January 13, 2015

REPORT ON

BURNCO Air Dispersion Modelling Detailed Model Plan

Submitted to:
Ministry of Environment
Suite 200 -10470 152nd Street
Surrey, BC
V3R 0Y3

Attention: Mr. Graham Veale, Air Quality Meteorologist

REPORT

Reference Number: 1114220046-539-R-Rev2-4700

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Golder Associates

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Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

BURNCO Rock Products Ltd. (BURNCO) has proposed to construct and operate an aggregate mine using wet extraction techniques in Howe Sound, BC (the Project), with an extraction rate between 1 and 1.5 million tonnes per year. Aggregate mining activities are based on a 16 year operation period within a glacial delta area of the lower McNab Creek valley with known aggregate reserves.

BURNCO is privately owned company and has proposed the aggregate mine entirely within privately owned lands.

The proposed Project is subject to an Environmental Assessment (EA) under the British Columbia *Environmental Assessment Act*, SBC 2002, c.43 (BCEAA), pursuant to Part 3 of the *Reviewable Projects Regulation* (B.C. Reg. 370/2002) since it is likely to exceed the specified aggregate production threshold. An assessment is also required under the *Canadian Environmental Assessment Act*.

Golder Associates Ltd. (Golder) is pleased to submit this detailed air dispersion modelling plan as specified within British Columbia (BC) Ministry of Environment (MoE) (2008) *Guidelines for Air Quality Dispersion Modelling in British Columbia* (hereafter referred to as the BC Modelling Guidelines).

Potential air quality concerns related to Project are expected to be airborne particulates resulting from on-site activities such as aggregate handling and processing, wind-blown emissions from aggregate stockpiles and land clearing. These particulates include total suspended particulates (TSP), particulate matter with a nominal aerodynamic diameter less than 10 µm (PM_{10}), and particulate matter with a nominal aerodynamic diameter less than 2.5 µm ($PM_{2.5}$). Due to the availability of power on site, through a BC Hydro transmission line coupled with a neighbouring sub-station, combustion equipment (both mobile and stationary) will be limited. Major mining equipment such as the dredger, screens and crushers will be powered electrically. Quarried and processed material will be transferred around the Project site using a network of conveyors, thereby limiting the use of haul vehicles.

Additional dispersion modelling will be undertaken at human health receptors (sensitive receptors within the local and regional study areas) to assess ambient concentrations of nitrogen dioxide (NO_2) and sulphur dioxide (SO_2), $PM_{2.5}$ and PM_{10} from the Project due to tug movements in the vicinity of the Project. This will include emissions of the tug while maneuvering in the vicinity of the Project dock area. Since only one tug movement per day is expected, and tug maneuvering is expected to be less than an hour in duration, the ambient concentrations will be compared to relevant short term (1 hour) ambient air quality criteria for NO_2 and SO_2, and short term (24 hour) ambient air quality criteria for $PM_{2.5}$ and PM_{10}. The Project contribution of NO_2 and SO_2 will be added to background concentrations for comparison to relevant ambient criteria. The contribution of $PM_{2.5}$ and PM_{10} from tug boat emissions will be added to the contribution from the wider project and will be added to background concentrations for comparison to relevant ambient criteria. The background concentrations used the Project contribution and the combined background and project contributions will be provided. Additional longer averaging periods may be added based on the results of the short term (1 hour and 24 hour) comparison.

As a part of the air dispersion modelling assessment, Golder has submitted a conceptual model plan (Golder 2013) to BC MoE for the Project in December 2013. Since that submission there have been changes in the following:

- Land clearing mitigation measures,
- Site boundary,
- Processing Plant Site Layout, and
- Tugboat travel frequency.

2.0 GENERAL INFORMATION

2.1 Contact Information

Table 1: Contact Information

Organization	Contact Name/Position	Contact information	Address
Ministry of Environment	Graham Veale	604-582-5286	Ministry of Environment 2nd Floor 10470-152nd Street Surrey, BC V3R 0Y3
Consultant - Golder Associates	Jeffrey Ramkellawan	604-296-4355	Golder Associates Ltd. Suite 200 – 2920 Virtual Way, Vancouver, BC, V5M 0C4
Consultant - Golder Associates	Rachel Wyles	604-296-2826	Golder Associates Ltd. Suite 200 – 2920 Virtual Way, Vancouver, BC, V5M 0C4

2.2 Schedule

The anticipated application schedule with respect to air emission related activities is shown in Table 2 below.

Table 2: Schedule

Task	Date
Pre-application Meeting	February 27, 2013
Submission of draft conceptual model plan	April 29, 2013
Response to BC MoE comments on draft conceptual model plan	May 27, 2013
Submission of detailed model plan to BC MoE	August 8, 2014
Meeting with BC MoE to discuss comments on the detailed model plan	November 19, 2014
Anticipated required response/clarification of detailed model plan submitted to BC MoE	December 29, 2014
Final version submitted to BC MoE	January 13, 2015
Sign off from the BC MoE	Janury 16, 2015

2.3 Anticipated Changes

Information contained within the detailed model plan reflects the best available information to date. Changes to the Project description, that would result in significant changes to the air dispersion modelling approach are not anticipated.

3.0 FACILITY DESCRIPTION

A description of the Project facility location and an overview of the Project description, including process description and site layout are presented in this section.

3.1 Facility Location

Facility Name: BURNCO Aggregate Project
Company: BURNCO Rock Products Ltd. (BURNCO)
Location (Latitude, Longitude): Howe Sound BC (Lat. 49.564° N, Lon. 123.390° W)

3.2 Project Description

During the operational period of the aggregate facility five major activities will occur each year. These activities are land clearing (expected to occur over a 30 day period), aggregate extraction and initial processing (dredging, primary crushing and screening), conveying from pit to processing plant, processing (crushing and screening) and storage of material in the processing plant area and transfer to barge. A tugboat will be used to barge the aggregate from the Project to BURNCOs' facilities in Langley and Burnaby.

During each operational year the excavation pit will be expanded, land will therefore need to be cleared to accommodate the expansion. The overburden soil will be hauled and stored in berms (eventually vegetated) to the north and east of the pit area. Land clearing will be conducted using a dozer and excavator. The emissions from land clearing are expected to be a significant portion of the Project's particulate emissions; however, land clearing is expected to occur, at most, over 30 days throughout the year.

Due to the availability of power on site, through a BC Hydro transmission line coupled with a neighbouring sub-station, the need for diesel combustion equipment (both mobile and stationary) will be limited. The main aggregate extraction and processing equipment such as the dredger, screens and crushers will be powered electrically. Quarried and processed material will be transferred around the Project site using a network of conveyors, thereby eliminating the use of haul vehicles for aggregate movement. In the conceptual model plan submitted to BC MoE (Golder 2013), it was stated that due to the limited use of diesel combustion equipment, emissions such as SO_2 and NO_2 will be quantified and their impacts to the surrounding environment will be qualitatively discussed; while the particulate matters emissions, TSP, PM_{10}, and $PM_{2.5}$ will be assessed using dispersion modelling. However, based on a conversation with Health Canada tugboat exhaust effects will be modelled and assessed at sensitive receptors in the local and regional study areas.

Due to the wet mining process most of the conveyed material will have a moisture content of 5% or greater; for material conveyed from the stockpiles to the barge, covered conveyors will be used. BURNCO proposes to transport processed aggregate material by barge to BURNCO's existing facilities in Langley and Burnaby.

The wet extraction process will consist of a flooded aggregate pit area below existing groundwater levels. Sand and gravel will be extracted from the pit using an electrically powered floating clamshell dredge, equipped with a primary crusher and a floating conveyor system. No pit dewatering will be required, and no explosives will be used. The wet extraction technique will act as a fugitive dust and particulate control technique thus eliminating the potential for fugitive particulate emissions. A berm will also be built on the south and north sides of the pit area.

Once conveyed to the processing plant, using over water conveyors and an underground conveyor from the pit lake to the processing plant area, the aggregate material will be stored in surge pile. At the plant the aggregate material will undergo the following processing:

- Transfer of aggregate material from surge pile to dry screening using a partially underground conveyor;
- Dry screening to extract fines and 20 mm crushed gravel;
- Crushing the remaining aggregate material;
- Dry screening of the crushed material to separate the aggregate into three sizes fractions;
- The fines and the 20 mm crushed gravel will then be wet-screened to extract four more aggregate size fractions; and
- All seven aggregate sized fractions will be sourced to stockpiles in the plant area.

Within the plant area fugitive particulate emission control practices will include enclosure of crushers and screens, enclosure of transfer points, water sprays and covered conveyors from stockpiles to the barge.

4.0 AIR EMISSION CHARACTERIZATION

Based on the Project description, as described in Section 3.2, activities that would result in particulate emissions are listed in Table 3. Particulate matter associated with diesel vehicle exhaust will be included in the inventory and subsequent modelling.

Table 3: Emission Activity Types

Activities for Land Clearing	Activities for Aggregate Extraction and Processing
Bulldozing	Dredging
Excavating	Material handling
Fugitive road dust	Stockpile wind erosion
Material handling	Screening
Vehicle exhaust	Crushing
	Conveyor transfer points
	Propane combustion
	Vehicle and tugboat exhaust

Due to the nature of site operations the pit will be expanded each year therefore the location of the following activities will vary from year to year,

- Dredging,
- Excavating,
- Bulldozing,
- Primary crushing,
- Primary screening, and
- Fugitive unpaved road dust.

For the air quality assessment the aforementioned sources were placed where they would be expected to have most impact on the surrounding sensitive receptors (specifically the condominium residences).

Emission rates for the various emission activities will be calculated based on a relevant emission factors (such as US EPA AP-42) and activity data supplied by BURNCO. For emission activities that would have emission controls, as specified by BURNCO, an appropriate emission reduction factor will be applied to the emission rate calculation. The basis of the emissions for modelled parameters is as described below:

1) *US EPA AP-42 Emissions Factors, Chapter 11.9 Western Surface Coal Mining* (US EPA 1998);

2) *US EPA AP-42 Emissions Factors, Chapter 13.2.2 Unpaved Roads* (US EPA 2006);

3) *US EPA AP-42 Emissions Factors, Chapter 13.2.4 Aggregate Handling and Storage Piles* (US EPA 2006);

4) *Control of Open Fugitive Dust Source,* (US EPA 1988);

5) *US EPA AP-42 Emissions Factors, Chapter 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing* (US EPA 2004);

6) *US EPA AP-42 Emissions Factors, Chapter 1.5 Liquefied Petroleum Gas Combustion* (US EPA 2008);

7) *Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling – Compression Ignition*, | (US EPA 2010); and

8) *2005-2006 BC Ocean-Going Vessel Emissions Inventory* (Chamber of Shipping 2007).

