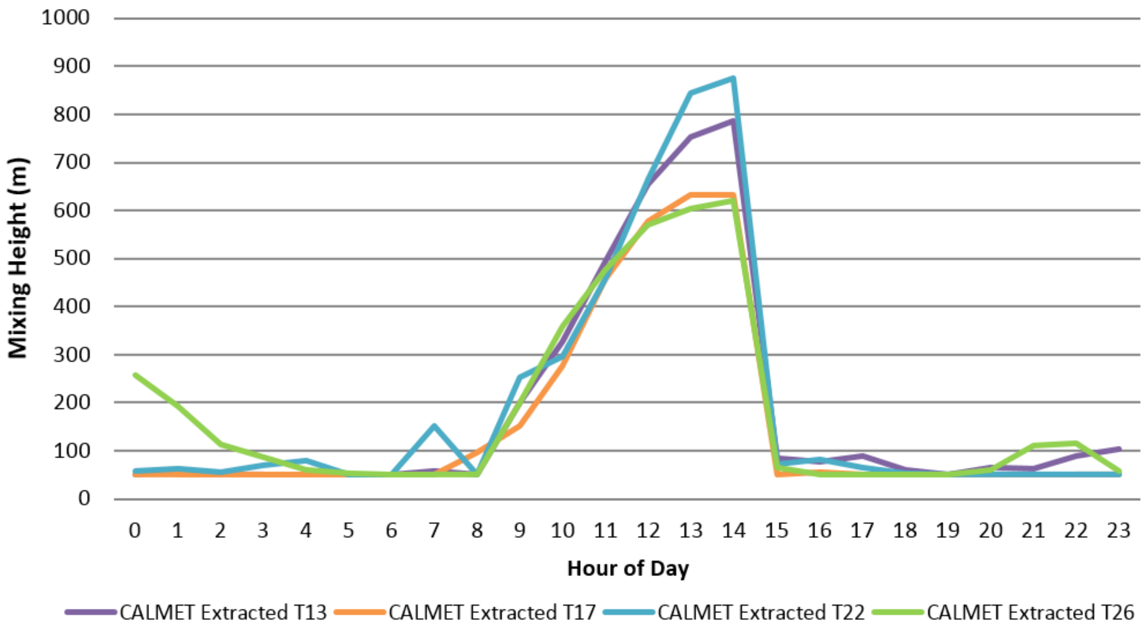


Figure B-64 CALMET Extracted Mixing Heights for December 8th, 2012

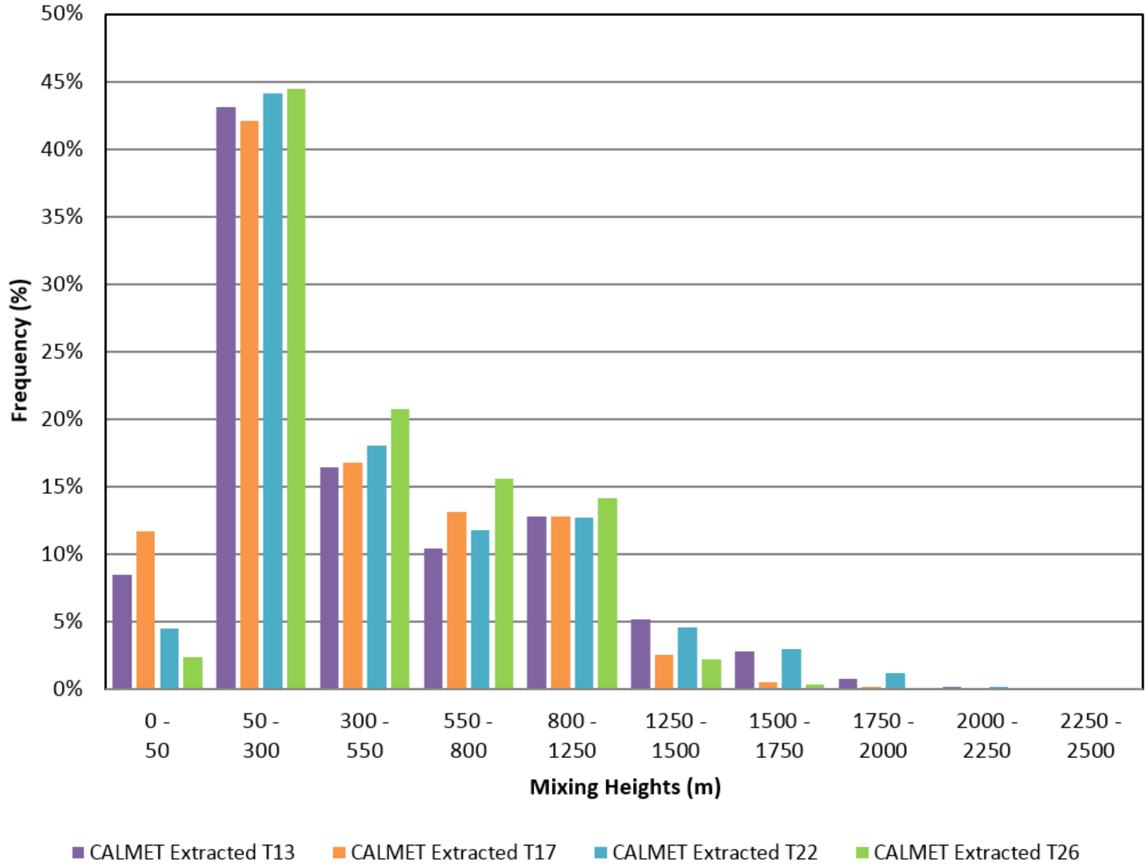


Figure B-65 CALMET Extracted Mixing Height Frequency Distribution