5.2 ATMOSPHERIC ENVIRONMENT (AIR QUALITY) ASSESSMENT

This section presents the methodologies and results of the assessment of potential effects and cumulative effects on the atmospheric environment (air quality) valued component (VC) as a result of the Woodfibre Liquefied Natural Gas (LNG) Project (Project). Other components of atmospheric environment are discussed separately, as follows:

- Section 5.3 Greenhouse Gas Management
- Section 5.4 Atmospheric Sound
- Section 5.5 Light

The processes used to select the atmospheric environment as a VC, assessment boundaries, and existing conditions relevant to the atmospheric environment are described in this section. Assessment findings, including evaluation of Project-related interactions and likely adverse effects, proposed approaches to mitigation, identification of likely residual and cumulative adverse effects, along with determination of adverse effects significance, are also presented. In addition, this section presents monitoring and follow-up programs to be undertaken with respect to atmospheric environment.

Additional information regarding the air quality assessment is provided in the following appendices:

- Appendix 5.2-1 – Air Quality and Meteorology Baseline Report
- Appendix 5.2-2 – Meteorology
- Appendix 5.2-3 – Dispersion Modeling Methodology
- Appendix 5.2-4 – Air Emission Details
- Appendix 5.2-5 – Volatile Organic Compounds Model Predictions

The potential effects to air quality are a component in a potential effects pathway, and results of this assessment support the assessment of other valued components (VCs) (see **Table 4-2 Component Linkages Matrix**):

- Section 5.11 Vegetation Communities
- Section 5.12 Avifauna
- Section 5.13 At-risk Bat Species
- Section 5.14 Amphibians
- Section 5.17 Marine Birds
- Section 7.5 Visual Quality
- Section 7.6 Current Use of Lands and Resources for Traditional Purposes
- Section 9.2.2 Human Health Risk Assessment

This section is supported by the assessment in **Section 5.7 Site Contamination.**

5.2.1 Atmospheric Environment Scoping and Rationale

This section provides an overview of the atmospheric environment VC and its regulatory setting, the rationale for the selection of the VC, the spatial and temporal boundaries for the VC with associated rationale, and the indicators that will be used to determine potential adverse effects to the VC.

5.2.1.1 Overview and Regulatory Setting

Air quality was selected as a VC due is its importance to human health and the environment. The atmospheric environment also provides a direct pathway for the transport of contaminants to people and human health environments.

The Project-related effects assessment of the atmospheric environment focused on contaminants that are expected to be emitted from the Project, for which relevant air quality criteria exist, and which are generally accepted as indicative of changing air quality. These contaminants are further described in **Section 5.2.1.3**. Changes in air quality can also have an effect on other disciplines, such as **Section 9.2.2 Human Health Risk Assessment**. The effects of changes in air quality are assessed as indirect effects in the pathways for those other disciplines, and are discussed in detail in their respective sections, if applicable.

Provincial and federal regulatory bodies have developed air quality objectives, criteria, and standards to ensure that the emission control policies from anthropogenic activities protect human health and the environment. In British Columbia (BC), the *Environmental Management Act*, SBC 2003, c. 53, allows for the establishment of non-statutory air quality criteria (objectives) in the province. The relevant air quality criteria used for assessing Project-related air quality effects include the BC objectives and federal objectives where provincial guidelines are not available. The BC Ministry of Environment (MOE) has set guidelines related to ambient air concentrations, which are summarized in the *British Columbia Ambient Air Quality Objectives – Provincial Air Quality Objective Information Sheet* (MOE 2013). There are two sets of federal objectives and criteria: the Canadian Ambient Air Quality Standards (CAAQS) (formerly National Ambient Air Quality Standards), and the National Ambient Air Quality Objectives (NAAQO). These objectives and standards are based on scientific studies that consider the existing conditions and the effects of contaminants on receptors such as humans, wildlife, vegetation, as well as aesthetic qualities such as visibility.

The NAAQO are benchmarks that can be used to facilitate air quality management on a regional scale, and provide goals for outdoor air quality that protect public health, the environment, or aesthetic properties of the environment (CCME 1999). The federal government has established the following NAAQO levels (Environment Canada 2010):

- The maximum desirable level defines the long-term goal for air quality and provides a basis for an anti-degradation policy for unpolluted parts of the country and for the continuing development of control technology.

- The maximum acceptable level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort, and well-being.
- The maximum tolerable level indicates time-based concentrations of air contaminants beyond which, owing to a diminishing margin of safety, immediate action is required to protect the health of the general population.

The MOE has defined three levels of ambient air quality objectives (AAQO), based on the NAAQO (A, B, and C). The CAAQS have been developed under the *Canadian Environmental Protection Ac*t, 1999, SC 1999, c. 33, and include standards for respirable particulate matter ($PM_{2.5}$) (or particulate matter of 2.5 microns (µm) or less in diameter) and ozone (O_3) that must be achieved by 2020 (Environment Canada 2012). There are two phase-in dates: 2015 and 2020 (Government of Canada 2013). **Table 5.2-1** lists federal and provincial ambient air quality objectives and standards for criteria air contaminants (CACs) relevant to this assessment.

The Government of BC has announced that they are in the process of updating the 1-hour air quality objectives for NO_2 and SO_2 (Government of BC 2014). These updated are meant to be consistent with U.S. Environmental Protection Agency national ambient air quality standards and have been included in **Table 5.2-1** (MOE 2014).

Table 5.2-1 Ambient Air Quality Objectives and Standards

Compound	Averaging Period	Criteria (µg/m^3)							
		Canadian Ambient Air Quality Standards [a]	Federal Objectives			Provincial Objectives			
			Maximum Desirable	Maximum Acceptable	Maximum Tolerable	Air Quality Objectives	Level A	Level B	Level C
Nitrogen dioxide (NO_2)	1-hour	—	—	400	1000	188[b][c]	—	—	—
	24-hour	—	—	200	300	—	—	—	—
	Annual	—	60	60	100	—	—	—	—
				100[b]					
Sulphur dioxide (SO_2)	1-hour	—	450	900	—	200[b][d]	—	—	—
	3-hour	—	—	—	—	—	—	—	—
	24-hour	—	150	300	800	—	—	—	—
	Annual	—	30	60	—	—	—	—	—
Carbon monoxide (CO)	1-hour	—	15,000	35,000	—	—	14,300	28,000	35,000
	8-hour	—	6,000	15,000	20,000	—	5,500	11,000	14,300
Total suspended particulates (TSP)	24-hour	—	—	120	400	—	120	200	260
	Annual	—	60	70	—	—	60	70	75
Inhalable particulate matter (PM_{10})	24-hour	—	—			50	—	—	—
Respirable particulate matter ($PM_{2.5}$)	24-hour	28/27	30[e]			25[e]	—	—	—
	Annual	10/8.8	—			8/6	—	—	—

Notes: (a) CAAQS published in the Canada Gazette Volume 147, No. 21 - May 25, 2013. The standards will be phased in in 2015 and 2020, with both numbers shown in the table. The larger (first) value represents the CAAQS for 2015; (b) U.S. Environmental Protection Agency National Ambient Air Quality Standards that are being considered to be adopted in BC (BC Oil and Gas Commission 2014, pers. comm.)Interim air quality objective (MOE 2014); (c) Criteria based on the daily 1-hour maximum, annual 98th percentile (1 year) value, averaged over three years; (d) Criteria based on the daily 1-hour maximum, annual 99th percentile, averaged over 3 years (1 year); (e) Compliance based on annual 98th percentile value; "—" signifies that no air quality criteria is available; µg/m3 – micrograms per cubic metre.

5.2.1.2 Selection of Valued Component

The selection of atmospheric environment as a VC followed a selection process as set out in **Section 4.3 Issues Scoping and Selection of Valued Components**. Air emissions from the Project, including Project-related shipping activities, have the potential to affect air quality within the assessment areas. These emissions are managed by the federal and provincial government, as well as local jurisdictions through regulatory limits, as previously summarized in **Section 5.2.1.1**.

5.2.1.3 Indicators

To focus the effects analysis for the atmospheric environment VC, indicators were selected. An indicator represents a measurable feature or issue related to the VC that has the potential to change as a result of the Project and can be described as an aspect or characteristic of the VC, which, if changed as a result of the Project, may represent an effect on the VC.

The indicators for the atmospheric environment VC are the indicator compounds that are expected to be emitted from the Project, for which relevant air quality criteria exist, and which are generally accepted as indicative of changing air quality. These indicator compounds, also referred to as CACs, fall into the following two general categories:

- combustion gases, including nitrogen oxides (NO_X) (expressed as NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO)
- particulate matter, including total suspended particulate (TSP), particles nominally smaller than 10 µm in diameter (PM_{10}) (also referred to as inhalable particulate matter) and particles nominally smaller than 2.5 µm in diameter ($PM_{2.5}$) (also referred to a respirable particulate matter)

The Project has the potential to emit other compounds for which no regulatory criteria are available. These compounds are important for the assessment of predicted Project-related effects on human health; therefore, in addition to the selected indicator compounds, the assessment includes five chemically similar groups of other compound groups, as follows:

- volatile organic compounds (VOCs)
- polycyclic aromatic hydrocarbons (PAHs)
- hydrogen sulphide (H_2S)
- hazardous air pollutants (HAPS)
- metal compounds (metals)

These five non-indicator compound groups were included in the dispersion modeling; however, the effects of changes in air quality of these non-indicator compounds are assessed as indirect effects in the pathways for the human health discipline, and are discussed in detail in **Section 9.2.2 Human Health Risk Assessment**.

Ozone is not directly emitted from Project activities; however, Project activities will result in the emission of precursor compounds (i.e., NO_X, CO, and VOCs), which can contribute to ozone formation under appropriate meteorological conditions. Given the relatively low ozone pre-cursor emissions compared to other significant sources in the region, ozone was not considered to be a suitable indicator compound for the Project, and has therefore not been considered in the effects assessment.

In **Table 5.2-2** below, the indicators are presented for atmospheric environment, as well as the rationale for their selection.

Table 5.2-2 Indicators for the Atmospheric Environment

Indicator	Rationale for Selection
NO_2, SO_2, CO, TSP, PM_{10}, and $PM_{2.5}$ (concentrations of CACs)	Assessed against the following regulatory requirements: BC AAQO, CAAQS, and NAAQO where applicable; also assessed against relevant air quality indicators and targets specified in the Sea-to-Sky Air Quality Management Plan.

5.2.1.4 Assessment Boundaries

This section describes the spatial and temporal boundaries of the assessment of atmospheric environment, as well as administrative or technical boundaries that may apply.