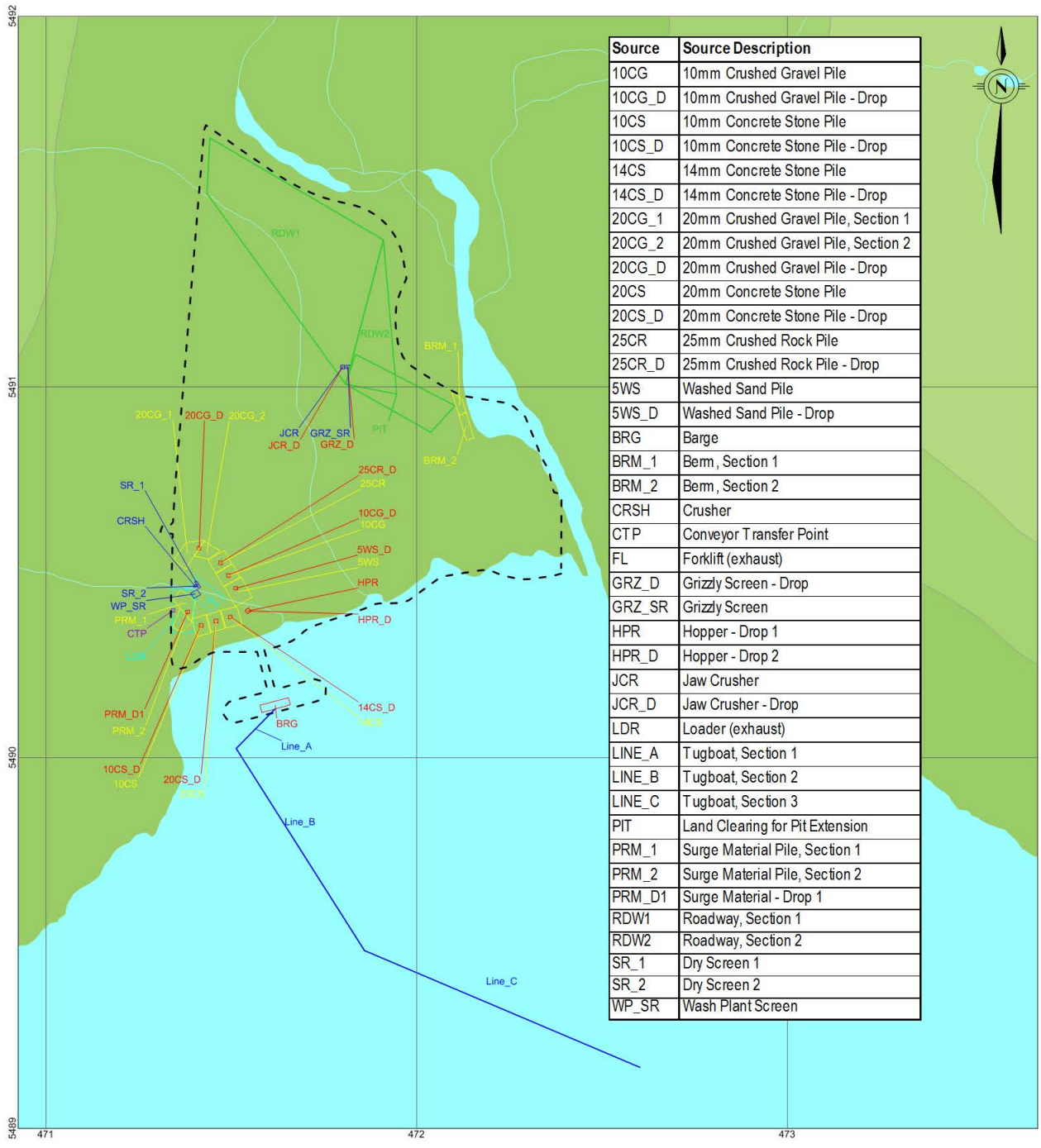
Based on the site layout the emission activities (Table 3) will be assigned to 37 area sources that were identified for inclusion in the air dispersion modelling; these sources, along with their emission activities, and emission calculation methods are listed in Table 4 and illustrated in Figure 1. Table 5 summarizes the combustion tugboat emissions that will be assessed at the health receptors.

Table 4: Emission Area Sources

Area Source		Activity Type	Substances			Basis of Emissions
Name	Description		TSP	PM_{10}	$PM_{2.5}$	
PIT	Pit – Land Clearing	Bulldozing, excavating	✓	✓	✓	(1)
		Fugitive road dust	✓	✓	✓	(2)
		Material handling	✓	✓	✓	(3)
		Engine exhaust	✓	✓	✓	(7)
BRM_1	Berm 1	Material handling	✓	✓	✓	(3)
		Stockpile wind erosion	✓	✓	✓	(4)
BRM_2	Berm 2	Material handling	✓	✓	✓	(3)
		Stockpile wind erosion	✓	✓	✓	(4)
JCR	Jaw Crusher	Material crushing	✓	✓	✓	(5)
JCR_D	Jaw Crusher - Drop	Material handling	✓	✓	✓	(3)
GRZ_SR	Grizzly Screen	Material screening	✓	✓	✓	(5)
GRZ_D	Grizzly Screen - Drop	Material handling	✓	✓	✓	(3)
PRM_D1	6” Pitrun Surge Material – Drop	Material handling	✓	✓	✓	(3)
PRM_1	6” Pitrun Surge Material 1	Stockpile wind erosion	✓	✓	✓	(4)
PRM_2	6” Pitrun Surge Material 2	Stockpile wind erosion	✓	✓	✓	(4)
FL	Forklift	Engine exhaust	✓	✓	✓	(7)
LDR	Loader	Engine exhaust	✓	✓	✓	(7)
SR_1	Dry Screen 1	Material handling	✓	✓	✓	(3)
		Material screening	✓	✓	✓	(5)
CRSH	Crusher	Material crushing	✓	✓	✓	(5)
		Welding propane combustion	✓	✓	✓	(6)
SR_2	Dry Screen 2	Material handling	✓	✓	✓	(3)
		Material screening	✓	✓	✓	(5)
25CR	25 mm Crushed Rock	Stockpile wind erosion	✓	✓	✓	(4)
25CR_D	25 mm Crushed Rock – Drop	Material handling	✓	✓	✓	(3)
10CG	10 mm Crushed Gravel	Stockpile wind erosion	✓	✓	✓	(4)
10CG_D	10 mm Crushed Gravel – Drop	Material handling	✓	✓	✓	(3)
20CG_1	20 mm Crushed Gravel – Split 1	Stockpile wind erosion	✓	✓	✓	(4)
20CG_2	20 mm Crushed Gravel – Split 2	Stockpile wind erosion	✓	✓	✓	(4)
20CG_D	20 mm Crushed Gravel - Drop	Material handling	✓	✓	✓	(3)
WP_SR	Wash Plant Screen	Material handling	✓	✓	✓	(3)
		Material screening	✓	✓	✓	(5)
14CS	14mm Concrete Stone	Stockpile wind erosion	✓	✓	✓	(4)
14CS_D	14 mm Concrete Stone – Drop	Material handling	✓	✓	✓	(3)
10CS	10mm Concrete Stone	Stockpile wind erosion	✓	✓	✓	(4)
10CS_D	10 mm Concrete Stone - Drop	Material handling	✓	✓	✓	(3)
5WS	Washed Sand	Stockpile wind erosion	✓	✓	✓	(4)
5WS_D	Washed Sand - Drop	Material handling	✓	✓	✓	(3)
20CS	20mm Concrete Stone	Stockpile wind erosion	✓	✓	✓	(4)
20CS_D	20 mm Concrete Stone- Drop	Material handling	✓	✓	✓	(3)
HPR	Hopper	Material handling	✓	✓	✓	(3)
HPR_D	Hopper- Drop	Material handling	✓	✓	✓	(3)
BRG	Barge	Material handling	✓	✓	✓	(3)
RDW1	Roadway 1 to North Berm	Fugitive road dust	✓	✓	✓	(2)
		Engine exhaust	✓	✓	✓	(7)
RDW2	Roadway 2 to North Berm	Fugitive road dust	✓	✓	✓	(2)
		Engine exhaust	✓	✓	✓	(7)
CTP	Conveyor Transfer Point	Conveyor Drop	✓	✓	✓	(5)

Table 5: Tugboat Emission Source

Line Source		Activity Type	Substances				Basis of Emissions
Name	Description		SO_2	NO_2	PM_{10}	$PM_{2.5}$	
LINE	Tugboat Route	Ocean-Going Exhaust	✓	✓	✓	✓	(8)



Source	Source Description
10CG	10mm Crushed Gravel Pile
10CG_D	10mm Crushed Gravel Pile - Drop
10CS	10mm Concrete Stone Pile
10CS_D	10mm Concrete Stone Pile - Drop
14CS	14mm Concrete Stone Pile
14CS_D	14mm Concrete Stone Pile - Drop
20CG_1	20mm Crushed Gravel Pile, Section 1
20CG_2	20mm Crushed Gravel Pile, Section 2
20CG_D	20mm Crushed Gravel Pile - Drop
20CS	20mm Concrete Stone Pile
20CS_D	20mm Concrete Stone Pile - Drop
25CR	25mm Crushed Rock Pile
25CR_D	25mm Crushed Rock Pile - Drop
5WS	Washed Sand Pile
5WS_D	Washed Sand Pile - Drop
BRG	Barge
BRM_1	Berm, Section 1
BRM_2	Berm, Section 2
CRSH	Crusher
CTP	Conveyor Transfer Point
FL	Forklift (exhaust)
GRZ_D	Grizzly Screen - Drop
GRZ_SR	Grizzly Screen
HPR	Hopper - Drop 1
HPR_D	Hopper - Drop 2
JCR	Jaw Crusher
JCR_D	Jaw Crusher - Drop
LDR	Loader (exhaust)
LINE_A	Tugboat, Section 1
LINE_B	Tugboat, Section 2
LINE_C	Tugboat, Section 3
PIT	Land Clearing for Pit Extension
PRM_1	Surge Material Pile, Section 1
PRM_2	Surge Material Pile, Section 2
PRM_D1	Surge Material - Drop 1
RDW1	Roadway, Section 1
RDW2	Roadway, Section 2
SR_1	Dry Screen 1
SR_2	Dry Screen 2
WP_SR	Wash Plant Screen

500 0 500
SCALE METERS

LEGEND

- *Elevations are shown at 200 m contour intervals*
- *BURNCO fenceline*
- *Tug boat*
- *Stockpiles*
- *Material drops*
- *Screens and crushers*
- *Land clearing*
- *Loader and forklift(exhaust)*
- *Conveyor Transfer Point*

REFERENCES

DEM provided by GeoBase
Projection: UTM Zone 10 Datum: NAD 83.

PROJECT

BURNCO ROCK PRODUCTS LTD.
AGGREGATE PROJECT, HOWE SOUND, B.C.

TITLE

SOURCE LOCATION PLAN

Golder Associates

PROJECT	11-1422-0046		PHASE No.4700	
DESIGN	TB	20 Mar. 2014	SCALE AS SHOWN	REV.
AIR	TB	1 Dec. 2014	FIGURE: 1	
CHECK	JR	3 Dec. 2014		
REVIEW	SC	22 Dec. 2014		

//bur1-d-filesrv1/Active/_2011/1422/11-1422-0046/Phase 4700 Air Climate/07 Deliverables/detailed model plan/Final Version/Master Files/Figure 1 - source location plan_28NOV2014.srf

4.1 Source Emission Rate Variability

For particulate matter emission rates were calculated based on the maximum daily emission rate for the modelling year. Model predicted results will be combined with background concentrations and compared to BC's air quality guidelines for TSP, PM_{10} and $PM_{2.5}$. The shortest averaging period of BC's air quality guidelines for TSP, PM_{10} and $PM_{2.5}$ is 24 hours. Therefore, the maximum daily emission rates are expected to yield the most conservative model predicted concentrations.

The shortest averaging period of BC's air quality guidelines for SO_2 and NO_2 is 1 hour. Therefore, for these two compounds, the emission rates will be calculated based on the maximum hourly emission rate for the modelling year.

The use of variable emission rates within the model will not be undertaken.

5.0 DISPERSION MODEL

The Project is located in an area of complex terrain. The Project is located at the mouth of the McNab Creek valley, where the McNab creek meets Howe Sound. Wind patterns are expected to be influenced by the valley slopes, sea breeze and the land water interface.

The CALPUFF model, in 3D mode, will be used in the assessment as agreed within the conceptual model plan (Golder 2013). CALMET, the meteorological pre-processor to CALPUFF, will be used to generate the three-dimensional gridded meteorological inputs required for CALPUFF.

Due to the nature of the surrounding complex terrain and the nearest available meteorological station it was recommended by Golder the CALMET be executed using in house developed MM5 in no-observation mode. The approach to generate the dispersion meteorological dataset (CALMET) was previously discussed with Graham Veale on February 27, 2013, and later confirmed within the conceptual model plan (Golder 2013).

5.1 Model Version

Table 6 summarizes the model, the version and the level of the pre-processors, model and post-processers used in this assessment.

Table 6: Model and Versions Used in the Air Assessment

Model	Version	Level
CALPUFF	6.42	110325
CALMET	6.326	080709
CALPOST	6.292	110406

5.2 Model Modification

No modifications to the models are planned for this assessment.

5.3 Model Switches

CALMET and CALPUFF have various switch options which allow the modeller to customize modelling scenario that best fit each project.

Model switch selections for the air quality assessment are generally consistent with the recommendations in the BC Modelling Guidelines (BC MoE 2008). A summary of the CALMET and CALPUFF recommended switch selection along with the switches to be used within the assessment are detailed in Appendix A, Table A-2 and Table A-3. Where the air assessment switch selection differs from the recommended switch selection a justification is provided.

5.4 Model Approach

A level 3 Assessment, as defined in BC Modelling Guidelines (BC MoE 2008), is proposed for the Project due to the anticipated complex meteorological conditions based on the local terrain.

The technical assessment will assess the impact on local air quality resulting from emissions from the facility, and will also consider the existing air quality in the region. Regional air quality will represented by incorporating background concentrations of relevant air quality parameters. The background concentration will be added to the model predicted concentration and this combined total concentration will be compared to the BC ambient air quality guidelines.

5.4.1 Ambient Air Quality Guidelines

The BC MoE has defined three levels (A, B, C) of air quality objectives, based on the National Ambient Air Quality Objectives (NAAQO). The three levels and the equivalent NAAQO levels are summarized in British Columbia Ambient Air Quality Objective (BC MoE 2014b).

Due to the location of the site, close proximity to residences, the BC Level A criteria and the NAAQO maximum desirable levels are recommended for the assessment. The air quality objectives which will be used in the air quality assessment are summarized in Table 7.

Table 7: Ambient Air Quality Objective Values

Averaging Period	TSP		PM_{10}		$PM_{2.5}$		SO_2		NO_2	
	Value Set By	Value ($\mu g/m^3$)	Value Set By	Value ($\mu g/m^3$)	Value Set By	Value ($\mu g/m^3$)	Value Set By	Value ($\mu g/m^3$)	Value Set By	Value ($\mu g/m^3$)
1 Hour	N/A	N/A	N/A	N/A	N/A	N/A	BC	200	BC	188
24 Hour	NAAQO	120	BC	50	BC	25	N/A	N/A	N/A	N/A
Annual	BC	60	N/A	N/A	BC	8	N/A	N/A	BC	60

5.4.2 Background Ambient Air Quality

Regional background concentrations of TSP, PM_{10}, $PM_{2.5}$, SO_2, and NO_2 will be established using regional air quality stations.

Within the region, three air quality monitoring stations measure PM_{10} and $PM_{2.5}$ concentrations. These stations are:

- **Langdale Elementary**, operated by Howe Sound Pulp and Paper and located approximately 16 km to southwest;
- **Horseshoe Bay**, operated by Metro Vancouver and located approximately 23 km to southeast; and
- **Squamish**, operated by BC MoE and a National Air Pollution Surveillance (NAPS) and located approximately 23 km to northeast.

To establish background air quality concentrations one calendar years' worth of data will be downloaded from the BC Air Archive Website. The initial background analysis undertaken by Golder was completed prior to the BC MoE release of the 2013 calendar year data on the BC Air Archive Website. As well, within the draft detailed model plan submitted to the BC MoE on August 8, 2014; Golder, recommended averaging the data from Langdale Elementary, Horseshoe Bay and Squamish in establishing background concentrations within the Local Study Area. In conversation with the BC MoE on November 19, 2014 it was suggested that that the data from Langdale should be used to establish background concentrations in the local study area; as well the BC MoE suggested the use of the most recent calendar year's data. Table 8 presents a summary of the background particulate concentrations recommended in the draft detailed model plan (Golder 2014) along with data from Langdale Elementary for the 2013 calendar year (the station and data year recommended by the BC MoE to establish background concentrations).

Table 8: Background particulate concentrations

Compound	Averaging Period	Unit	Draft detailed model plan recommended Value	Langdale Elementary 2013
TSP[(a)]	24 hour	$\mu g/m^3$	**55**	39
	Annual	$\mu g/m^3$	**21**	21
PM_{10}	24 hour	$\mu g/m^3$	**26[(b)]**	19
$PM_{2.5}$	24 hour	$\mu g/m^3$	12[(c)]	**14**
	Annual	$\mu g/m^3$	4[(d)]	**6**

Notes:
(a) TSP concentrations derived from respective PM_{10} concentrations using the methods outlined in *Procedures for Estimating Probability of Nonattainment of a PM_{10} NAAQS Using Total Suspended Particulate or PM_{10} Data* (US EPA 1986)
(b) Average of the 98th percentile concentrations for 2010 from Langdale Elementary and Squamish
(c) Average of the 98th percentile concentrations for 2012 from Langdale Elementary, Squamish and Horseshoe Bay
(d) Average of annual concentrations derived from average of Langdale Elementary, Squamish and Horseshoe Bay

From Table 8 it is observed that the background concentrations for TSP and PM_{10} recommended from the draft detailed model plan (Golder 2014) are conservative or similar to the Langdale Elementary 2013 data; and data for $PM_{2.5}$ is more conservative for Langdale Elementary. Therefore, to establish background particulate concentrations within the LSA the bolded values within Table 8 will be used.

Please note that there are no records of TSP measurement in the BC Air Archive Website. The Squamish station is also a NAPS station, NAPS stopped publishing daily TSP records in 2002. Therefore a literature review on the relationship between TSP and PM_{10} was undertaken. The US EPA published *Procedures for Estimating Probability of Nonattainment of a PM_{10} NAAQS Using Total Suspended Particulate or PM_{10} Data* (1986) which will be used to establish the TSP value. The 24 hour average and the annual average of PM_{10} concentration values were used to calculate the 24 hour average and annual TSP background concentrations.

The background concentrations for PM_{10} and $PM_{2.5}$ (Table 8) in column entitled "Draft detailed model plan recommended Value" were calculated using the method described in Section 10.1.5 of the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MoE 2008).

The analysis for establishing background concentrations of SO_2 and NO_2 were undertaken by Golder based on the methods detailed in *Guidance on Application of Provincial Interim Air Quality Objectives for NO_2 and SO_2* (BC MoE 2014a) . The 98th percentile NO_2 and 99th percentile SO_2 daily 1-hour maximum concentration from Squamish and Langdale Elementary were averaged for the most recent calendar year (2013). The averaged 98th percentile NO_2 and 99th percentile SO_2 values was compared to the respective percentile daily 1-hour maximum concentrations measured at Langdale Elementary (Table 9); the maximum value was used to establish the background concentrations. The proposed background concentrations for SO_2 and NO_2 are the bolded values in Table 9.

Table 9: Background SO_2 and NO_2 concentrations

Compound	Averaging Period	Unit	Average Concentrations[(a)]	Langdale Elementary Concentrations[(a)]
SO_2	1 hour	ppb	8	**13**
NO_2	1 hour	ppb	21	**22**
	Annual	ppb	**5.1**	5.0

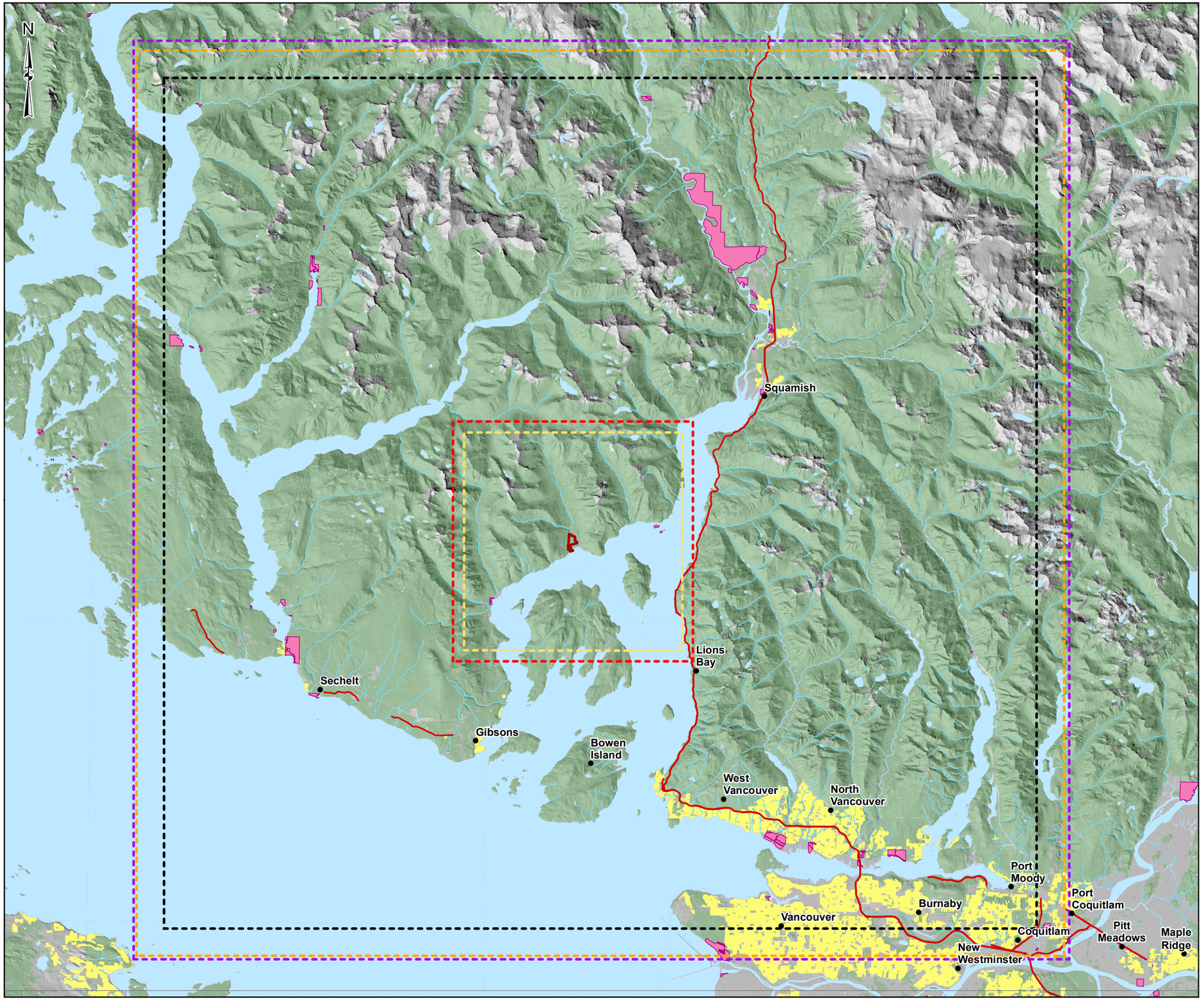
Notes:
(a) SO_2 1 hour based on the 99th percentile daily maximum 1-hour concentrations. NO_2 1-hour based on the 98th percentile daily maximum 1-hour concentrations.

6.0 MODEL INPUT

The following sections describe the CALMET/CALPUFF model input and output data.

6.1 CALMET Parameters

Figure 2 shows the CALMET (meteorological pre-processor of CALPUFF) and MM5 (mesoscale meteorological model) domains.



LEGEND

- Project Boundary
- Local Study Area
- Regional Study Area
- Local Study Area CALMET
- Regional Study Area CALMET
- MM5 Extent
- Vegetation
- Residential Area
- Indian Reserve
- Highway
- Road
- Railway
- Ferry

REFERENCE

Elevation and indian reserves from Geobase, base data from CanVec. DEM from British Columbia Imagery WMS.
Projection: UTM Zone 10 Datum: NAD 83

SCALE

10 0 10

SCALE 1:350,000 KILOMETRES

PROJECT

BURNCO ROCK PRODUCTS LTD.
BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.

TITLE

AIR QUALITY LOCAL AND REGIONAL STUDY AREAS & MM5 EXTENTS

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No. 4700	
DESIGN	TB	25 Nov. 2014	SCALE AS SHOWN	REV. 0
GIS	DL	04 Dec. 2014		
CHECK	JR	22 Dec. 2014		
REVIEW	SC	22 Dec. 2014		

FIGURE 2

Path: X:\Project Data\BC\McNab\Figures\MXD\Air Quality\BURNCO_Figure_02_Air_Quality_Study_Areas.mxd

The CALMET modelling domain is a 22 by 22 km square area centred on the Project, with a grid resolution of 100 by 100 m, refer to Table 10. The CALPUFF domain is contained within the CALMET domain, there is a 10 grid cell buffer between the CALMET and CALPUFF domain to account for potential edge effects. The fine grid resolution (100 m) will aid in accounting for coastal and valley effects surrounding the Project.

Table 10: CALMET and CALPUFF Domain Extent

Domain	Location	Easting (m)	Northing (m)
CALMET	Lower left	460,771	5,479,514
	Upper right	482,771	5,501,514
	Domain centre	471,771	5,490,514
CALPUFF	Lower left	461,771	5,480,514
	Upper right	481,771	5,500,514
	Domain centre	471,771	5,490,514

The CALMET grid will be comprised of 11 vertical layers as listed in Table 11.

Table 11: CALMET Vertical Layers

Layers	Height (m)
Layer 11	3,000
Layer 10	2,200
Layer 9	1,600
Layer 8	1,200
Layer 7	800
Layer 6	400
Layer 5	200
Layer 4	100
Layer 3	50
Layer 2	20
Layer 1	0

6.1.1 Human Health Domain

To assist the Human Health discipline in completing their effects assessment a regional air quality dispersion model will be used only to predict ambient concentrations at health receptors identified by the Human health team. This will include the communities of Langdale and New Brighton. The expanded CALMET model domain for the health receptors would cover an area of 85 by 83 km, and have a grid resolution of 250 m.