5.2.1.4.1 Spatial Boundaries

Spatial boundaries define the geographical extents within which environmental effects are considered. The study areas developed for the atmospheric environment VC encompass the environment that can reasonably be expected to be affected by the Project, or which may be relevant to the assessment of cumulative effects. A local assessment area (LAA) and a regional assessment area (RAA) have been defined for this Project. Each of the defined spatial boundaries is provided in **Figure 5.2-1**, and is summarized in **Table 5.2-3**. The boundaries for these areas are based on the following:

- location of emission sources
- potentially sensitive receptor locations
- the extent of the dispersing plume(s)

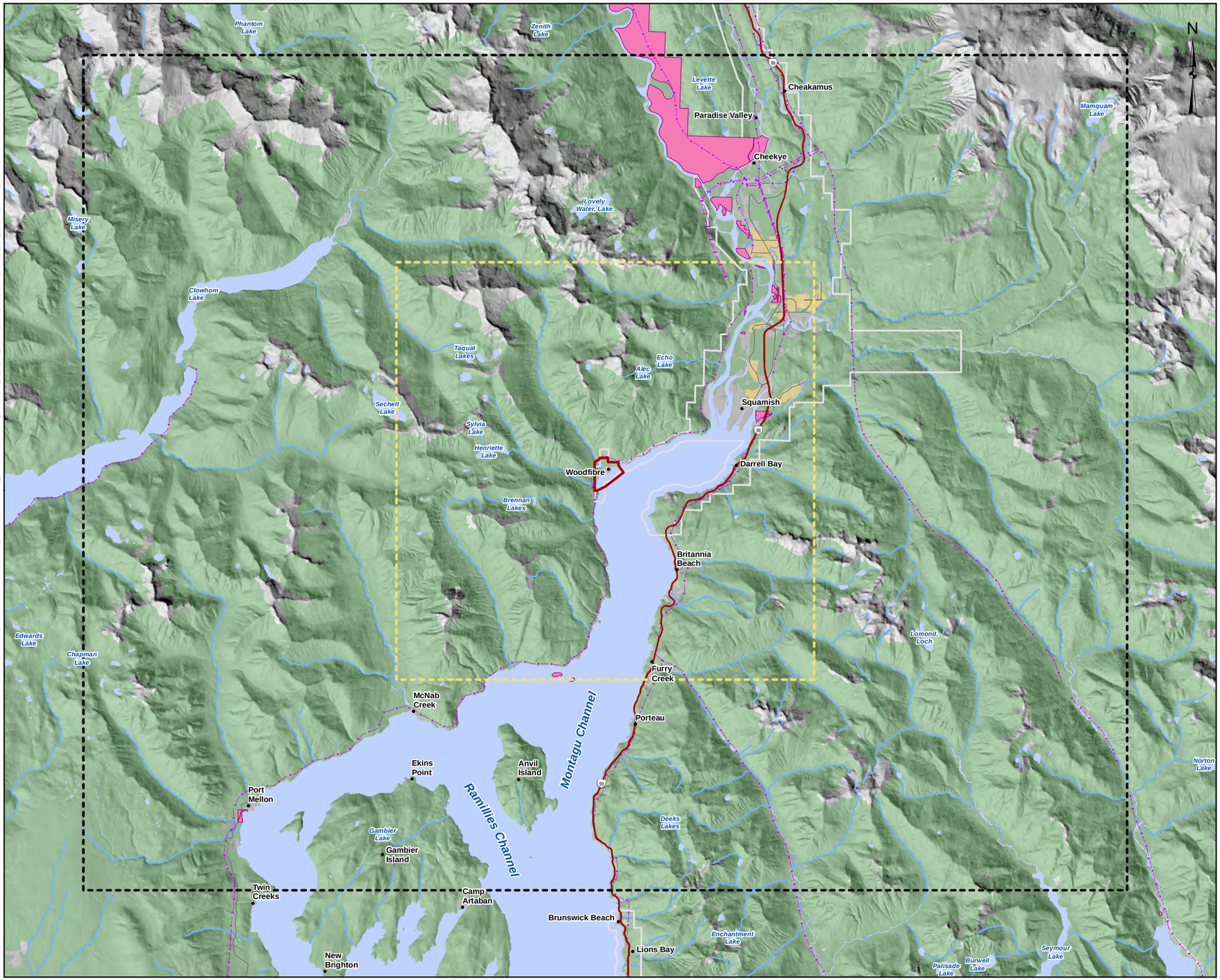
Concentrations of potential Project emissions within a facility property line are excluded from assessment per relevant air quality regulations and guidelines. For this analysis, concentrations within the Project area were not included. The Project area is contained within the LAA.

The LAA encompasses the area where Project-related direct effects on air quality are expected. In determining the LAA boundaries, consideration was given to the nature and characteristics of the atmospheric environment, the location where offsite maximum effects from the Project are expected, the expected pathways of effects for other VCs, and the maximum extent of potential adverse effects on the atmospheric environment. The LAA for air quality is defined as a 20-km x 20-km area centered around the Project area.

The RAA was established to provide a regional context for the assessment of Project-related effects, and encompasses the LAA. The RAA was also established to encompass the area within which the residual effects of the Project are likely to overlap with the residual effects of other existing or reasonably foreseeable projects and activities. As a result, the RAA is the area within which the cumulative effects assessment has been conducted. The RAA for atmospheric environment (air quality) is defined as a 50-km x 40-km area centred on the Project area.

Table 5.2-3 Spatial Boundary Definitions for Atmospheric Environment

Spatial Boundary	Description of Assessment Area
Local Assessment Area	The LAA is a 20-km x 20-km area surrounding the Project. This is the area within which greatest changes to air quality are expected as a result of Project-related effects.
Regional Assessment Area	The RAA, approximately a 50-km x 40-km area centred on the Project, corresponds to the area used for the dispersion modeling domain and for assessment of cumulative effects.



LEGEND

- PROJECT AREA
- ATMOSPHERIC ENVIRONMENT LOCAL ASSESSMENT AREA (LAA)
- ATMOSPHERIC ENVIRONMENT REGIONAL ASSESSMENT AREA (RAA)
- PARK / PROTECTED AREA
- SKEWLWIL'EM SQUAMISH ESTUARY
- FOREST AREA
- URBAN AREA
- INDIAN RESERVE
- MUNICIPAL BOUNDARY
- HIGHWAY
- ARTERIAL ROAD
- TRANSMISSION LINE (ELECTRIC)
- WATERCOURSE

REFERENCE

MUNICIPALITIES FROM GEOBC. BASE DATA FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. HILLSHADE PROVIDED BY GOVERNMENT OF BRITISH COLUMBIA.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

SCALE

5 0 5
KILOMETRES

PROJECT
WOODFIBRE LNG LIMITED
WOODFIBRE, HOWE SOUND, B.C.

TITLE
LOCAL AND REGIONAL ASSESSMENT AREAS FOR ATMOSPHERIC ENVIRONMENT

Golder Associates

PROJECT NO. 13-1422-0006			PHASE 6000 TASK 6030		
DESIGN	TB	17 Sep. 2014	SCALE: 1:180,000	REV. 0	FIGURE 5.2-1
GIS	RH	30 Sep. 2014			
CHECK	JR	16 Oct. 2014			
REVIEW	SC	16 Oct. 2014			

PATH: \\golder.gds\gal\Vancouver\CAD-GIS\VAN\2013\13-1422\13-1422-0006 - WoodfibreMapping\MXD\Air\WOODFIBRE_ATMOSPHERIC_ENVIRONMENT_FIGURE_5_2_01_Local_and_Regional_Areas_for_Atmospheric_Environment.mxd Date: 10/16/2014

5.2.1.4.2 Temporal Boundaries

Temporal characteristics of the Project's construction (including decommissioning of temporary construction-related facilities), operation, and decommissioning phases are defined in **Section 2.2 Description of the Proposed Project**. The construction phase of the Project is expected to span a period of 24 months. The operation life of the Project is anticipated to be at least 25 years. If, after that timeframe, the Project can continue to operate in an effective and environmentally sound manner, plans will be developed for continued operation. Decommissioning at the end of Project life will last approximately 24 months. The assessment of the atmospheric environment VC focuses on the operation phase of the Project, as the other phases are anticipated to have lower emission levels than when the Project is in full operation.

5.2.1.4.3 Administrative Boundaries

The Project is located in the Sea-to-Sky Corridor of BC. This airshed is managed through the Sea-to-Sky Air Quality Management Plan and Implementation Plan (The Sheltair Group 2007, 2008). The Sea-to-Sky airshed extends from Bowen Island to just north of Pemberton, and contains the communities of Langdale and Port Mellon along the western edge of the Howe Sound and the communities of Furry Creek and Squamish along the eastern edge of Howe Sound. The RAA is essentially contained within the southern portion of the Sea-to-Sky airshed. The Sea-to-Sky Air Quality Management Plan is a regional collaboration action plan for protecting air quality in the airshed; this plan promotes actions in the airshed and includes programs, policies, and bylaws that can be implemented to manage air quality and greenhouse gas (GHG) emissions. Specifically, the Project has the potential to be affected by following actions identified in the Sea-to-Sky Air Quality Management Plan:

- Promote the use of best available technology and practise for construction and related equipment.
- Implement a public education and outreach campaign.
- Coordinate air quality initiatives with other organizations.
- Incorporate the Air Quality Management Plan vision into other planning processes.

The Sea-to-Sky Air Quality Management Plan relies on federal and provincial ambient air quality criteria (**Table 5.2-1**) to assist in determining the health of an airshed. The Project is located outside the administrative boundaries of Metro Vancouver; therefore, Metro Vancouver ambient air quality criteria do not apply to the Project. The air quality modeling assessment followed the requirements of *Guidelines for Air Quality Dispersion Modelling in British Columbia* (MOE 2008), which outlines specific requirements for assessments. Details of these boundaries are provided in **Appendix 5.2-1 Air Quality and Meteorology Baseline Report**.

5.2.1.4.4 Technical Boundaries

The technical boundaries for the assessment of the atmospheric environment VC are based on the accuracy of the air quality and the meteorological monitoring data used to evaluate the local and regional airshed. Air quality data outside of the technical boundaries such as those in Metro Vancouver are primarily influenced by urban and industrial developments in Metro Vancouver; therefore, they are not appropriate for the evaluation of potential Project-related effects to air quality. The selection of the technical assessment boundaries, including meteorological data domain, dispersion modeling domain, LAA, and RAA, was based on inputs from MOE.

5.2.2 Existing Conditions

This section presents the existing conditions of the atmospheric environment in the vicinity of the Project. Background information about air quality in the region is provided, along with a description of desktop and field studies that guided the assessment

5.2.2.1 Introduction

To appropriately assess the effects of the Project on air quality, it is necessary to establish existing air quality conditions for indicator compounds and meteorological conditions in the Project assessment areas. This VC assessment therefore begins with a summary of the existing conditions of the atmospheric environment. The technical atmospheric environment baseline report is provided in **Appendix 5.2-1 Air Quality and Meteorology Baseline Report.**

Since the interactions of the effects associated with past and existing projects are not expected to change over time, these projects are considered through the documentation of the existing conditions for this VC. A summary of the projects, the effects of which are included in the existing conditions, is presented in **Table 4-7 Existing Conditions – Past and Existing Projects.** Projects and activities that are considered in the existing conditions for this VC include (but are not limited to) Howe Sound Pulp and Paper Corporation, the Sea-to-Sky Highway (Improvement Project), Squamish Terminals and BC Ferries.