6.1.2 Planned Terrain and Land Use

Terrain and land use inputs are an integral part of the CALMET model. The following sections will discuss how the terrain and land use data were generated.

6.1.2.1 Terrain

The Project is located in the glacial delta of the McNab Valley and the terrain to the north of the Project is dominated by the McNab Creek valley. The Project is situated at an elevation of approximately at 9 meters above sea level (masl). Two kilometers to the east of the Project the terrain rises to 640 masl and 2.5 km to the west of the site the terrain rises to 914 masl. The Howe Sound boarders the Project site to the south. Gambier Island is located approximately 3 km south of the Project, the Island's terrain rises steeply to 760 masl. These terrain characteristics will be captured by the DEM data provided by GeoBase in *Canadian Digital Elevation Data* (Government of Canada et al. 1999), using 1:250,000 data (approximately 90 by 90 m). The terrain data will be converted to a 100 by 100 m dataset using global information system (GIS) software, which will be fed into the CALMET model. The terrain elevation data can be seen in Figure 7.

Golder understands that it is the BC MoE's directive to recommend the use of the GeoBase's 1:50,000 DEM data. However, with regards to the Project the major emission sources (stock piles, screens and crushers) are low lying, emission sources will lack buoyancy and emissions will be fugitive in nature (equipment will be electrically powered); therefore, it is expected that the air quality effects from the project will be localized in nature. Although the 1:50,000 base map may provide more detailed terrain information than the 1:250,00 datasets, both datasets will need to be resampled to create a coarser (100 m) grid for use in the assessment. Furthermore, due to the localized nature of the project effects (no regional transport of particulate matter) it is expected that the additional data provided in the 1:50,000 dataset will not significantly affect the originally proposed method to estimate the offsite project effects.

6.1.2.2 Land Use

The dominant land cover, to the north of the Project is coniferous forest. To the south, the land cover is water, with forested areas on Gambier Island. The proposed aggregate pit and processing areas have been logged in the mid 2000's and have not re-established. These land use categories are captured in *Land Cover Map of Canada 2005* (Canada Centre for Remote Sensing et al. 2008) obtained from Natural Resources Canada (NRC). The land use data within the modelling domain is illustrated in Figure 8.

The land cover data provided by NRC (250 by 250 m resolution), was downscaled to a 100 by 100 m grid using global information software (GIS). The land use class conversion from NRC to CALMET land use category is shown in Table 12. Six different CALMET land use categories were used, they are rangeland, deciduous forest land, evergreen forest land, water, wetland and barren land.

Geophysical parameters (surface roughness, albedo, Bowen ratio, etc.) are subject to seasonal changes. To capture these seasonal changes within the air quality assessment two seasons were defined based on the observed precipitation trends (Figure 6); a foliage and a non-foliage season. The foliage season is defined to be May to September while the non-foliage season is set as January to April and October to December. Two GEO.dat files were created for input into CALMET one for the foliage season and one for the non-foliage season. The detailed seasonal geophysical parameters by land category are discussed in 6.1.2.4 to 6.1.2.9.

Table 12: Natural Resources Canada and CALMET Land Use Codes

NRC Land Use Code	NRC Land Use Category	CALMET Code	CALMET Category
1	Temperate or Subpolar Needle-leaved Evergreen Closed Tree Canopy	42	Evergreen Forest Land
2	Cold Deciduous Closed Tree Canopy	41	Deciduous Forest Land
3	Mixed Needle-leaved Evergreen – Cold Deciduous Closed Tree Canopy	42	Evergreen Forest Land
4	Mixed Needle-leaved evergreen – Cold Deciduous Closed Young Tree Canopy	42	Evergreen Forest Land
5	Mixed Cold Deciduous – Needle-leaved Evergreen Closed Tree Canopy	42	Evergreen Forest Land
6	Temperate or Subpolar Needle-leaved Evergreen Medium Density, Moss-shrub Understory	42	Evergreen Forest Land
7	Temperate or Subpolar Needle-leaved Evergreen Medium Density, Lichen-shrub Understory	42	Evergreen Forest Land
8	Temperate or Subpolar Needle-leaved Evergreen Low Density, Shrub-moss Understory	42	Evergreen Forest Land
9	Temperate or Subpolar Needle-leaved Evergreen Low Density, Lichen (Rock) Understory	42	Evergreen Forest Land
10	Temperate or Subpolar Needle-leaved Evergreen Low Density, Poorly Drained	42	Evergreen Forest Land
11	Cold Deciduous Broad-leaved, Low to Medium Density	41	Deciduous Forest Land
12	Cold Deciduous Broad-leaved, Medium Density, Young Regenerating	41	Deciduous Forest Land
13	Mixed Needle-leaved Evergreen – Cold Deciduous, Low to Medium Density	42	Evergreen Forest Land
14	Mixed Cold Deciduous – Needle-leaved Evergreen, Low to Medium Density	41	Deciduous Forest Land
15	Low Regenerating Young Mixed Cover	42	Evergreen Forest Land
16	High-low Shrub Dominated	30	Rangeland
18	Herb-shrub-bare Cover	30	Rangeland
19	Wetlands	60	Wetland

NRC Land Use Code	NRC Land Use Category	CALMET Code	CALMET Category
20	Sparse Needle-leaved Evergreen, Herb-shrub Cover	42	Evergreen Forest Land
23	Herb-shrub Poorly Drained	60	Wetland
25	Low Vegetation Cover	70	Barren Land
32	Lichen-spruce Bog	60	Wetland
37	Water Bodies	50	Water
38	Mixes of Water and Land	50	Water

6.1.2.3 Geophysical Parameters

The CALMET model requires surface geophysical parameters to calculate the meteorological conditions near the surface level. The geophysical parameters used in CALMET are roughness length, albedo, Bowen ratio, soil heat flux, leaf area index and anthropogenic heat flux. The CALMET model allows each land use class to have user defined geophysical values.

Geophysical parameter values are subject to change seasonally. Geophysical parameters can vary between seasons, some examples include albedo values altering as water bodies freeze and leaf area index values altering as plant foliage change between seasons

The following sections below will discuss the geophysical parameters and the source of geophysical parameter values.

6.1.2.4 Roughness Length

Roughness length is a measure of the drag experienced by wind above surface. This parameter is expressed in meters, where smaller values represent smooth surface and larger values represent rough surface. The default roughness length value for “barren land” was used, provided in *A User’s Guide for the CALMET Meteorological Model, Version 5* (Earth Tech Inc. 2000). The “barren land” class does not undergo seasonal change within the CALMET model. For the other five land use types roughness length values were taken from Table 9.3 of *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MoE 2008). For the foliage season, summer roughness length values were used while for non-foliage season, winter values were used. Table 13 presents roughness lengths used for foliage and non-foliage seasons.

Table 13: Roughness Length Used in CALMET

Land Use Description	Roughness Length (m) – Foliage Season	Roughness Length (m) – Non-foliage Season
Rangeland	0.1	0.001
Deciduous Forest Land	1.3	0.5
Evergreen Forest Land	1.3	1.3
Water	0.0001	0.0001
Wetland	0.2	0.05
Barren Land	0.05	0.05

6.1.2.5 Albedo

Albedo is a ratio of the reflected incoming solar radiation by surface. This parameter ranges from 0 to 1, where 0 indicates the surface absorbing all solar radiation, while 1 indicates the surface reflecting all incoming solar radiation. For this study, the default albedo value for "barren land" was used, provided in *A User's Guide for the CALMET Meteorological Model, Version 5* (Earth Tech Inc. 2000). For the other five land use types, values were taken from Table 9.4 of *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MoE 2008). This table lists common land use types for four seasons. Table 14 below shows albedo values used within CALMET for this study.

Table 14: Albedo Values Used in CALMET Model

Land Use Type	Albedo (no unit) – Foliage Season	Albedo (no unit) – Non-foliage Season
Rangeland	0.18	0.6
Deciduous Forest Land	0.12	0.5
Evergreen Forest Land	0.12	0.35
Water	0.1	0.14
Wetland	0.14	0.3
Barren Land	0.3	0.3

6.1.2.6 Bowen Ratio

Bowen ratio is a ratio of the sensible to latent heat flux at surface. This default value, provided in *A User's Guide for the CALMET Meteorological Model, Version 5* (Earth Tech Inc. 2000) for "barren land" was used for Bowen ratio. For the other five land types, values presented, in Table 9.5 of *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MoE 2008) were used. Table 15 shows Bowen ratios used within CALMET for this study.

Table 15: Bowen Ratios Used in CALMET Model

Land Use Type	Bowen Ratio (no unit) – Foliage Season	Bowen Ratio (no unit) – Non-foliage Season
Rangeland	0.8	1
Deciduous Forest Land	0.3	1
Evergreen Forest Land	0.3	0.8
Water	0.1	0.1
Wetland	0.1	0.1
Barren Land	1	1

6.1.2.7 Soil Heat Flux

The soil heat flux constant is a function of the surface properties and is used to compute the flux of heat into the soil. The default CALMET values were used for all six land types, with no seasonal changes. Table 16 presents soil heat flux values used for this study.

Table 16: Soil Heat Flux Values Used in CALMET Model

Land Use Type	Soil Heat Flux (W/m^2)
Rangeland	0.15
Deciduous Forest Land	0.15
Evergreen Forest Land	0.15
Water	1
Wetland	0.25
Barren Land	0.15

6.1.2.8 Leaf Area Index

Leaf area index (LAI) is a ratio of area of leaves per unit area. LAI parameters were defined based on *Canada Wide Leaf Area Index from SPOT-VEGETATION* (NRC et al. 2004). This file was processed by GIS to match each land use grid cell to a LAI value. This data was tabulated and the average LAI value was calculated for each land use category. This procedure was used for both seasons. Table 17 shows the LAI values used in CALMET.

Table 17: LAI Values Used in CALMET Model

Land Use Type	LAI (m^2/m^2) – Foliage Season	LAI (m^2/m^2) – Non-foliage Season
Rangeland	4.7	3.44
Deciduous Forest Land	4.89	3.35
Evergreen Forest Land	5.79	4.4
Water	0	0
Wetland	4.71	2.8
Barren Land	0.05	0.05

6.1.2.9 Anthropogenic Heat Flux

Anthropogenic heat flux is used to estimate the heat flux at surface as a result of human activities. The CALMET default values were used in this assessment.

6.1.3 Planned Meteorological Data Input and Processing

The approach to generate the dispersion meteorological dataset was previously discussed with Graham Veale on February 27, 2013.

Based on the valley setting of the Project it is expected that near-by meteorology stations (stations located outside the McNab Valley structure) will not be representative of the onsite meteorology.

Therefore, Golder is recommending the use of the 2012 calendar year of MM5 data that will be generated in-house. CALMET will be executed with the MM5 data in no-observation mode since the near-by meteorology stations will not influence CALMET's simulated onsite meteorology. Data from near-by meteorology stations for 2012, Port Mellon, will be used to validate the resulting dispersion meteorological dataset.

Table 18: Surface Meteorological Data

Surface Met Data and Location	Data Source	Period of Record	% of Wind Speeds = 0.0 km/h	Stability Class Method
Latitude 49°31'00.000" N Longitude 123°29'00.000" W	Meteorological Services of Canada, Port Mellon Station	January to December 2012	23%	Not Applicable

6.1.3.1 Upper-Air Meteorological Data

As stated earlier, CALPUFF model will run in no-observation mode and no upper-air meteorological data will be used for this Project.

6.1.3.2 Mesoscale Meteorological Model Output

MM5 model will be generated in-house specifically for this Project for the year of 2012. This model output will be used as the meteorological input data for CALMET in no-observation mode.

Table 19: Mesoscale Meteorological Model Output

Model	Agency / Organization Providing Data	Horizontal Grid Resolution (km)	Data Period	Forecast / Hindcast	Planned Model Output Use
MM5	Golder Associates	36 km (first domain) 12 km (second domain) 4km (third domain)	January 2012 / December 2012	Hindcast	CALMET as observations

6.1.3.3 Data Processing

As stated in Table 19, the model will use MM5 as its meteorological input data in no-observation mode. Therefore, no data processing will be required. The same is true for the mixing height method. The modelled mixing height will be used as the input to CALPUFF.

6.2 CALPUFF – Input File

CALPUFF input files contain source emission rate, location information and receptors. The emission information were discussed in 4.0, and receptors used in the assessment is discussed in 6.2.1. Emission sources such as land clearing will vary from year to year. In this modelling process, the emission source was placed on the south east corner of the pit area, where it is expected to have the most impact on the seasonally occupied buildings to the south east.

Air emission characterization indicates that there will not be any building downwash in the Project, as there will not be any point sources. Therefore BPIP-PRIME will not be applicable in this modelling assessment.

6.2.1 Receptor Placement

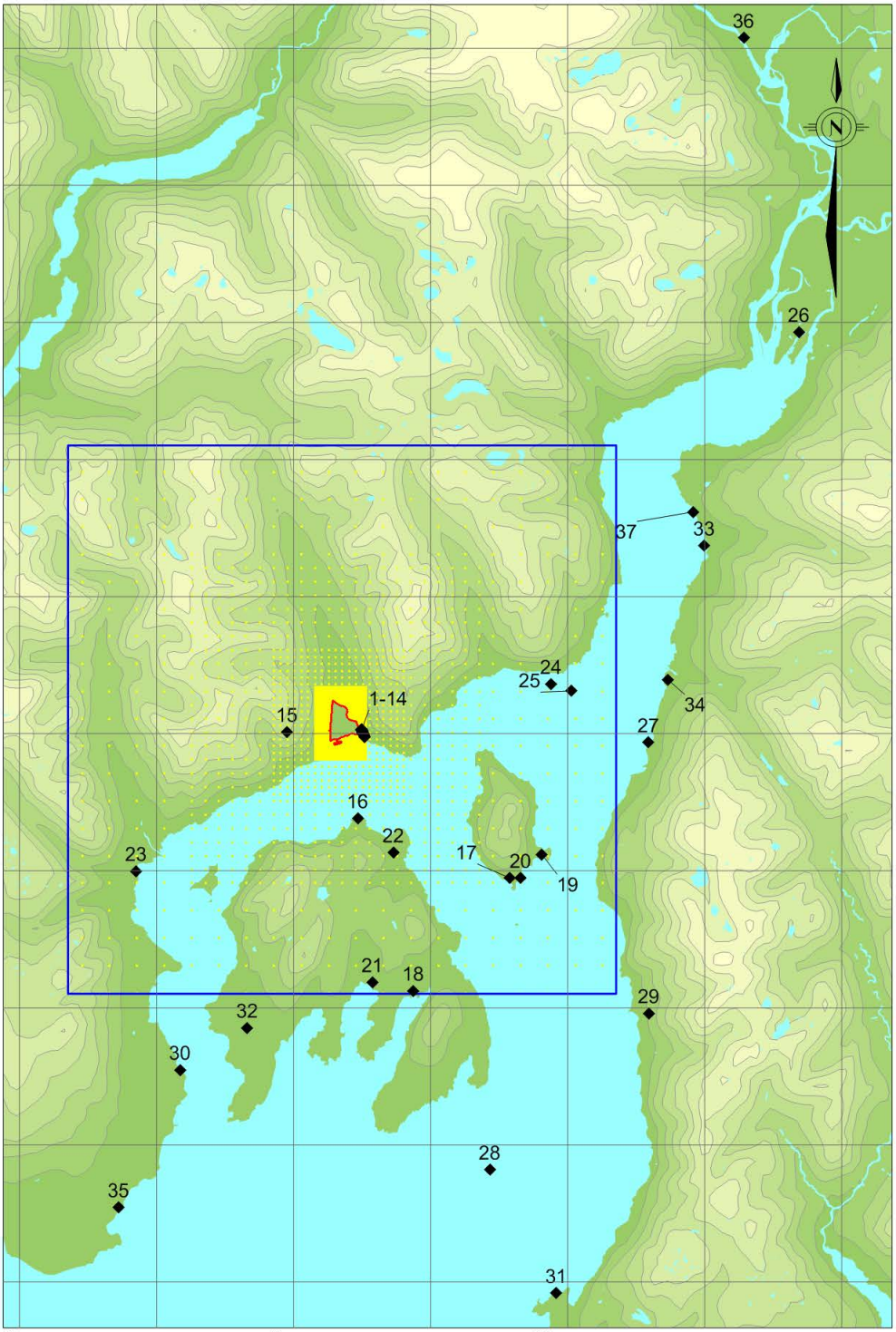
The CALPUFF domain is a 20 by 20 km rectangle centered on the Project. This domain size is expected to be sufficiently large to include all potentially sensitive receptors that may be impacted by on-site sources. A standard nested receptor grid as per BC Modelling Guidelines (BC MoE 2008) will be used in the assessment as follows:

- 50 m spacing within 500 m of source locations;
- 250 m spacing within 2 km of source locations;
- 500 m spacing within 5 km of source locations; and
- 1,000 m spacing beyond 5 km of the source.

Receptors will also be placed at 20 m intervals along the property boundary of the facility.

Discrete potentially sensitive receptors will include twelve seasonal cottages located within 0.37 km of the Project's fenceline and a recreational area (campsite) located >3 km from the Project on Gambier Island near Ekins Point. A beach, which is exposed during low tide, south of the Project is not contained within BURNCO's property boundary and, may be publicly accessible. This beach area is within 500 m of Project emission sources and the nested receptor grid spacing over the beach area is 50 m. Figure 3 shows the receptor grid within the CALPUFF domain.

These discrete receptors will be located in areas that are suspected to be more sensitive than other areas within the domain. These areas include seasonally occupied buildings, piers, meteorological stations, and native reserves. These discrete receptors can be seen on Figure 3.



Label	Sensitive Receptor
1 - 14	Residence 1- 14 (Strata)
15	Residence 15
16	Ekins Point
17	Anvil Island
18	Camp Artaban
19	Anvil Island Residential Area 1
20	Anvil Island Residential Area 2
21	Gambier Island Residential Area 1
22	Gambier Island Residential Area 2
23	KAIKALAHUN 25 Reserve
24	KWUM KWUM Reserve
25	Defence Island
26	Squamish
27	Porteau Cove
28	Bowen Island
29	Lions Bay
30	Langdale
31	Horseshoe Bay
32	New Brighton
33	Britannia Beach
34	Furry Creek
35	Gibsons
36	Ch'iyakmesh Reserve
37	Unknown First Nations Reserve

LEGEND

- Elevations are shown at 200 m contour intervals
- Gridded Receptors
- Fenceline Receptors
- Discrete Receptors
- Local Study Area

REFERENCES

DEM provided by GeoBase
Projection: UTM Zone 10 Datum: NAD 83.

PROJECT

BURNCO ROCK PRODUCTS LTD.
AGGREGATE PROJECT, BRITISH COLUMBIA

TITLE

RECEPTOR LOCATIONS

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No.4700	
DESIGN	TB	02 Aug. 13	SCALE AS SHOWN	REV.
AIR	TB	25 Nov. 14	**FIGURE: 3**	
CHECK	JR	18 Dec. 14		
REVIEW	SC	22 Dec. 14		

//bur1-d-fileserv1/Active/_2011/1422/11-1422-0046/Phase 4700/07 Deliverables/detailed model plan/Final Version/Master files/Receptor Locations_27NOV2014.srf

6.3 Special Topics

For each activity that occurs within the Project site, the daily emission rates will be calculated which will represent the maximum emission rate. In reality, this would not be the case since processes are expected to encounter delays over the course of its operational life.

For the particulate concentration model executions, the air quality assessment, will not include deposition; this will result in conservative particulate concentration predictions.

6.3.1 Stagnation Conditions

There is a concern for stagnation conditions, as the Project site is surrounded by valleys to the north. However, to account for stagnation, the Project will use the CALMET model in 3D mode, which can handle the dispersion in complex terrain in calm wind situations.

6.3.2 Shore/Coastal Effects

The Project site is located on the edge of a large water body, and is expected to be influenced by coastal effects. CALPUFF model will be used to account for the complex wind pattern generated by this terrain features. Running CALMET in no-observation mode will be sufficient due to the terrain features that the Project is located. In this Project, the coastal fumigation effect is not expected to be a factor, as there will be no stacks.

6.3.3 Horizontally Oriented Stacks and Stacks with Raincaps

There are no point sources associated with the Project. All emission sources are fugitive particulate matter emissions. Therefore, these cases are not to be considered within this Project.

6.3.4 Plume Condensation (Fogging) and Icing

As mentioned earlier, there will be no combustion or cooling tower stack emissions from this Project. Therefore, there will be no concerns for the effect on visibility around the Project site.

6.3.5 NO to NO_2 Conversion

As mentioned in the conceptual model plan, after analyzing the emission sources of the Project, it is understood that most of the emissions are fugitive dust emissions and that the exhaust emissions will be limited. The processing facilities (screens, crushers, conveyors and dredging) will be operated by electricity and the sources of NO_x emissions are limited to the internal combustion engine vehicles for maintenance vehicles. In addition to the exhaust emissions, there will also be minor combustion emissions from propane usage for equipment maintenance.

Emissions from the tugboat moving the barges in and out of the facility will be modelled and assessed at the residences neighbouring the Project. The model will initially assume 100 percent conversion of nitrogen oxides (NO_x) to NO_2.

7.0 METEOROLOGICAL DATA ASSESSMENT

The air quality assessment will be undertaken using MM5, CALMET and CALPUFF. Quality assurance and quality check (QA/QC) procedures will be applied to assure the quality of the three models' input and output data. Many of the QA/QC procedures follow the recommendations described in section 10.2.1.1 and 10.2.1.2 in *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MoE 2008).

7.1 MM5 QA/QC

The air quality assessment will be undertaken in no-observation mode where CALMET relied on mesoscale data as the initial guess field. The mesoscale data that was used to drive CALMET was Pennsylvania State University/National Centre for Atmospheric Research mesoscale model (MM5) and was generated by Golder in-house. This section will discuss the MM5 validation process.

The Squamish Airport Meteorological Station, or alternatively referred as Squamish station (WMO ID 71207) was used in the MM5 validation. The MM5 validation has been completed by comparing four meteorology parameters in the MM5 grid cell over the Squamish station location against the observation data from the Squamish station. The four meteorological parameters of interest are wind speed and wind direction, temperature and precipitation. Data completeness for the Squamish station is 99.9 % for wind speed, wind direction and temperature and 95.9% complete for precipitation.

In addition to comparing MM5 data to observation additional another QA/QC procedure will be undertaken and results will be included in the Environmental Assessment. The additional QA/QC procedure will include two wind rose plots for one location close to water to demonstrate sea-land (summer afternoon) and land-sea (early morning) circulation.

7.1.1 Wind Speed and Direction

Figure 4 compares a wind rose generated by MM5 data against a wind rose generated by observation data. As illustrated in Figure 4, the MM5 model predicts slower wind speed for the winds from southerly to easterly wind; MM5 predicts higher winds for from the NW to the N. However, despite the minor discrepancies in wind speeds, the wind patterns are well captured by MM5. There is a high dominance winds from the SSE, SE and NNW for 2012; this is captured in both the Squamish station and MM5.