5.2.2.2 Background Information

The existing air quality in the RAA was characterized by reviewing publicly available literature and using data collection sources to identify background concentrations of indicator compounds in the Project area. Air quality monitoring stations in the Sea-to-Sky airshed are well established in the Metro Vancouver region; additional field studies were not undertaken to characterize the existing air quality in the Project area because adequate data is available for this purpose from existing literature and data sources.

Baseline meteorology conditions are required as input for the air dispersion modeling assessment. The inputs for the assessment are based on measurements at existing meteorological monitoring stations in the Sea-to-Sky airshed. The climate normals data (30-year averages) for the period from 1981 through to 2010 provide the data required to establish the baseline meteorological environment (Environment Canada 2014). Climate normals represent the average climatic conditions for the area.

5.2.2.3 Desktop and Field Studies

In 2013, Woodfibre LNG Limited (Proponent or WLNG) initiated environmental studies on the atmospheric environment to support Project planning and assessment. Building on available information, these studies were designed to address known data gaps. **Table 5.2-4** provides a summary of conducted desktop studies on atmospheric environment (refer also to **Appendix 5.2-2 Meteorology** and **Appendix 5.2-1 Air Quality and Meteorology Baseline Report**).

Table 5.2-4 Summary of Atmospheric Environment Desktop and Field Studies

Study Name	Study Purpose
Baseline Air Quality Study	A desktop study to characterize existing air quality conditions in the Project RAA.
Baseline Meteorology Study	A desktop study to characterize existing meteorology conditions in the Project RAA.

5.2.2.4 Description of Existing Conditions

5.2.2.4.1 Air Quality

To establish existing air quality conditions, data from the ambient air monitoring stations located in the Sea-to-Sky airshed were used (**Table 5.2-5**). Detailed data analysis is provided in **Appendix 5.2-3 Dispersion Modeling Methodology** and **Appendix 5.2-1 Air Quality and Meteorology Baseline Study**. Brief descriptions of the rationale for the selection of these stations are provided below:

- The Langdale Elementary air quality station is located 35 km south-southwest of the Project in the town of Gibson. The station was commissioned in December 1995. The Langdale air quality monitoring station is operated by Howe Sound Pulp and Paper, and is subject to the MOE quality assurance and quality control procedures; MOE also archives the data. Measured concentrations at this location are influenced by local industry, and therefore present a conservatively high estimate of the air quality in the assessment areas.
- The Squamish air quality station is located 8 km northeast of the Project, and was commissioned in 1984. The National Air Pollution Surveillance Network (NAPS) and MOE both share this air quality monitoring station. Because Squamish is an urban centre, air quality data collected at this station represent a conservatively high representation of the air quality in the assessment areas.
- Operated by Metro Vancouver, the Horseshoe Bay air quality station is located 33 km south of the Project site and is situated in a residential setting in the District of West Vancouver. The existing air quality station was established in 2010 and is influenced by transportation sources at the Horseshoe Bay ferry terminal; air quality measurements at this site therefore represent conservatively high estimate of the air quality in the assessment areas.

Table 5.2-5 Ambient Monitoring Stations in the Assessment Areas

Station Name	MOE ID	NAPS ID	Distance from Project	Period Analyzed
Langdale Elementary	E222778	N/A	35km SSW	2013 and 2010
Squamish	0310172	101601	8km NE	2013 and 2010
Horseshoe Bay	E206164	N/A	33km S	2013

Details on the selection of the appropriate air quality monitoring data are provided in **Appendix 5.2-3 Dispersion Modeling Methodology** and **Appendix 5.2-1 Air Quality and Meteorology Baseline Report**.

Data collected from the air quality stations were analyzed based on the recommendations outlined in MOE's *Guidelines for Air Quality Dispersion Modelling in British Columbia* (MOE 2008) to estimate the background air quality concentrations for the indicator compounds. Data analysis resulted in identification of a data gap: within the RAA, no air quality stations measure TSP. The Proponent subsequently conducted a literature review on the relationship between TSP and PM_{10}. The study team used the United States (US) Environmental Protection Agency's (EPA's) *Procedures for Estimating Probability of Non-attainment of a PM_{10} NAAQS Using Total Suspended Particulate or PM_{10} Data* (US EPA 1986) to establish the TSP:PM_{10} ratio, then estimate background TSP concentrations. The resulting analysis showed that existing concentrations of all indicator compounds are below the most stringent air quality criteria listed in **Table 5.2-6**.

Table 5.2-6 Ambient Air Quality Criteria and Regional Background Concentrations

Pollutant	Averaging Period	Ambient Air Quality Criteria ($\mu g/m^3$)	Average Background Concentration[(a)(c)] ($\mu g/m^3$)
NO_2	1-hour	188	27.3
	24-hour	200	18.6
	Annual	60	9.7
SO_2	1-hour	200	7.9
	24-hour	150	4.8
	Annual	30	2.1
CO	1-hour	14,300	469.5
	8-hour	5,500	376.7
TSP	24-hour [(b)]	120	54.8
	Annual	60	20.7
PM_{10}	24-hour	50	26.2
$PM_{2.5}$	24-hour	25	11.7
	Annual	8	4.7

Notes: (a) Short-term concentrations are based on the 98th- percentile value. Annual concentrations are based on the 100th- percentile; and (b) TSP 24-hour background concentration derived from the 98th- percentile PM_{10} value of the 24-hour average value for 2010. (c) Background concentration is the average across all selected stations for the respective indicator compound.

Data representing non-indicator compounds were not available from the air quality monitoring stations that were selected to provide values for the indicator compounds. Two NAPS air quality monitoring stations elsewhere in the Greater Vancouver area provided background VOC and metal concentrations, on Rumble Street in Burnaby and at the Vancouver International Airport in Richmond. Details pertaining to the background concentrations for non-indicator compounds are provided in **Appendix 5.2-1 Air Quality and Meteorology Baseline Report**.

5.2.2.4.2 Meteorology

Due to the complex nature of the terrain within the assessment areas, meteorological conditions, specifically wind speed and direction, will have localized patterns. The complex topography and the land-water interface within the Howe Sound results in terrain-induced meteorological conditions and coastal flow conditions. As a result, it is expected that available meteorological stations (i.e., Environment Canada, MOE, and BC Wildfire Management Branch) within the LAA and RAA will not be representative of the meteorological conditions at the Project location.

In general, the winds in the Sea-to-Sky airshed follow a north-south pattern (MWLAP 2002). In winter when large-scale, low-pressure systems dominate the area, winds are generally from the northwest to northeast. In summer, the dominating high-pressure systems provide winds from the south; this condition is enhanced by a land-sea breeze that draws winds from the south into the mountains from slopes warmed by daytime sun.

For the purposes of this assessment, a meteorological dataset was developed using a mesoscale model, which was downscaled to represent the local scale for the 2012 calendar year. This data was validated against the meteorological monitoring stations listed in **Table 5.2-7** and found to be representative of the meteorological conditions for the RAA. Details of this assessment and development of the meteorological data set for use in the dispersion modeling is detailed in **Appendix 5.2-3 Dispersion Modeling Methodology**.

Table 5.2-7 Meteorological Station Summary Table

Monitoring Station	Monitoring Network	UTM Zone 10		Elevation (m asl)	Distance from Project
		Easting (m)	Northing (m)		
Pam Rocks	Environment Canada	478,351	5,481,739	4.9	20km SSW
Port Mellon	Environment Canada	465,015	5,485,006	7.6	23km SSW
Squamish Airport	Environment Canada	488,481	5,514,182	53.7	14km NE
MOE Squamish	MOE	488,867	5,505,988	20.0	8.4km NE

Note: m – metres; asl – metres above sea level; SSW – south, south west; NE – north east.

Two additional stations in the RAA, TS McNab, operated by the BC Ministry of Forests, and Deeks Peak, operated by the BC Ministry of Transportation and Infrastructure, were deemed not suitable for meteorological data comparison purposes. Details of the rationale for the exclusion of these two stations are provided in **Appendix 5.2-1 Air Quality and Meteorology Baseline Report**.

5.2.3 Assessment of Project-related Effects

This section describes the methods for characterizing potential effects, presents the potential interactions between the Project activities and the VC, and provides mitigation measures to avoid and reduce potential adverse interactions before characterizing the residual effects and their significance. The general approach used to evaluate the potential changes to air quality from the Project includes the following steps:

- Establish the existing air quality and meteorological conditions in the Project study areas.
- Develop a representative, site-specific meteorological dataset for use in the dispersion modeling assessment.
- Quantify the air emissions from the Project for the phase of activity (i.e., construction, operation, and decommissioning) likely to result in the highest overall changes in air quality.
- Predict the concentrations and deposition rates of indicator compounds released from the Project phase that will likely result in the highest overall changes to air quality using dispersion modeling.
- Use dispersion modeling to predict the concentrations and deposition rates of the non-indicator compounds that are required as inputs in other disciplines affected by changes in air quality (e.g., human health).
- Compare the predicted indicator compound concentrations to available criteria and standards, and assess the relevant significance of these effects.

5.2.3.1 Assessment Methodology

The potential residual effects of the Project are assessed in this section, with the methodology outlined in **Section 4.0 Environmental Assessment Methods**. Potential interactions between the Project activities and air quality are determined and described, mitigation is proposed to avoid or minimize potential adverse interactions, and the residual effects and their significance are described. Descriptions of the effects assessment approach and the residual effects characteristics and significance definitions for air quality are provided in the following sections.

5.2.3.1.1 Effects Assessment Approach

Air emissions (i.e., CAC and GHG emissions) from Project construction, operation, and decommissioning phases were estimated based on planned activities and equipment use. Criteria air contaminant emission estimates, professional judgment, and experience in conducting similar assessments guided the assessment of the potential effects of Project construction on air quality. The method used for calculating and quantifying the air emissions is described below:

- **Identify emissions sources** – Identification of emission sources is based on the equipment listed in the Project description and on detailed information provided by the Proponent.
- **Calculate emission rates** – Air emission rates were calculated using accepted methods, such as emission factors, and were based on the forecasted activities provided in the Project description.
- **Summarize overall emissions** – The calculated emissions were summarized by assessment case and by activity type.

Details of the specific emission calculation methods and resulting emissions are provided in **Appendix 5.2-4 Air Emission Details**. The detailed emission sources, substances emitted, and the reference methodology for emission rate calculations (as listed above) are provided in **Table 5.2-8**.