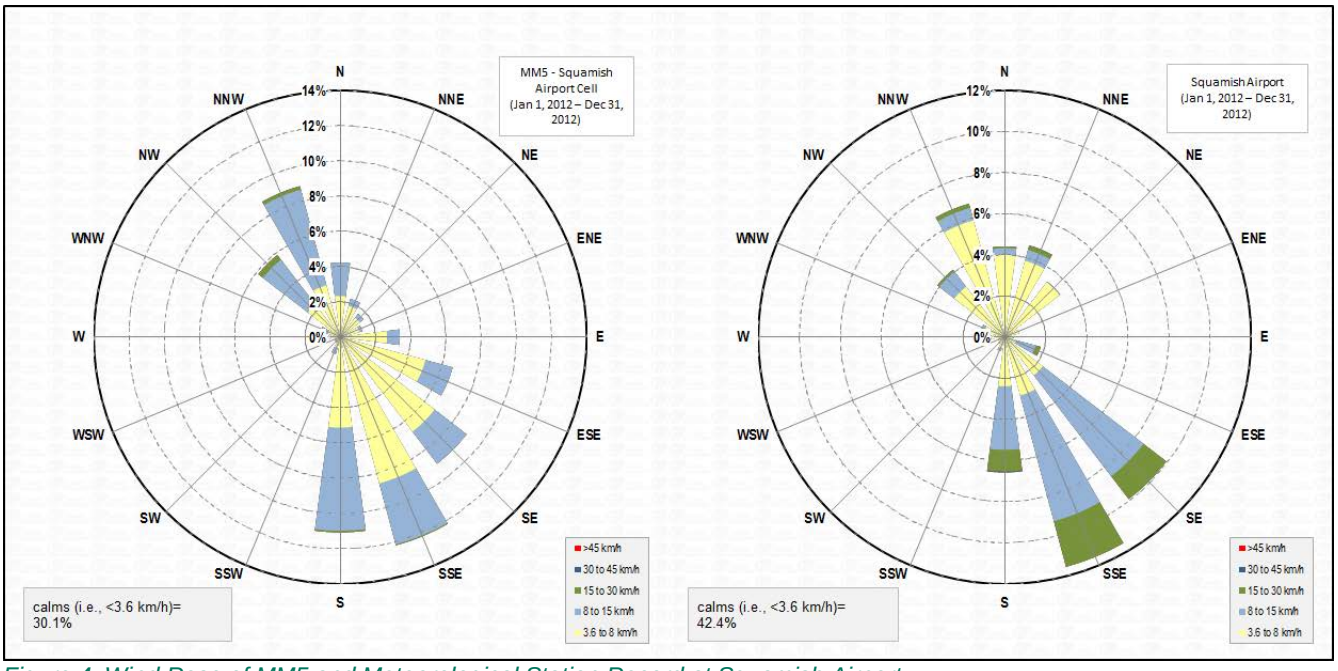


Figure 4: Wind Rose of MM5 and Meteorological Station Record at Squamish Airport

7.1.2 Temperature

Figure 5 compares temperature trends between the MM5 model and station data. The graph was built using hourly predicted (MM5) and recorded (Squamish) temperature data from January 1 to December 31, 2012. The graph shows that MM5 model predicts fairly similar temperature distribution range with more occurrences of predicted temperature near freezing. MM5 model predicts slightly colder temperature over Squamish Airport.

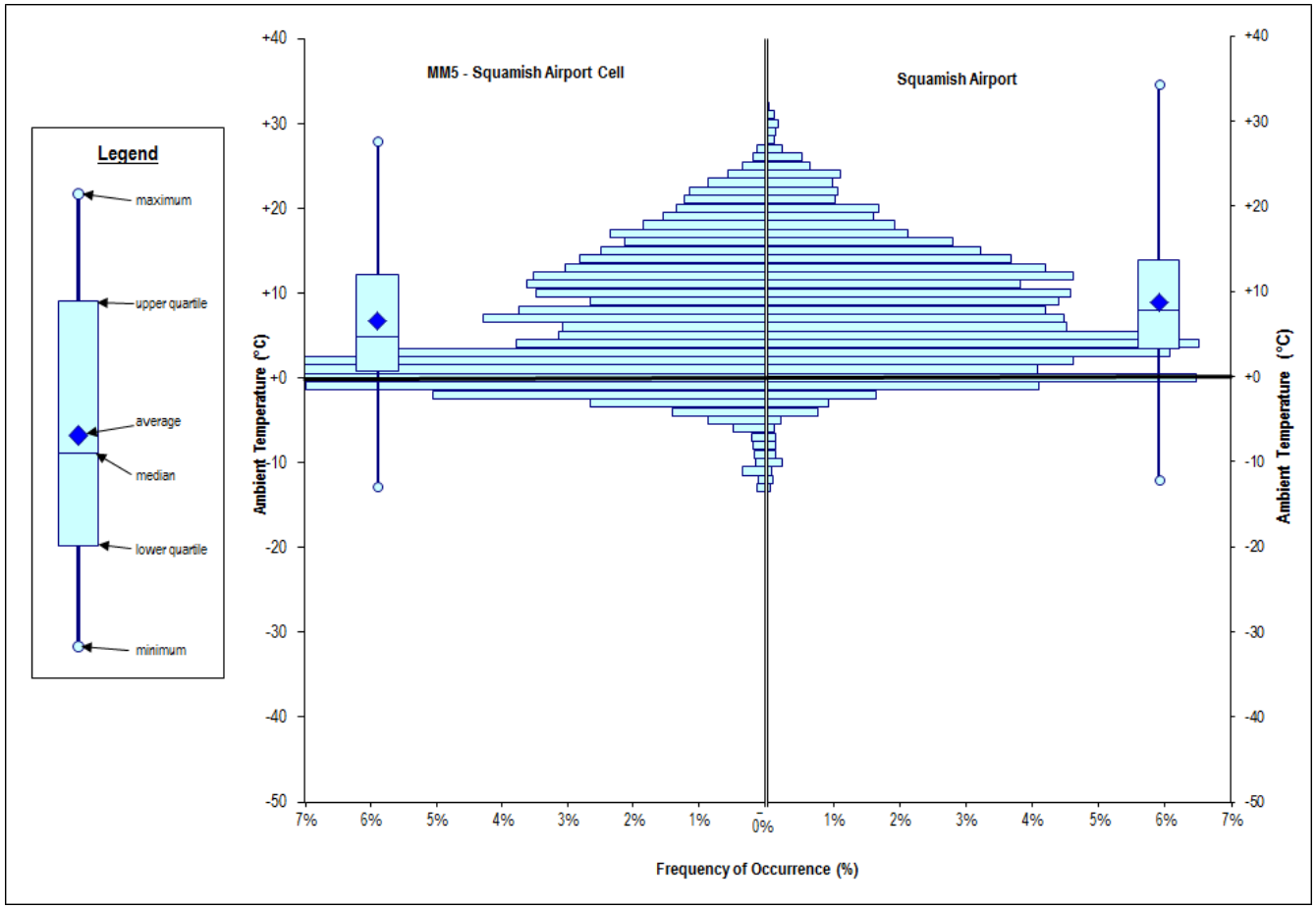
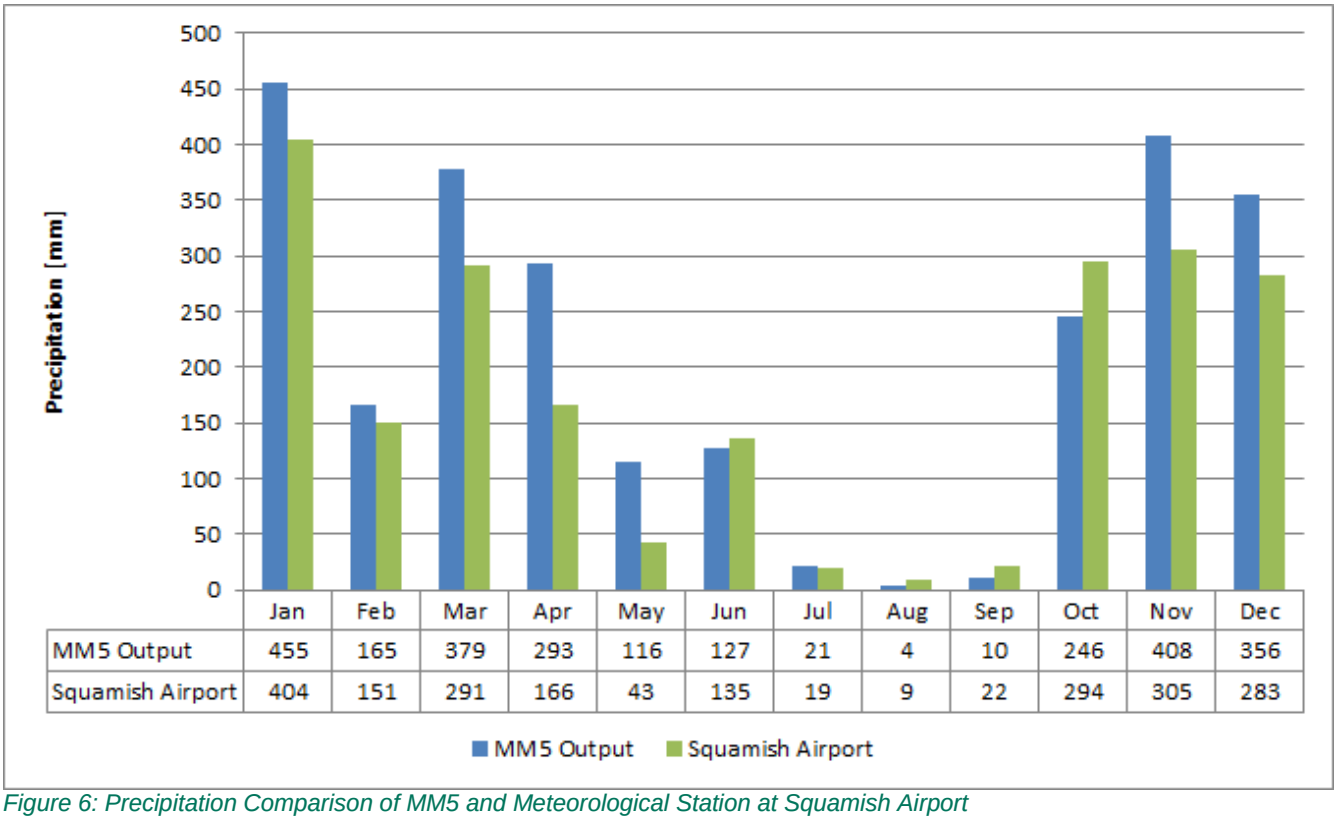


Figure 5: Temperature Distribution of MM5 and Meteorological Station at Squamish Airport

7.1.3 Precipitation

Figure 6 compares precipitation data for the year of 2012. In general, the precipitation trend is well captured. As the precipitation record shows, there is a significant precipitation trend change during in the summer months (July August and September). The graph shows that the MM5 model captures this trend quite well. However, the MM5 model tends to overestimate the precipitation and throughout the year, the model predicted 22% more precipitation than the recorded amount.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MM5 Output	455	165	379	293	116	127	21	4	10	246	408	356
Squamish Airport	404	151	291	166	43	135	19	9	22	294	305	283

Figure 6: Precipitation Comparison of MM5 and Meteorological Station at Squamish Airport

7.2 CALMET QA/QC

In order to assure a reliable CALPUFF model data, the CALMET model input and output had undergone quality assurance and quality control procedures.

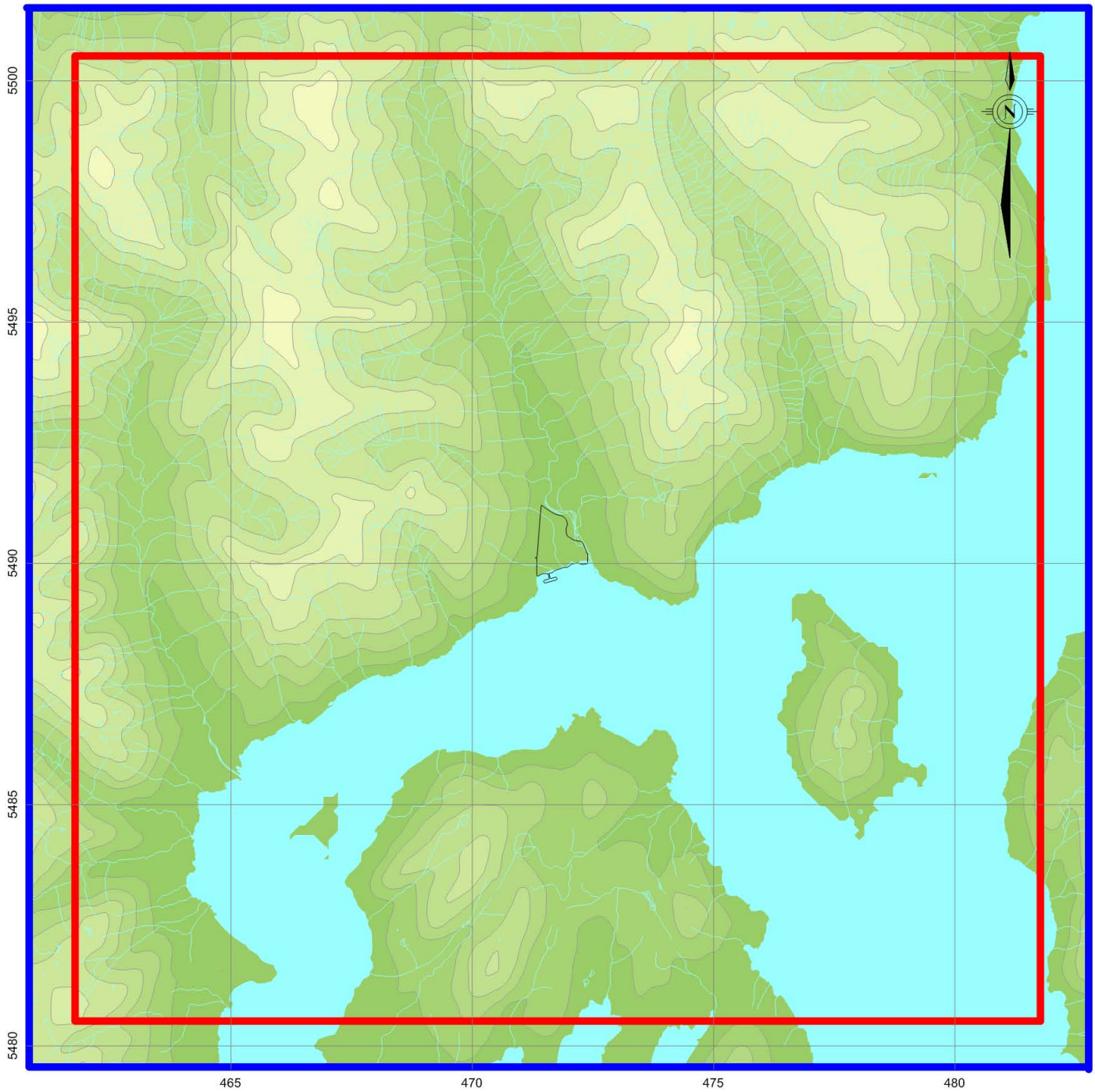
The validation of the CALMET output (data) was a similar process as the MM5 validation. The meteorological data from Port Mellon station and the CALMET output over the grid cell at the Port Mellon station location were compared. The validation process was conducted on wind speed and direction, and temperature. Port Mellon was selected to be an ideal location for the validation process since the topographical features are similar. Both the Project site and Port Mellon station are surrounded by a valley, where the meteorological features are expected to be influenced. In addition, Project site and Port Mellon station both have a large water body on the south. For the reasons stated above, Port Mellon was selected to be the station for CALMET output validation.

In addition to comparing model (CALMET) predictions at the Port Mellon station location to observation data additional CALMET QA/QC procedures will be undertaken and included in the Environmental Assessment report. These QA procedures will include:

- Two-dimensional hourly CALMET wind vector plots over the Local Study Area, for a sequential 3-hour period to illustrate sea breeze (on a summer afternoon) and land breeze (early morning).
- Two-dimensional hourly CALMET wind vector plots over the Local Study Area, at three different heights (surface, 300 m and 1,400 m), for a sequential 3-hour period for stable atmospheric conditions (i.e. clear night in winter, illustrating drainage flow) and for unstable atmospheric conditions (i.e. a hot, calm daytime in summer, illustrating upslope flow).
- CALMET generated diurnal plots of P-G stability class and mixing heights.
- Seasonal diurnal windrose plots.
- Wind rose plots of terrain induced wind patterns specifically at the mouth of the McNab Creek valley, and at two other upstream locations in the valley.

7.2.1 Terrain and Land Use File

The terrain, land use and surface property input data in the CALMET model have important roles in the 3D meteorological data generation, as these are a key driver in predicting the meteorological trend over the modelling domain. As discussed in the Planned Terrain and Land Use section, the terrain digital elevation model (DEM) was taken from GeoBase. The terrain contour map which is used in the CALMET (local study area) model can be seen in Figure 7. The land use category map within the CALMET domain can be seen in Figure 8.



LEGEND

- *Project Boundary*
- *CALPUFF domain*
- *CALMET domain*

0 200 400 600 800 1000 1200 1400 1600 Terrain elevation (masl)

REFERENCES

DEM provided by GeoBase
Projection: UTM Zone 10 Datum: NAD 83

PROJECT

BURNCO ROCK PRODUCTS LTD.
AGGREGATE PROJECT, HOWE SOUND, B.C.

TITLE

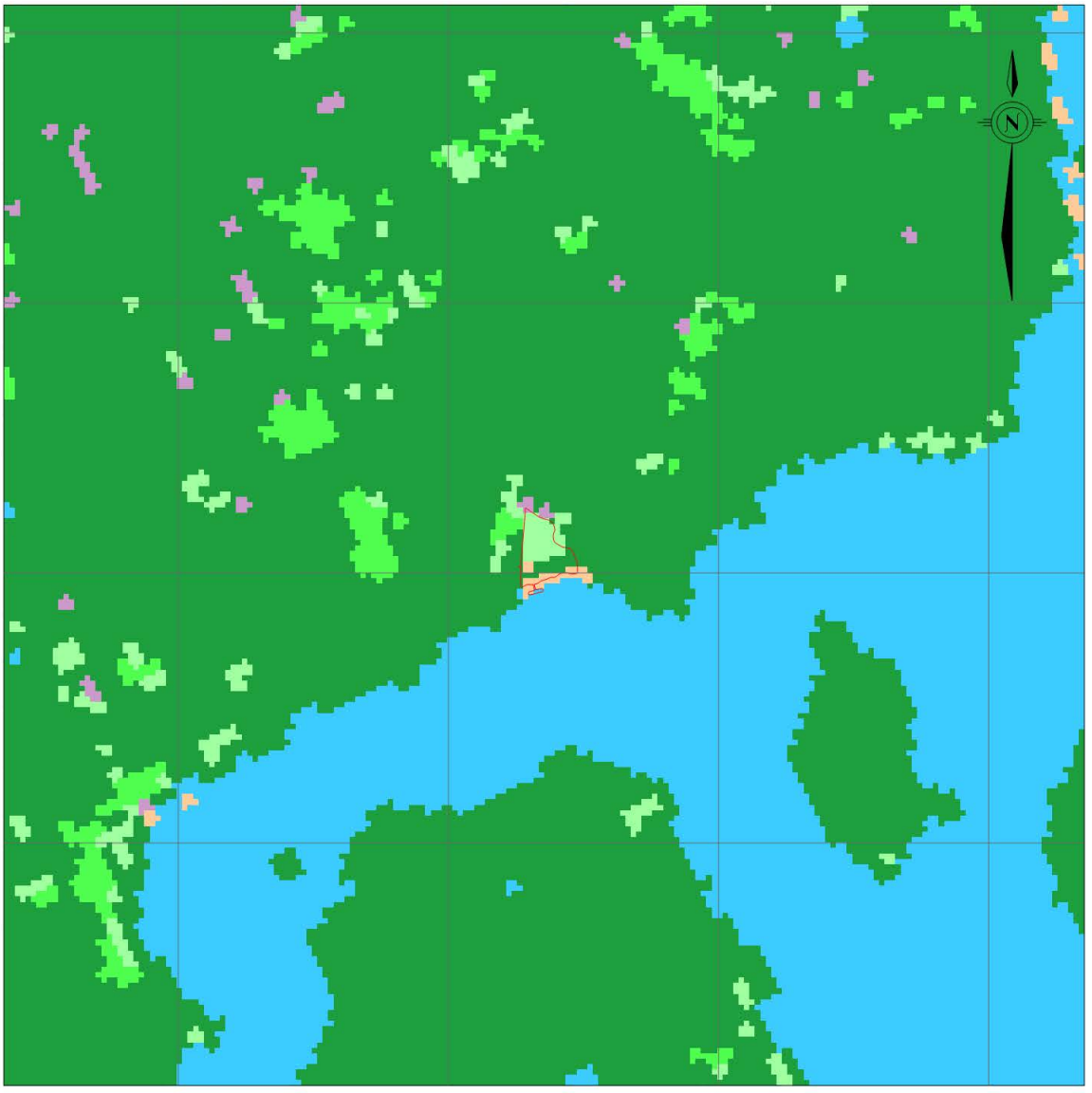
CALMET AND CALPUFF LOCAL STUDY AREA DOMAIN

Golder Associates

PROJECT	11-1422-0046		PHASE No.4700	
DESIGN	SD	11 Apr. 13	SCALE AS SHOWN	REV.
AIR	TB	06 May. 14	**FIGURE: 7**	
CHECK	JR	06 May. 14		
REVIEW	SC	07 Aug. 14		

//bur1-d-filesrv1/Active/_2011/1422/11-1422-0046 Burnco McNab Creek EA/Phase 4700 Air Climate/07 Deliverables/detailed model plan/Figures/Master files/Figure 7.srf

Local Study Area



5 0 5
SCALE KILOMETERS

LEGEND

BURNCO fenceline

REFERENCES

Land use provided by Land Cover Map of Canada 2005
Projection: UTM Zone 10 Datum: NAD 83.

PROJECT
BURNCO ROCK PRODUCTS LTD.
AGGREGATE PROJECT, BRITISH COLUMBIA

TITLE
LAND USE CATEGORIES WITHIN LOCAL STUDY AREA CALMET MODEL

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No.4700	
DESIGN	TB	02 Aug. 13	SCALE AS SHOWN	REV.
AIR	TB	25 Apr. 14	**FIGURE: 8**	
CHECK	JR	25 Apr. 14		
REVIEW	SC	07 Aug. 14		

//bur1-d-filesrv1/Active/_2011/1422/11-1422-0046/Phase 4700/07 Deliverables/detailed model plan/Figures/Master files/Figure 8.srf

7.2.2 Wind Speed and Direction

Figure 9 illustrates the hourly wind roses generated from the CALMET model compared to that observed at Port Mellon for 2012. The CALMET wind data were taken from the surface layer (10 m above ground). The figure shows that CALMET predicts a lower frequency of calm periods. However, the dominant northerly wind pattern, as observed in Port Mellon, is captured well by the CALMET model. The wind speed distribution is also well predicted by CALMET. The similarities in predominant wind direction and wind speed distribution suggest that CALMET was able to incorporate the complex terrain features surrounding the Port Mellon station and generate a representative wind rose when compared to observation data. This also suggests that CALMET was able to generate winds around the Project, with similar valley structure surrounding the site and a large water body on the south.

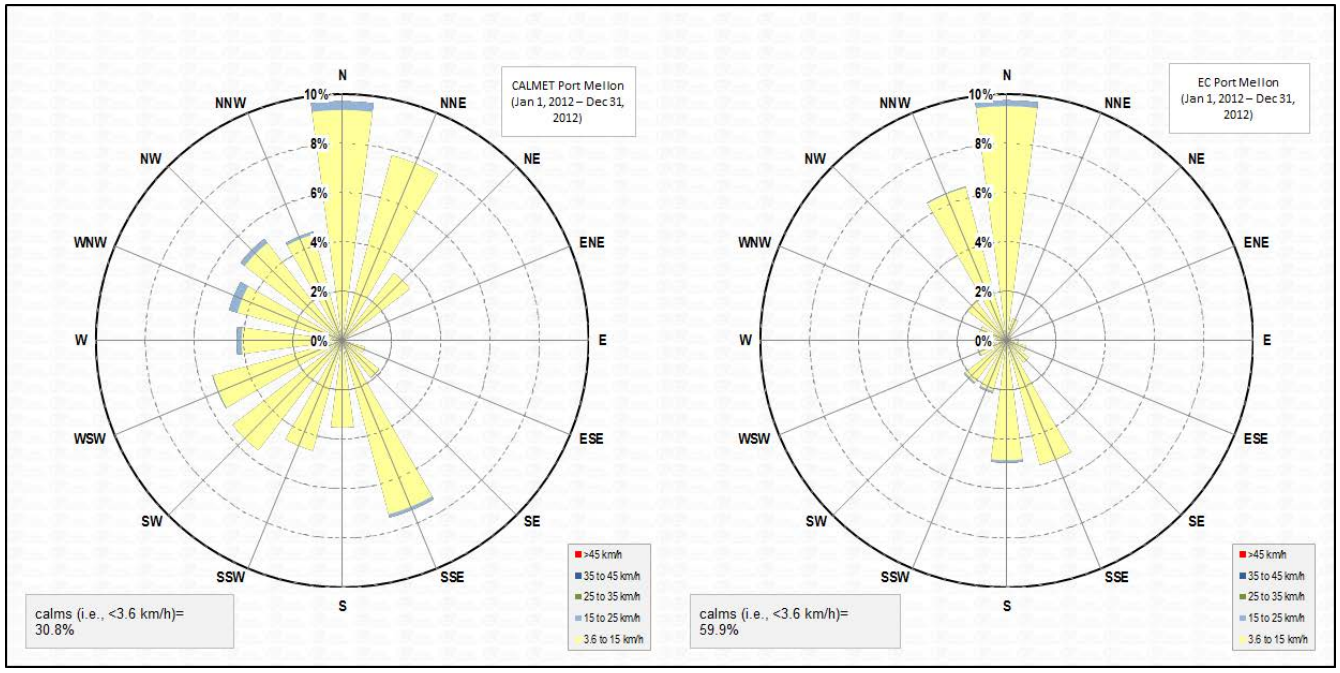


Figure 9: Wind Rose Comparison of CALMET and Meteorological Data at Port Mellon Station

7.2.3 Temperature

Figure 10 presents a temperature distribution comparison between the CALMET model predicted values and observed record at Port Mellon monitoring station. The observed record shows that the majority of the time, the observed temperature range between 0 to 20°C. The CALMET model shows a similar distribution to Port Mellon Station record, and shows colder prediction than the record. This can also be seen by looking at maximum and minimum, mean and median temperature as well. The CALMET model predicts highest modes around 0°C, for the observed record, the highest mode is seen around 6°C. As the figure shows, CALMET model predicts colder weather patterns.