Table 5.2-8 Emission Activities, Compounds Emitted

Phase	Source	Description	Indicator and Non-Indicator Compounds
Construction	Landfill	FE	VOCs, PAHs, H_2S HAPS
	Non-road Engines	EE	NOx, CO, SO_2, TSP, PM_{10}, $PM_{2.5}$, VOCs, PAHs, Metals
	Material Handling	FE	TSP, PM_{10}, $PM_{2.5}$
	Excavation	FE	TSP, PM_{10}, $PM_{2.5}$
	Grading	FE	TSP, PM_{10}, $PM_{2.5}$
	Marine Vessel Exhausts	EE	NOx, CO, SO_2, TSP, PM_{10}, $PM_{2.5}$, VOCs, PAHs, Metals
Normal Operation	Landfill	FE	VOCs, PAHs, H_2S HAPS
	Amine Unit Incinerator	EE	NOx, CO, SO_2, TSP, PM_{10}, $PM_{2.5}$, VOCs, H_2S HAPS
	Process Combustion	EE	NOx, CO, SO_2, TSP, PM_{10}, $PM_{2.5}$, VOCs, H_2S HAPS
	Flare Pilots	EE	NOx, CO
	Fugitive Emissions from LNG Facility	FE	VOCs, PAHs, H_2S HAPS
	Combustion from HVAC equipment	EE	NOx, CO,
	Marine Vessel Exhausts	EE	NOx, CO, SO_2, TSP, PM_{10}, $PM_{2.5}$, VOCs, PAHs, Metals
Upset Conditions	Landfill	FE	VOCs, PAHs, H2S HAPS
	Fugitive Emissions from LNG Facility	FE	VOCs, PAHs, H_2S HAPS
	Combustion from HVAC equipment	EE	NOx, CO,
	Marine Vessel Exhausts	EE	NOx, CO, SO_2, TSP, PM_{10}, $PM_{2.5}$, VOCs, PAHs, Metals
	Emergency Generators	EE	NOx, CO, SO_2, TSP, PM_{10}, $PM_{2.5}$, VOCs, PAHs, Metals
	Flaring	EE	NOx, CO, TSP, PM_{10}, $PM_{2.5}$, VOCs,

Notes: EE – exhaust emission; FE – fugitive emission.

Due to the intermittent, short-term, and fugitive nature of construction and decommissioning, it is expected that effects from the construction and decommissioning phases will be less than during the operation phase. The air quality assessment therefore focuses on predicting maximum offsite effects from the operation phase of the Project, which is considered the Project phase that will likely result in the highest overall changes to air quality. Maximum offsite effects were assessed using an air quality dispersion model in accordance with MOE Guidelines (MOE 2008). Specifically, the CALPUFF version 6.42 (level 110325) dispersion model (i.e., run in dynamic (3D) mode with a fine resolution meteorological data set) was used in predicting concentrations and deposition rates. The CALPUFF model was selected for the following reasons:

- widely accepted in Canada for environmental assessments
- regarded as a recommended refined air dispersion model by the MOE (MOE 2008)
- offers superior handling of complex topography compared to the other refined models recommended by MOE
- predicts concentrations and deposition rates at distances as small as tens of metres and extending out far enough to enclose the entire modeling domain (i.e., 35 km x 35 km)
- simulates both wet and dry deposition of gaseous and particulate compounds, and models the atmospheric chemistry necessary to predict potential acid inputs

The full capabilities of the CALPUFF model can be realized when a dynamic (3D) meteorological data set is developed covering the area where predictions are required. This 3D dispersion meteorological data set allows the meteorological conditions to vary across the modeling domain for each hour that is modeled. The data file is generated using the CALMET pre-processor. To ensure a full range of possible meteorological conditions are included, a one-year data set for 2012 was generated using mesoscale meteorological (MM) model data as input. Using one year's worth of meteorological data is consistent with MOE recommendations when the data is produced from a MM model (2008); this approach has been outlined and accepted in both the conceptual and detailed model plans submitted to MOE (Golder 2014a and 2014b). This data was validated against local monitored meteorological data. Details of the meteorological data set development are provided in **Appendix 5.2-2 Meteorology**.

The effects assessment included a comparison of predicted air quality concentrations against the most stringent BC criteria (i.e., Level A) – CAAQS and the equivalent NAAQO maximum desirable levels – to predict potential Project-related effects and determine their significance. The CALPUFF model was also used in predicting concentrations and deposition rates of non-indicator compounds (i.e., those compounds used by other technical disciplines in this environmental assessment in assessing the indirect effects of air quality). The model results of 15 VOCs that can potentially be emitted from the Project under normal operations were compared against Alberta Ambient Air Quality Objectives due to the lack of federal or BC ambient air quality criteria for individual VOCs. Details of the VOCs model results are provided in **Appendix 5.2-5 Volatile Organic Compounds Model Predictions**.

5.2.3.1.2 Residual Effects Characterization

The residual air quality effects of the Project represent those effects that remain after mitigation measures have been incorporated. In calculating the air emission rates used as inputs to the dispersion model, consideration was given to Project design elements that reduce emissions, as well as in-design (Project) mitigation that will be in place. The predicted effects therefore represent the residual effects of the Project with the design mitigation in place.

Definitions for ratings applied to residual effects criteria, developed with specific reference to the atmospheric environment, are presented in **Table 5.2-9**. Where possible, definitions take into account the technical guidance that has been produced.

Table 5.2-9 Criteria Used to Characterize Residual Effects on the Atmospheric Environment

Criteria	Description	Definition of Rating
Magnitude	Expected size or severity of the residual effect	• **Negligible** – Project plus background concentrations are less than or equal to 10% of air quality criteria (**Table 5.2-1**) • **Low** – Project plus background concentrations are between 10% and 50% of air quality criteria • **Moderate** – Project plus background concentrations are between 50% and 100% of the air quality criteria • **High** – Project plus background concentrations are equal to or greater than the air quality criteria
Geographic Extent	Spatial scale over which the residual effect is expected to occur	• **Local** – effect limited to LAA • **Regional** – effect extends beyond the LAA into the RAA • **Beyond Regional** – effect extends beyond the RAA
Duration	Length of time over which the residual effect is expected to persist	• **Short-term** – conditions causing effect are short-term and evident during the construction or decommissioning and reclamation phases • **Long-term** – conditions causing effect are evident for an extended period, and last throughout the operation phase • **Permanent** – conditions causing effect extend over several Project phases, and extend into and beyond the decommissioning and reclamation phase
Frequency	How often the residual effect is expected to occur	• **Infrequent** – conditions or phenomena causing the effect occur infrequently • **Frequent** – conditions or phenomena causing the effect occur at regular, although infrequent intervals • **Continuous** – conditions or phenomena causing the effect occur at regular and frequent intervals
Reversibility	Whether or not the residual effect can be reversed once the physical work or activity causing the effect ceases	• **Low** – effect is readily reversible once the Project activities cease • **High** – effect cannot be reversed, or will take an extended time after Project activities cease to be reversed
Context	Refers primarily to the sensitivity and resilience of the VC to change caused by the Project	• **Low** – effect takes place within an area with low sensitivity (i.e., without human activity) • **Moderate** – effect takes place within an area with moderate human sensitivity (i.e., with human development and activity but no residences) • **High** – effect takes place within a highly sensitive receptor (i.e., residences and dwellings)

In assigning magnitude for air quality, consideration is given to the maximum prediction outside of the Project area, since the regulatory air quality criteria do not apply within the Project area. **Table 5.2-10** presents the criteria for assigning magnitude to the predicted changes to air quality as a result of Project-related effects. If the predicted maximum concentrations exceed the recommended criteria defined in **Section 5.2.1.1**, the effect is considered to be of high magnitude. A moderate magnitude is assigned when the maximum prediction is between 50% and the relevant criteria. A low magnitude is assigned when the maximum concentration is between 10% and 50% of the relevant criteria. The threshold for negligible is set at 10% of the relevant criteria.

Table 5.2-10 Air Quality Magnitude Criteria

Compound	Averaging Period	Magnitude Level Definition (µg/m³)			
		Negligible	Low	Moderate	High
NO_2	1 hour (proposed)	≤18.8	≤94.0	<188	≥188
	24 hour	≤20	≤100	<200	≥200
	Annual	≤6	≤30	<60	≥60
SO_2	1 hour (proposed)	≤20	≤100	<200	≥200
	3 hour	≤37.5	≤187.5	<375	≥375
	24 hour	≤15	≤75	<150	≥150
	Annual	≤3	≤15	<30	≥30
CO	1 hour	≤1,430	≤7,150	<14,300	≥14,300
	8 hour	≤550	≤2,750	<5,500	≥5,500
TSP	24 hour	≤12	≤60	<120	≥120
	Annual	≤6	≤30	<60	≥60
PM_{10}	24 hour	≤5	≤25	<50	≥50
$PM_{2.5}$	24 hour	≤2.5	≤12.5	<25	≥25
	Annual	≤0.8	≤4	<8	≥8

5.2.3.1.3 Definition of Significance

The following definitions were used when assigning significance:

Negligible (N) When model predictions, coupled with background concentrations, are assigned a negligible weighting for the magnitude criteria. Negligible effects are not carried forward to the cumulative effects assessment.

Not significant (NS) Those effects that are greater than negligible and that do not meet the definition of significant. Not significant effects are carried forward to the cumulative effects assessment.

Significant (S) Where offsite Project-related predicted concentrations, coupled with background concentrations, are assigned a high magnitude, or the effects extend beyond the RAA. Other residual categories such as duration, frequency, reversibility, and context are also considered based on professional judgement when determining significance. Significant effects are carried forward to the cumulative effects assessment.

For the purposes of the assessment of air quality, all predicted effects are assumed to be of an adverse direction as the Project will increase concentrations of indicator compounds; and will be fully reversible, as air quality concentrations will return to background conditions once emissions from the Project cease.

As a result, the overall residual effect for changes to air quality as a result of Project-related effects will rely on the measures of magnitude, geographic extent, duration, frequency, and context.

5.2.3.1.4 Likelihood

Likelihood refers to whether or not a residual effect is likely to occur based on a variety of factors, including the likelihood of a physical work or activity causing a disturbance to occur, and the likelihood of mitigation being successful (EAO 2013). The effects assessment on the atmospheric environment analyzed the likelihood of each residual effect occurring, and defines the terms unlikely and likely qualitatively as follows:

- **Unlikely** – the residual effect is unlikely to occur
- **Likely** – the residual effect is likely to occur

The criteria of likelihood are not explicitly addressed for air quality since all predicted air quality effects are assumed likely to occur.

5.2.3.1.5 Confidence and Risk

The level of confidence for each residual effect prediction takes into consideration any uncertainty associated with each prediction. If there were no substantial limitations with respect to the effects prediction, then the level of confidence in the residual effect prediction was determined to be high. Confidence levels are defined as follows:

- **Low** – low degree of certainty in the effects prediction
- **Moderate** – moderate degree of certainty in the effects prediction
- **High** – high degree of certainty in the effects prediction

5.2.3.2 Potential Interactions of the Project and Proposed Mitigation

Potential interactions between the Project activities and the atmospheric environment are presented in the following sections, and are followed by mitigation measures proposed to avoid or minimize the interactions.

Western Forest Products committed to obtaining a COC prior to transferring the Woodfibre property to WLNG. The MOE issues two COCs (uplands and waterlot) on December 22, 2014. The COCs include conditions required to assure existing site contamination do not pose a risk to other VCs, including air quality. Refer to **Section 5.7 Site Contamination** for further information relating to the COC and site contamination.

5.2.3.2.1 Potential Interactions

Potential interactions between the Project and the atmospheric environment will be in the form of maximum offsite (outside of Project area) concentrations resulting from emission-producing activities during each phase of the Project (construction, operation, and decommissioning). As described in **Section 5.2.3**, due to the intermittent, short-term, and fugitive nature of construction and decommissioning, it is expected that effects from the construction and decommissioning phases will be less than during the operation phase. The air quality assessment will therefore focus on predicting maximum offsite effects from the operation phase of the Project, which is considered to be the Project phase that will likely result in the highest overall changes to air quality.

Assuming that the primary sources of emissions during construction are the same for decommissioning, effects resulting from emissions during decommissioning are expected to be similar to those during construction, although to a lesser degree as the extent and duration of work is expected to be less. The primary sources of emissions during construction include the following:

- **Landfill** – Two closed landfills are located onsite and are legacy facilities from historic operations at the site. Due to the nature of material decomposition within the landfills, the landfills will emit non-indicator compounds during the operation, construction, and de-commissioning phases of the Project.
- **Non-road engines** (vehicle exhaust) – Onsite construction equipment will include equipment such as excavators, pumps, generators, dump trucks, cranes, forklifts, graders, and loaders. The operation of this equipment will result in emissions of indicator and non-indicator compounds as a result of diesel combustion.
- **Material handling** – Materials such as soil, gravel, and overburden will be moved and handled during the construction phase. This material movement will result in the release of fugitive particulate emissions (TSP, PM_{10} and $PM_{2.5}$).
- **Excavating** (bulldozing) – Bulldozing operations will result in the release of fugitive particulate emissions (TSP, PM_{10} and $PM_{2.5}$).
- **Grading** – Surface grading will result in in the release of fugitive particulate emissions (TSP, PM_{10}, and $PM_{2.5}$).
- **Marine vessels** – Marine vessels will be used to transport crews and materials from Squamish to the Project. The operation of these vessels will result in emissions of indicator and non-indicator compounds as a result of fuel combustion.

Maximum daily construction emissions for indicator compounds are summarized in **Table 5.2-11**.

Table 5.2-11 Maximum Daily Construction Emissions for Indicator Compounds

Activity	Maximum Daily Emission rate (tonnes/day)					
	NO_2	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$
Landfill	—	—	—	—	—	—
Non-road Engines	0.36	<0.01	0.15	0.03	0.03	0.03
Material Handling	—	—	—	0.01	<0.01	<0.01
Excavation	—	—	—	0.34	0.07	0.04
Grading	—	—	—	0.06	0.03	0.02
Marine Vessel	0.04	<0.01	<0.01	<0.01	<0.01	<0.01
Total	0.40	<0.01	0.15	0.43	0.14	0.08

Notes: "—" signifies no predicted emissions from source.

The CAC emission contribution from the Project is assessed as approximately 0.1% of the total daily BC CAC emissions for 2012. **Table 5.2-12** provides a comparison of predicted Project CAC emissions during normal operations and emissions reported in Canada and BC for 2012.

Table 5.2-12 Comparison of Project Criteria Air Contaminant Emissions to National and Provincial Criteria Air Contaminant Emissions from Industrial Sources

Reporting Year	Parameter	Canadian Industrial Emissions (tonnes/day)	BC Industrial Emissions (tonnes/day)	Project Emissions: Construction (tonnes/day)	Project Emissions as % of BC Emissions
2012	NO_X	5,425	160	0.4	0.3%
	SO_2	3,528	139	<0.1	<0.1%
	CO	22,614	318	0.15	<0.1%
	TSP	62,279	338	0.43	0.1%
	PM_{10}	19,400	115	0.14	0.1%
	$PM_{2.5}$	3,749	35	0.08	0.2%

Notes: Daily emission rates for Canadian and BC totals approximated, assuming emissions occur consistently throughout the year (i.e., annual total divided by 365 days).
Source: Environment Canada 2013.

During the operation phase of the Project, there will be two primary emission schemes: normal operations and upset flaring. The normal operations scheme is represented by conditions under which the facility will operate for the vast majority of the time. The upset scheme will be regarded as abnormal conditions where flaring and emergency power generation will be taking place. Therefore, emission activities are classified as follows:

1) activities only during normal operations
2) activities during both normal operations and upset operations
3) activities only during upset operations

The primary sources of CAC emissions during Project operation will include the following:

- **Amine Incinerator** – An amine treatment process will be used for removing acid gas (e.g., carbon dioxide (CO_2) and sulphur compounds) contained in the feed gas prior to compression and refrigeration. A thermal oxidizer or incinerator will oxidize the sulphur compounds into a more stable and less toxic form (e.g., SO_2) prior to releasing them to the atmosphere. The thermal oxidation process will result in the emission of indicator and non-indicator compounds.
- **Process Combustion** – Process heat requirements at the Project facility will be provided by a hot oil heater. The heater will burn natural gas, resulting in the emission of indicator and non-indicator compounds.
- **Flare Pilots** – All emergency flare stacks at the Project will have a pilot flame that will burn continuously to ensure that relieved gases will be ignited during an emergency situation. The pilot flame is sustained by burning natural gas, which will result in the emission of indicator and non-indicator compounds.
- **Fugitive Emissions** – There is a potential for non-indicator compound emission releases during the LNG process that cannot be attributable to a specific location; these are known as fugitive emissions. Fugitive emissions occur over a general area and emissions may be the result of losses from pipe fittings, filling and emptying of storage vessels, and release of remnant gases in a flare or a stack. Well managed and newly built facilities can limit fugitive emission releases, but cannot entirely eliminate them with existing best management practices (BMPs) and technology.
- **Combustion from HVAC (heating, ventilating and air conditioning) Equipment** – Natural gas combustion equipment is used to provide comfort heating to the facility for approximately six months of the year. Combustion of natural gas will result in the release of indicator and non-indicator compounds.
- **Marine Vessel Exhaust** – Passenger ferries and water taxies will travel between Squamish and the site daily to transport employees. An LNG carrier will be stationed at the facility, with an auxiliary engine running, as part of the LNG storage and shipping operations. Emission from these marine vessels will be indicator compounds due to the combustion of fuel.
- **Landfill** – Two closed landfills are located onsite. The landfills are historic facilities and were operational earlier on in the site's history. Due to the nature of material decomposition within the landfills, the landfills will emit non-indicator compounds during the construction, operation, and de-commissioning phases of the Project.
- **Emergency Generators** – When power is unavailable at the facility, emergency generators will be used to meet emergency power demands. Emissions from emergency generators will result in the combustion of diesel and the release of indicator and non-indicator compounds.
- **Flaring** – During upset conditions process gas will be flared. Emissions from flaring will be as a result of the combustion of process gas and the release of indicator and non-indicator compounds.

The annual emissions during the operation phases for indicator compounds are summarized in **Table 5.2-13**. Details regarding emission rates and source parameterization can be found in **Appendix 5.2-3 Dispersion Modeling Methodology** and **Appendix 5.2-4 Air Emission Details**.

Table 5.2-13 Indicator Compound Emission Rates (tonnes/day) – Operation Phase

Emission Category	Emission Activity	Indicator Compounds (tonnes/day)					
		NO_2	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$
Normal operations	Amine incinerator	0.09	0.06	0.01	<0.01	<0.01	<0.01
	Flare pilots	<0.01	—	<0.01	—	—	—
	Hot oil heater	0.03	0.04	0.04	0.002	<0.01	<0.01
Normal operations and upset conditions	Marine vessel exhaust	0.69	0.02	0.06	0.01	0.01	0.01
	Landfill	—	—	—	—	—	—
	Fugitive emission	—	—	—	—	—	—
	Combustion from HVAC equipment	<0.01	—	<0.01	—	—	—
Upset operations only	Flaring	1.66	—	9.04	3.28	3.28	3.28
	Emergency generators	0.34	0.01	0.13	0.01	0.01	0.01
Total normal operations		0.81	0.12	0.11	0.02	0.02	0.01
Total upset operations		2.70	0.03	9.22	3.30	3.30	3.30

Notes: — signifies no predicted emissions from source.

The CAC emission contribution during the operation phase of the Project is approximately 0.1% of the total daily BC CAC emissions for 2012. **Table 5.2-14** provides a comparison of Project CAC emissions for normal operations, with emissions reported in Canada and BC for 2012.

Table 5.2-14 Comparison of Project Criteria Air Contaminant Emissions to National and Provincial Criteria Air Contaminant Emissions from Industrial Sources

Reporting Year	Parameter	Canadian Industrial Emissions (tonnes/day)	BC Industrial Emissions (tonnes/day)	Project Emissions: Normal Operations (tonnes/day)	Project Emissions as % of BC Emissions
2012	NO_X	5,425	160	0.81	0.5%
	SO_2	3,528	139	0.12	0.09%
	CO	22,614	318	0.11	0.03%
	TSP	62,279	338	0.02	<0.01%
	PM_{10}	19,400	115	0.02	0.01%
	$PM_{2.5}$	3,749	35	0.01	0.04%

Notes: Daily emission rates for Canadian and BC totals approximated assuming emissions occur consistently throughout the year (i.e., annual total divided by 365 days)
Source: Environment Canada 2013.