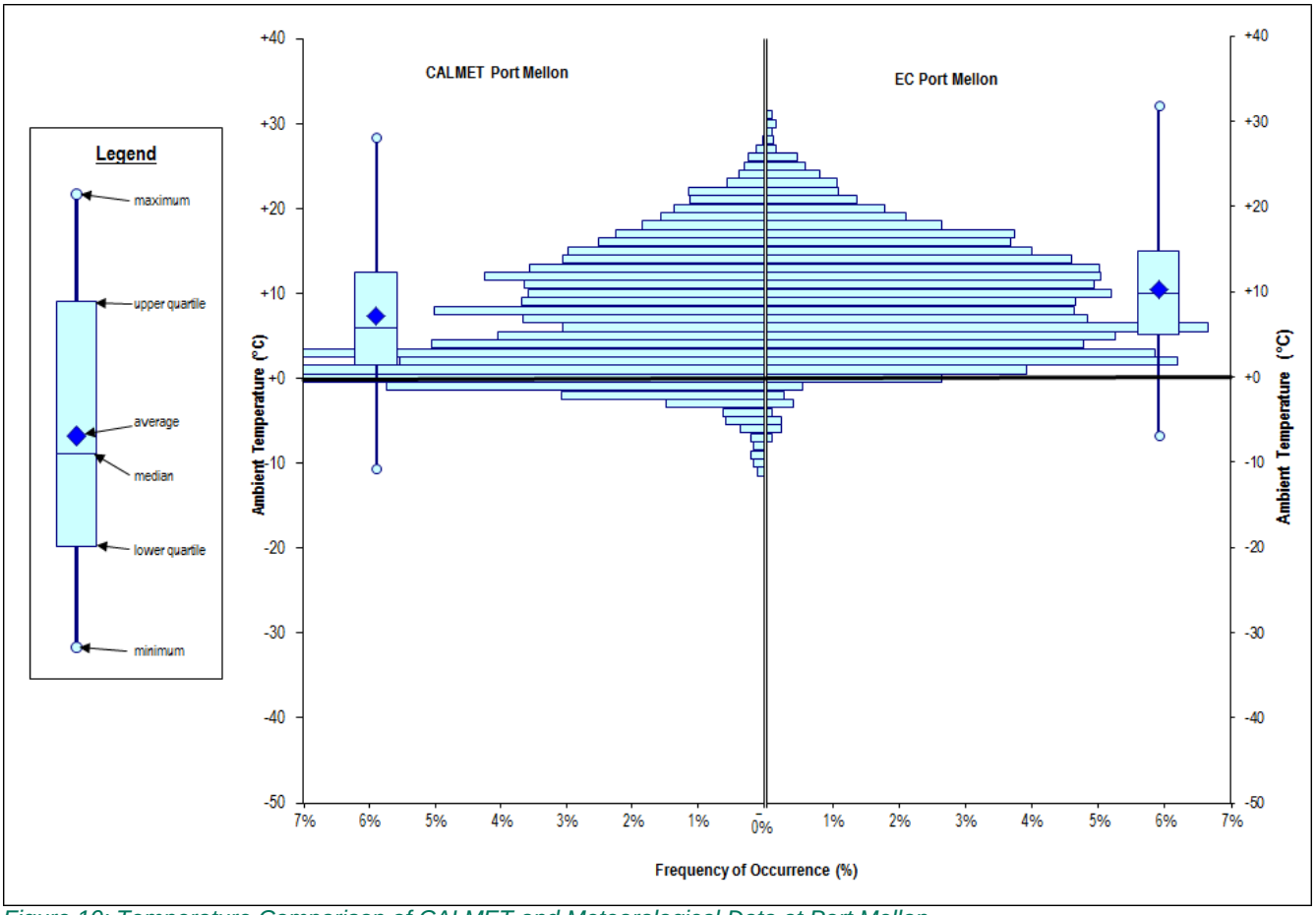


Figure 10: Temperature Comparison of CALMET and Meteorological Data at Port Mellon

8.0 PLANNED CALPUFF MODEL OUTPUTS

The following model outputs will be generated and submitted to decision makers and stakeholders. These are consistent with the recommended model outputs for a Level 3 assessment as detailed within Section 10.4.2 of *Guidelines for Air Quality Dispersion Modelling in British Columbia* (2008 BC MoE). The modelling assessment over the entire domain will be conducted on TSP, PM_{10}, and $PM_{2.5}$, and these output or data include:

- Background concentration of the relevant air quality parameters;
- Particulate and metal concentration and deposition values will be provide to other disciplines (human health and surface water) within the Environmental Assessment to aid them in completing their technical assessments (note that deposition will not be turned on within the air quality modelling);
- Emission rates used in the assessment;
- Predicted concentration contours with the expected maximum;
- Table of exceedance frequencies above the values presented in Table 7; and
- Table of predicted maximum concentration at discreet receptors.

Similarly the model will be executed for tugboat combustion emissions (NO_2, SO_2, $PM_{2.5}$ and PM_{10}) at only health receptors. The anticipated model output for these parameters would be.

- Background concentration of the relevant air quality parameters;
- Emission rates used in the assessment; and
- Table of predicted concentrations and exceedance frequencies (if applicable) at health receptors for 1-hour (NO_2 and SO_2) and 24-hour (PM_{10} and $PM_{2.5)}$ periods.

9.0 MEETING WITH BC MOE NOVEMBER 2014

On November 19, 2014 a teleconference meeting was held with Li Huang and Graham Veale with the BC MoE to address outstanding comments they had concerning the draft detailed model plan (submitted August 8, 2014). During this meeting the outstanding questions the BC MoE had regarding the conceptual and detail model plan were addressed and solutions were provided that would satisfy the BC MoE requirements. A summary of the MoE questions/concerns and the accepted solutions are listed in Table 20.

Table 20: BC MOE Concerns with the Detailed Model Plan and Agreed Solutions

BC MoE Concern/Question	Agreed Solution
Section 1.0 Introduction (Pg. 2, paragraph 1)- Statement regarding acceptance of conceptual model plan	Reference to acceptance of the conceptual model plan has been removed (Page 2, paragraph 1)
Section 2.2 Schedule (Pg. 3): Table 2 implies acceptance of the conceptual model plan	Table 2 has been updated to remove references to final conceptual model plan
Concerns regarding using conservative background particulate concentrations measured at Langdale Elementary versus the average of the 98th percentile of Langdale Elementary, Squamish and Horseshoe Bay for 2012 versus 2013.	Section 5.4.2 has been updated to provide more detail and Table 8 illustrates the different background concentration values (Langdale Elementary vs station average) and the background concentration to be used for the project.
Request for more QA/QC procedures on the MM5 and CALMET datasets	These QA/QC procedures will be included in the Environmental Impact Assessment. The additional QA/QC procedures that will be include are detailed in Sections 7.1 and 7.2.
Request for map detailing MM5, CALPUFF LSA and RSA and receptors	Please refer to Figure 2 and Figure 3
Clarification regarding project and tugboat PM_{10} and $PM_{2.5}$ effects at receptors in both the LSA and RSA	Yes the project and tugboat maneuvering will be assessed at sensitive receptors in both the LSA and RSA (Section 1.0 6th paragraph)
The version of CALPOST being used	Table 6 has been updated to include the CALPOST version
Concerns regarding the use of the 1:50,000 DEM	Statements regarding the BC MoE directive and the emission source properties have been added to Section 6.1.2.1.
Seasonality of geophysical parameters	References to winter snow cover conditions have been removed. Values used are consistent with previously accepted surface parameters for the region.
Deposition discussion on Page 25 of Draft Detailed model plan.	Paragraph in Section 6.3 has been reworded.

10.0 CLOSURE

We trust that this memo provides the information required at this time. We hope that the anticipated ministry review completion date of the detailed model plan is December29, 2014.

Please do not hesitate to contact us should you have any questions or comments regarding the above.

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Ministry Acceptance of Plan: _____ Date: JAN 21/15.
GRAHAM VEALE
AIR QUALITY METEOROLOGIST

TB/JR/RW/ls

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APPENDIX A

CALMET and CALPUFF Switch Selection

Table A1: Legend for Table A2 and A3

Do not touch
Recommended Default
Expert Judgment Required
Not used

Table A2: Proposed CALMET Group 5 Switches

Group	CALMET Parameter	Value		Comments
		BC Modelling Guide	Proposed Value for BURNCO Project Modelling	
Input Group 5- Wind Field Options and Parameters	IWFCOD	1	1	
	IFRADJ	1	1	
	IKINE	0	0	
	IOBR	0	0	
	ISLOPE	1	1	
	IEXTRP	-4	-1	no extrapolation is done, (no surface station data will be used)
	ICALM	0 or 1	0	
	BIAS	varies	NZ*0	
	RMIN2	-1	10	snce using MM5 data this variable is not used in calculations
	IPROG	2,4 or 14	14	
	ISTEPPGS	not specified	3,600	
	IGFMET	not specified	0	
	LVARY	T	F	do not use varying radius of influence since running in no-obs mode
	RMAX1	varies	n/a	Not applicable since CALMET in no-obs mode
	RMAX2	varies	n/a	Not applicable since CALMET in no-obs mode
	RMAX3	varies	n/a	Not applicable since CALMET in no-obs mode
	RMIN	0.1	0.1	
	TERRAD	varies	5	
	R1	varies	n/a	Not applicable since CALMET in no-obs mode
	R2	varies	n/a	Not applicable since CALMET in no-obs mode

Group	CALMET Parameter	Value		Comments
		BC Modelling Guide	Proposed Value for BURNCO Project Modelling	
	RPROG	(varies)	54	
	DIVLIM	$5x10^{-6}$	0.000005	
	NITER	50	50	
	NSMTH	2	2, 4, 4, 4, 4, 4, 4, 4, 4, 4	
	NINTR2	99	99, 99, 99, 99, 99, 99, 99, 99, 99, 99	
	CRITFN	1	1	
	ALPHA	0.1	0.1	
	FEXTR2	(varies)	0, 0, 0, 0, 0, 0, 0, 0, 0, 0	Used only if IEXTRP = 3 or -3.
	NBAR	0 depends	0	
	XBBAR, YBBAR, XEBAR, YEBAR	varies	0, 0, 0, 0	
	IDIOPT1	0	0	
	ISURFT	varies	-1	
	IDIOPT2	0	0	
	IUPT	varies	-1	
	ZUPT	200	200	
	IDIOPT3	0	0	
	IUPWIND	-1	-1	
	ZUPWND	1, 1000	1, 1000	
	IDIOPT4	not specified	0	
	IDIOPT5	not specified	0	
	LLBREZE	not specified	F	

Table A3: Proposed CALPUFF Group 2 Switches

Group	CALMET Parameter	Value		Comments
		BC Modelling Guide	Proposed for BURNCO Project	
Group 2 - Technical Options	MGAUSS	1	1	
	MCTADJ	3	3	
	MCTSG	0	0	
	MSLUG	0	0	
	MTRANS	1	1	
	MTIP	1	1	
	MBDW	2	2	
	MRISE	not specified	1	
	MSHEAR	0	0	
	MSPLIT	0	0	
	MCHEM	1	0	No chemical transformations.
	MAQCHEM	0	0	
	MWET	1	0	Deposition not to be modelled
	MDRY	1	0	Deposition not to be modelled
	MTILT	not specified	0	
	MDISP	2 or 3	2	
	MTURBVW	(3)	3	
	MDISP2	(2)	3	
	MTAULY	not specified	0	
	MTAUADV	not specified	0	
	MCTURB	not specified	1	
	MROUGH	0	0	
	MPARTL	1	1	
	MPARTLBA	not specified	1	
	MTINV	0	0	
	MPDF	0 or 1	1	
	MSGTIBL	0	0	
	MBCON	0	0	
	MSOURCE	not specified	0	
	MFOG	0	0	
	MREG	0	0	

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