Potential interactions between Project activities and the atmospheric environment during the construction, operation, and de-commissioning of the Project are identified in **Table 5.2-15**. The following criteria have been used to indicate the degree of the effect from the interaction:

- No interaction is predicted
- Minor interaction (i.e., an adverse effect may result from an interaction, but standard measures to avoid or minimize the potential effect are available and well understood to be effective, and any residual effects are negligible
- Carried forward means that interactions may result in an adverse effect

Table 5.2-15 Potential for Interactions between Project-related Activities and the Atmospheric Environment

Project Activities and Physical Works	Atmospheric Environment Interaction	Nature of Interaction and Rationale for Interaction Rating
Construction Phase		
All Project construction activities and works	See below	Offsite effects from construction emission-producing activities will be short term, intermittent, and localized in nature (i.e., fugitive dust will deposit close to the source) and less than the operation phase; therefore, the interaction is considered minor.
Transportation of construction crews to the Project area via crew boat or ferry; transportation of materials and supplies to the Project area via barge; and emergency transportation via helicopter	Minor interaction	
Site clearing	Minor interaction	
Blasting where required to accommodate Project infrastructure	Minor interaction	
Demolition of infrastructure not required for Project	Minor interaction	
Upgrades to existing buildings and infrastructure, including site administration and safety facilities	Minor interaction	
Installation of stormwater and erosion and sediment control measures	Minor interaction	
Construction of Mill Creek water intake, pipeline and water storage tank	Minor interaction	
Installation of batch plant	Minor interaction	
Upgrading and construction of onsite roads	Minor interaction	
Construction and upgrading of small craft floats	Minor interaction	
Waste material disposal at permitted offsite and onsite landfills	Minor interaction	
Construction of electrical substations and transformers and cables and powerlines	Minor interaction	
Construction of land-based civil works, including foundation excavation, cast-in-place concrete, and structures	Minor interaction	
Construction of the foundation and load-out quay for land-based LNG facility, including natural gas piping Transfer of the LNG facility to its foundation	Minor interaction	

Project Activities and Physical Works	Atmospheric Environment Interaction	Nature of Interaction and Rationale for Interaction Rating
Construction of FSO jetty, including pile driving and shoreline modifications to accommodate structural infrastructure, including possible dredging, and permanent mooring of FSO	Minor interaction	
Connection of utilities (e.g., electrical, controls, gas, water) to LNG facility and FSO	Minor interaction	
Installation of seawater cooling system, including inlet and outlet structures	Minor interaction	
Re-vegetation of areas of the Green Zone	Minor interaction	
Operation Phase		
All Project operation activities and works	See below	Offsite effects from emission activities from the normal operations will be present throughout the facility operation, and therefore have been carried forward to the effects assessment.
Commissioning of equipment for startup	Carried forward	
Delivery of natural gas via piping from the from the FortisBC natural gas metering station to the LNG facility	Carried forward	
Pre-treatment and liquefaction of natural gas at the LNG facility	Carried forward	
Storage and offloading of LNG at the FSO	Carried forward	
Mooring of LNG carriers at the FSO for LNG transfer	Carried forward	
Shipping within Howe Sound (approximately 40 LNG carriers per year) in established shipping lanes	Carried forward	
Patrolling of Control Zones around LNG facility, FSO, and LNG carriers	Carried forward	
Extraction of water from Mill Creek	Carried forward	
Supporting infrastructure: transport of employees through private passenger ferry terminal; transport of supplies using barges; site administration and safety facilities and emergency transportation via helicopter	Carried forward	
Decommissioning Phase		
All Project decommissioning activities	Please see below	Offsite effects from de-commissioning emission producing activities will be short-term, intermittent, and localized in nature (i.e., fugitive dust will deposit close to the source) and less than the construction phase; therefore, the interaction is considered minor.
Dismantling of equipment and buildings that will not continue to serve a purpose, including selling reusable equipment and materials and recycling scrap equipment and materials	Minor interaction	
Removal of LNG facility and FSO from the Project area	Minor interaction	

5.2.3.2.2 Potential Adverse Effects

Based on the interactions table, the potential adverse effects are described in the following sections.

Increase in offsite indicator compound concentrations as a result of construction-based emissions activities

Emission rates for the construction phase have been quantified and are presented in **Table 5.2-11**. Detailed construction emission information is also provided in **Appendix 5.2-4 Air Emission Details**. Emissions from construction activities and associated offsite effects are expected to be intermittent, short in duration, and localized in extent. The effects of construction emissions can also be further mitigated by a construction management plan (e.g., mitigation **M5.2.1** – fugitive dust management plan); therefore, it is expected that construction effects will be less than the effects of the Project's operation phase (i.e., any residual construction effects will be less than interactions from the operation phase). As a result, this interaction is not further assessed.

Increase in offsite indicator compound concentrations as a result of Project emissions during the operation phase under normal operations

Project interactions from the operation phase (normal operations) were determined by quantifying emission rates for onsite activities (**Table 5.2-13**). Offsite effects from emission activities are estimated using an air dispersion model, and predictions are coupled with background concentrations to assess the effects of changes to air quality from the Project.

Increase in offsite indicator compound concentrations as a result of Project emissions during the operation phase under upset conditions

Project interactions from the operation phase (upset conditions) were determined by quantifying emission rates from onsite activities (**Table 5.2-13**). Offsite effects from emission activities are estimated using an air dispersion model. Model predictions are coupled with background concentrations to assess the effects of changes to air quality from the Project. Due to the limited nature of upset conditions on the Project, only normal operations residual effects are carried through to the assessment of significance and cumulative effects.

Deposition of nitrogen and sulphur compounds emitted from the Project may contribute to the acidification of the terrestrial and aquatic ecosystems

Currently, there is no guideline from the MOE on when acidification effects should be evaluated in environmental assessments. Based on guidelines from other jurisdictions, such as those in Alberta (ESRD 2013), regional acid deposition modeling should only take place under the following conditions:

- the development's combined emissions of SO_2, NO_X, and ammonia (NH_3) are greater than 0.175 tonnes/day of H^+ (hydrogen ion used for acid deposition)

- there is evidence that regional soil and surface water is more sensitive to acidification than is estimated in the provincial framework
- there is existing deposition and/or acidification impact monitoring that indicates a potential concern if acid deposition increases.

NO_X and SO_2 emitted from the Project are considered acid precursors; however, these emissions are low (0.02 tonne/day of H^+ when compared to the 0.175 tonne/day H^+ in the Alberta threshold). Furthermore, there is also no indication of regional ecosystems being more sensitive to acidification, nor evidence of existing regional acidification issue. Therefore, potential interaction between Project emissions and regional acidification is limited. For this reason this interaction is not further assessed.

Increase in offsite indicator compound concentrations as a result of decommissioning activities

Emissions from closure and decommissioning activities and associated offsite effects are expected to be less than those produced during the construction phase and effects from the Project's operation phase. As a result, any residual effects will be less than interactions from the operation phase; for this reason this interaction is not further assessed.

5.2.3.2.3 Proposed Measures to Mitigate Project-related Effects

A mitigation control is any practical means or measure taken to avoid, minimize, restore onsite, compensate, or offset the potential adverse effects of the Project (EAO 2013). The following sections describe mitigation measures to control emissions of indicator compounds during the different phases of the Project.

Measures to avoid or reduced Project-related effect to air quality are included in Project design, including using electricity to drive the LNG facility and the equipment necessary to provide shore power to LNG carriers will be made available at the FSO. Woodfibre LNG Limited will provide electrical power to the FSO and shore power for berthing LNG carriers.

M5.2-1 – Dust Control Plan

Woodfibre LNG Limited will prepare and implement a Dust Control Plan for construction, operation and decommissioning activities. The objectives of this plan will be to prevent and control dust emissions. Monitoring will be conducted to make sure that mitigation measures are properly implemented and are effective. Mitigation measures to reduce the emission of fugitive particulate matter (i.e., dust), may include activities such as watering of exposed surfaces, reducing the height of material drops, covering stockpiles, and controlling the speed of onsite off-road vehicles.

M5.2-2 – Limit Use of Generators

Woodfibre LNG Limited will limit the use of generators to emergency power during operation.

Table 5.2-16 presents a summary of potential Project-related effects and proposed mitigations measures to address changes in the atmospheric environment.

Table 5.2-16 Summary of Potential Effects and Mitigations for Atmospheric Environment

Summary of Potential Effect	Project Design Measure / Mitigation	Mitigation Number
Construction		
Changes to Indicator compounds	Dust Control Plan	M5.2-1
Operation		
Changes to indicator and non-indicator compounds	Provide electrical power to the FSO and shore power for berthing LNG carriers.	Project design
	Limit use of emergency power generators during operation	M5.2-2
Decommissioning		
Changes to indicator compounds	Dust Control Plan	M5.2-1

Due to the nature of the effects assessment and the fact that the Project design mitigation measures outlined above are already incorporated into the assessment, all of the effects predicted by the dispersion modeling assessment were considered residual effects.

5.2.3.3 Residual Effects and their Significance

The potential residual effects of the Project and their significance are described in terms of the effects characteristics and the definitions for significance for atmospheric environment.

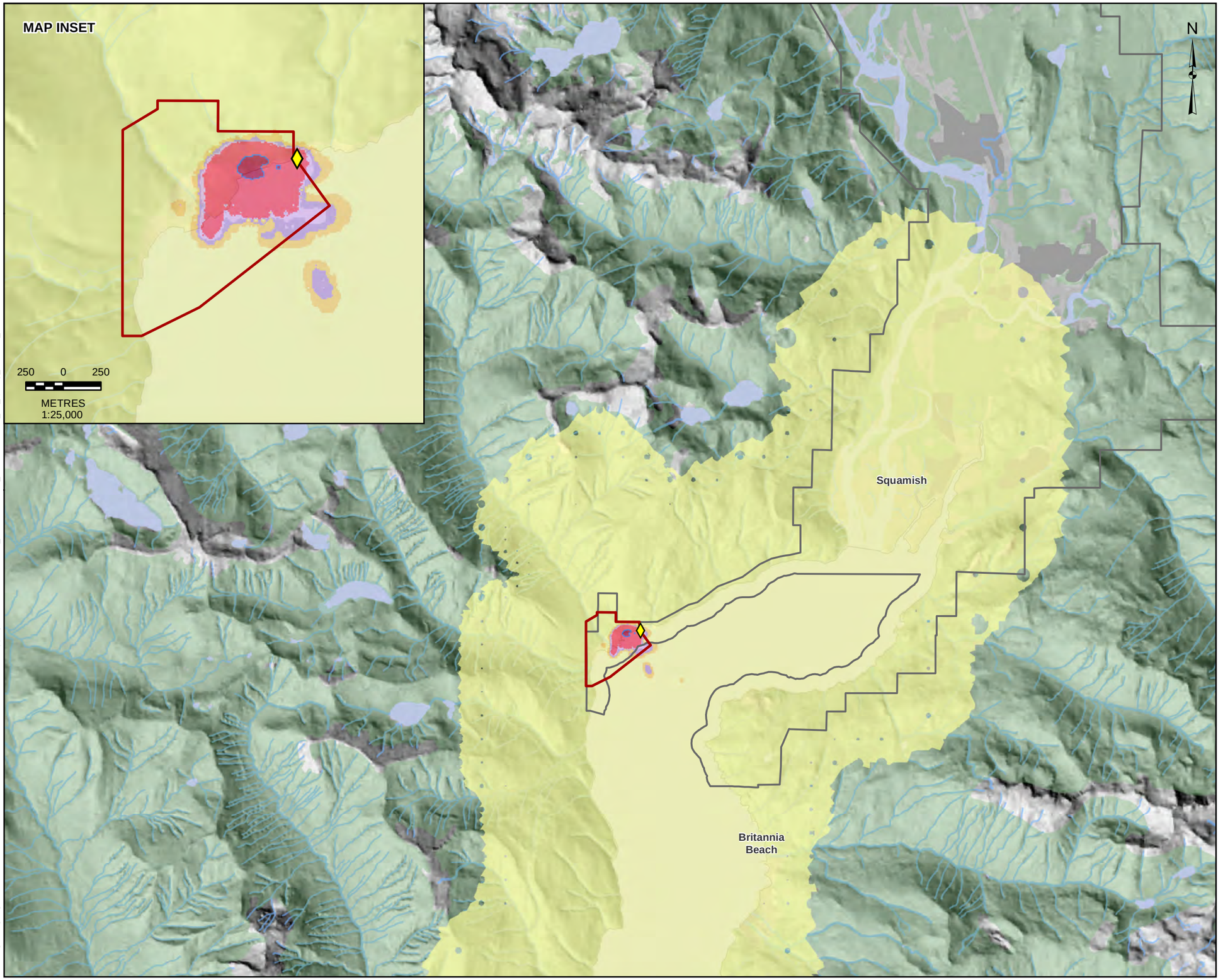
Air dispersion modeling was undertaken for Project operation, and the results of the dispersion modeling were compared with the applicable federal and provincial standards and guidelines for CACs, in accordance with the standards outlined in **Table.5.2-1**. As a conservative (i.e., worst case) approach, it was assumed that all units would be operating simultaneously, at 100% capacity. All predicted concentrations are well below their respective standards and guidelines. The modeling results are summarized in **Table 5.2-17**. Because upset conditions will only be applicable for short-term periods, annual model predictions are not presented in this report.

Contour plots (i.e., isopleth plots) of the predicted emission concentrations for each indicator compound and averaging period are provided in **Figure 5.2-2** through to **Figure 5.2-23**.

Table 5.2-17 Predicted Air Concentrations for Indicator Compounds

Indicator Compound	Averaging Period	Ambient Air Quality Criteria ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Normal Operations	Normal Operations Including Background Operation[a]	Normal Operations[a] Percent of Air Quality Criteria	Assigned Magnitude Criteria	Upset Including Background[a]
NO_2	1 hour[b] [c]	188	27.3	n/a[e]	53.5	28%	Low	65.1
	24 hour	200	18.6	n/a[e]	38.2	19%	Low	40.3
	Annual	60	9.7	n/a[e]	33.9	57%	Moderate	—
SO_2	1 hour[b] [c]	200	7.9	21.1	29.0	15%	Low	25.1
	24 hour	150	4.8	9.1	13.9	9%	Negligible	13.2
	Annual	30	2.1	3.2	5.3	18%	Low	—
CO	1 hour	14,300	469.5	62.2	531.7	4%	Negligible	910.9
	8 hour	5,500	376.7	25.5	402.2	7%	Negligible	455.9
TSP	24 hour	120	54.8	3.7	58.5	49%	Low	66.1
	Annual	60	20.7	1.3	22	37%	Low	—
PM_{10}	24 hour	50	26.2	3.7	29.9	60%	Moderate	37.5
$PM_{2.5}$	24 hour	25	11.7	3.4	15.1	60%	Moderate	23.0
	Annual	8	4.7	1.2	5.9	74%	Moderate	—

Notes: (a) includes background concentrations; (b) US EPA National Ambient Air Quality Standards that are being considered to be adopted in BC; (c) Based on 98th-percentile value; (d) Based on 99th-percentile value (e) NO_2 predicted concentrations were calculated on an hourly basis where Project-related effects were coupled with background concentration, and the Ambient Ration Method was then used to convert NO_x to NO_2; therefore, the addition of a background concentration to Project-related effects is non-linear for NO_2 and normal operations; Project-only effects have not been provided.



LEGEND

- PROJECT AREA
- URBAN AREA
- FOREST AREA
- DISTRICT OF SQUAMISH MUNICIPALITY
- WATERCOURSE
- MAXIMUM OFFSITE LOCATION

1-HOUR NO_2 CONCENTRATION ($\mu g/m^3$)

- < 31.3
- 31.3 - 40.0
- 40.1 - 45.0
- 45.1 - 50.0
- 50.1 - 55.0
- 55.1 - 187.9
- > 188

NOTES

PREDICTED NO_2 CONCENTRATIONS WERE CALCULATED USING THE AMBIENT RATIO METHOD. BACKGROUND 1-HOUR NO_2 CONCENTRATION TAKEN AS 27.3 $\mu g/m^3$.

REFERENCE

MODELLED CONCENTRATIONS FROM CALPUFF VERSION 6.42. MUNICIPALITIES FROM GEOBC. BASE DATA FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. HILLSHADE PROVIDED BY GOVERNMENT OF BRITISH COLUMBIA.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

SCALE

2 0 2
KILOMETRES

PROJECT
WOODFIBRE LNG LIMITED.
WOODFIBRE, HOWE SOUND, B.C.

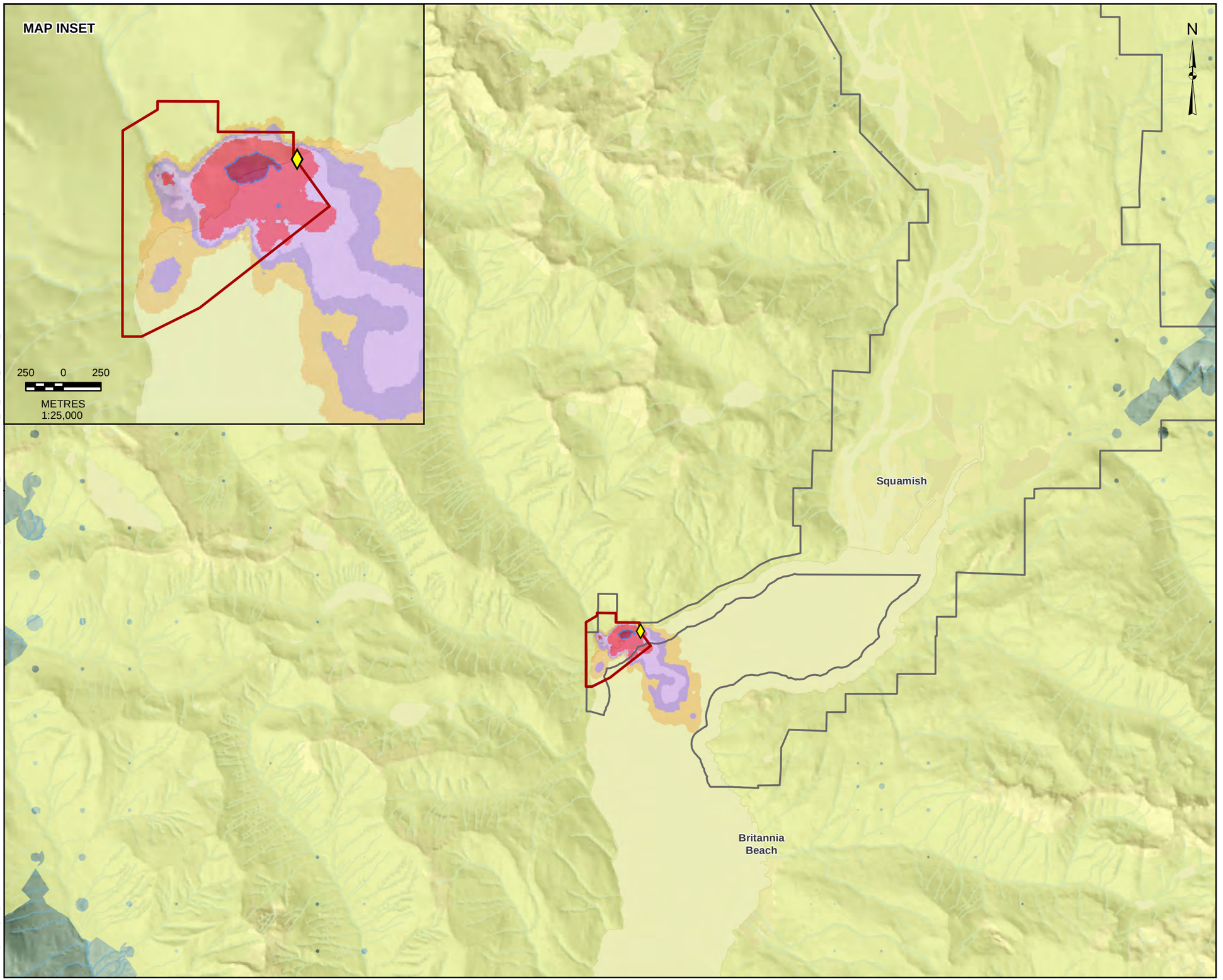
TITLE
1-HOUR NITROGEN DIOXIDE (NO_2) PREDICTIONS, NORMAL OPERATIONS

Golder Associates

PROJECT NO. 13-1422-0006			PHASE 6000 TASK 6030	
DESIGN	TB	12 Sep. 2014	SCALE 1:80,000	REV. 1
GIS	RH	07 Jan. 2015		
CHECK	JR	07 Jan. 2015		
REVIEW	SC	07 Jan. 2015		

FIGURE 5.2-2

PATH: \\golder.gds\gal\Vancouver\CAD-GIS\VAN\2013\13-1422\13-1422-0006 - WoodfibreMapping\MXD\Air\WOODFIBRE_ATMOSPHERIC_ENVIRONMENT_Air_Quality_Contours_DDP.mxd Date: 1/7/2015 Time: 3:32:28 PM



LEGEND

- PROJECT AREA
- URBAN AREA
- FOREST AREA
- DISTRICT OF SQUAMISH MUNICIPALITY
- WATERCOURSE
- MAXIMUM OFFSITE LOCATION

1-HOUR NO_2 CONCENTRATION ($\mu g/m^3$)

- < 31.3
- 31.3 - 40.0
- 40.1 - 45.0
- 45.1 - 50.0
- 50.1 - 55.0
- 55.1 - 187.9
- > 188

NOTES

PREDICTED NO_2 CONCENTRATIONS WERE CALCULATED USING THE AMBIENT RATIO METHOD. BACKGROUND 1-HOUR NO_2 CONCENTRATION TAKEN AS 27.3 $\mu g/m^3$.

REFERENCE

MODELLED CONCENTRATIONS FROM CALPUFF VERSION 6.42. MUNICIPALITIES FROM GEOBC. BASE DATA FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. HILLSHADE PROVIDED BY GOVERNMENT OF BRITISH COLUMBIA.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

SCALE

2 0 2
KILOMETRES

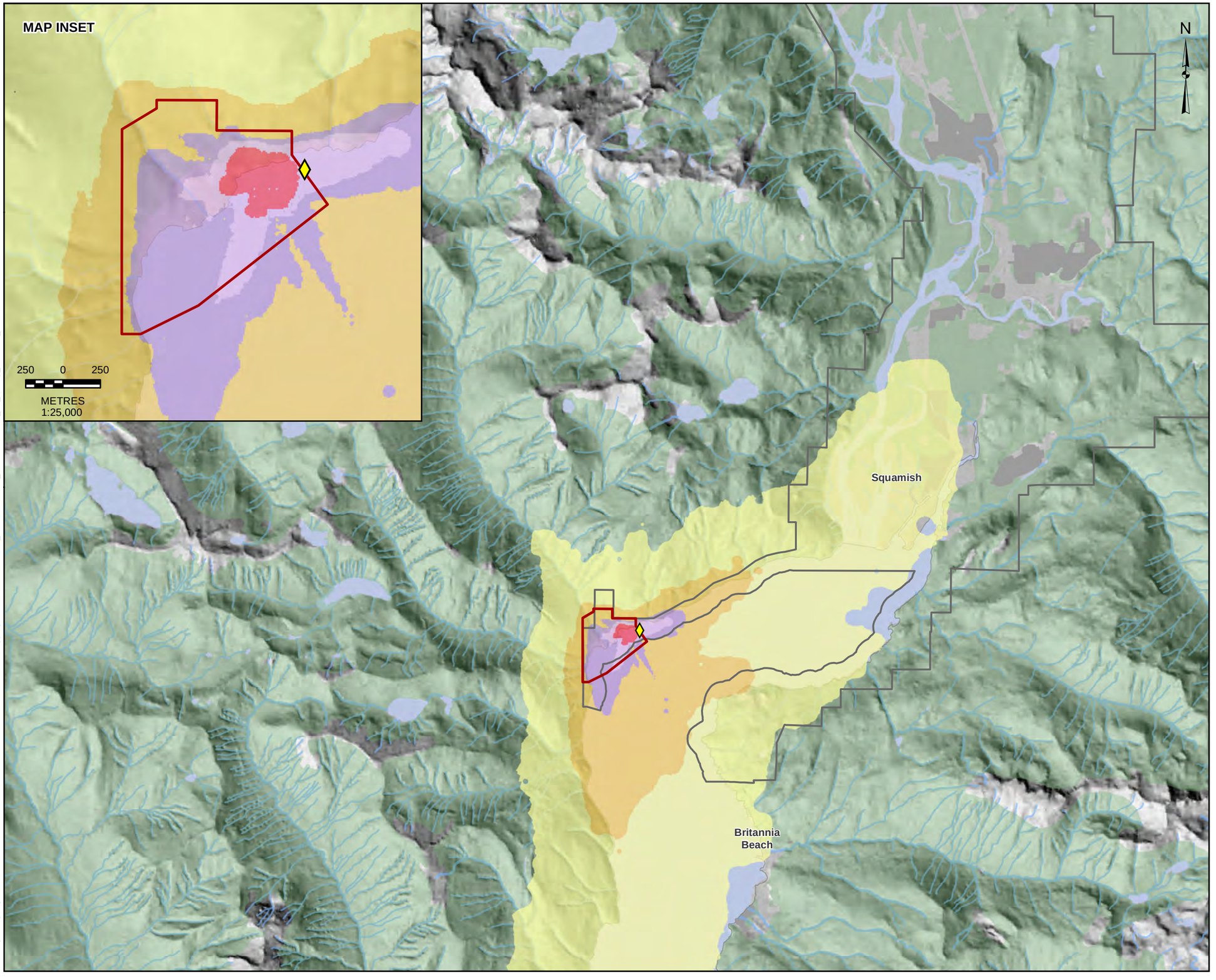
PROJECT
WOODFIBRE LNG LIMITED.
WOODFIBRE, HOWE SOUND, B.C.

TITLE
1-HOUR NITROGEN DIOXIDE (NO_2) PREDICTIONS, UPSET CONDITIONS

Golder Associates

PROJECT NO. 13-1422-0006			PHASE 6000 TASK 6030	
DESIGN	TB	12 Sep. 2014	SCALE 1:80,000	REV. 1
GIS	RH	07 Jan. 2015		
CHECK	JR	07 Jan. 2015	FIGURE 5.2-3	
REVIEW	SC	07 Jan. 2015		

PATH: \\golder.gds\gal\Vancouver\CAD-GIS\VAN\2013\13-1422\13-1422-0006 - WoodfibreMapping\MXD\Air\WOODFIBRE_ATMOSPHERIC_ENVIRONMENT_Air_Quality_Contours_DDP.mxd Date: 1/7/2015 Time: 3:33:09 PM



LEGEND

- PROJECT AREA
- URBAN AREA
- FOREST AREA
- DISTRICT OF SQUAMISH MUNICIPALITY
- WATERCOURSE
- MAXIMUM OFFSITE LOCATION

24-HOUR NO_2 CONCENTRATION ($\mu g/m^3$)

- < 31.3
- 31.3 - 32.0
- 32.1 - 33.0
- 33.1 - 34.0
- 34.1 - 40.0
- 40.1 - 199.9
- > 200

NOTES

PREDICTED NO_2 CONCENTRATIONS WERE CALCULATED USING THE AMBIENT RATIO METHOD. BACKGROUND 24-HOUR NO_2 CONCENTRATION TAKEN AS 18.6 $\mu g/m^3$.

REFERENCE

MODELLED CONCENTRATIONS FROM CALPUFF VERSION 6.42. MUNICIPALITIES FROM GEOBC. BASE DATA FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. HILLSHADE PROVIDED BY GOVERNMENT OF BRITISH COLUMBIA.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

SCALE

2 0 2
KILOMETRES

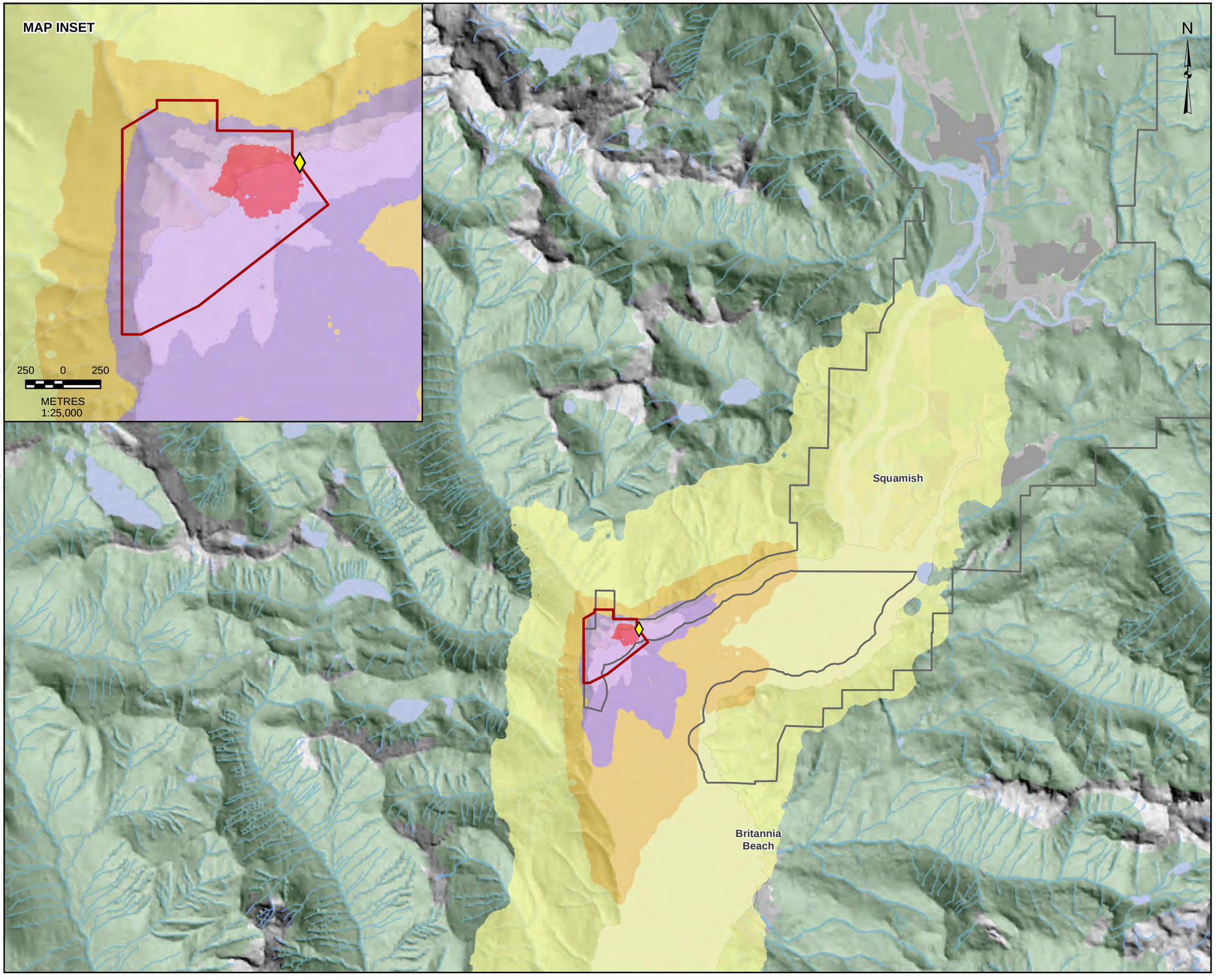
PROJECT
WOODFIBRE LNG LIMITED.
WOODFIBRE, HOWE SOUND, B.C.

TITLE
24-HOUR NITROGEN DIOXIDE (NO_2) PREDICTIONS, NORMAL OPERATIONS

Golder Associates

PROJECT NO. 13-1422-0006			PHASE 6000 TASK 6030	
DESIGN	TB	12 Sep. 2014	SCALE 1:80,000	REV. 1
GIS	RH	07 Jan. 2015	FIGURE 5.2-4	
CHECK	JR	07 Jan. 2015		
REVIEW	SC	07 Jan. 2015		

PATH: \\golder.gds\gal\Vancouver\CAD-GIS\VAN\2013\13-1422\13-1422-0006 - Woodfibre\Mapping\MXD\Air\WOODFIBRE_ATMOSPHERIC_ENVIRONMENT_Air_Quality_Contours_DDP.mxd Date: 1/7/2015 Time: 2:57:25 PM



LEGEND

- PROJECT AREA
- URBAN AREA
- FOREST AREA
- DISTRICT OF SQUAMISH MUNICIPALITY
- WATERCOURSE
- MAXIMUM OFFSITE LOCATION

24-HOUR NO_2 CONCENTRATION ($\mu g/m^3$)

- < 31.3
- 31.3 - 32.0
- 32.1 - 33.0
- 33.1 - 34.0
- 34.1 - 40.0
- 40.1 - 199.9
- > 200

NOTES

PREDICTED NO_2 CONCENTRATIONS WERE CALCULATED USING THE AMBIENT RATIO METHOD. BACKGROUND 24-HOUR NO_2 CONCENTRATION TAKEN AS 18.6 $\mu g/m^3$.

REFERENCE

MODELLED CONCENTRATIONS FROM CALPUFF VERSION 6.42. MUNICIPALITIES FROM GEOBC. BASE DATA FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. HILLSHADE PROVIDED BY GOVERNMENT OF BRITISH COLUMBIA.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

SCALE

2 0 2
KILOMETRES

PROJECT
WOODFIBRE LNG LIMITED.
WOODFIBRE, HOWE SOUND, B.C.

TITLE
24-HOUR NITROGEN DIOXIDE (NO_2) PREDICTIONS, UPSET CONDITIONS

Golder Associates

PROJECT NO. 13-1422-0006			PHASE 6000 TASK 6030	
DESIGN	TB	12 Sep. 2014	SCALE 1:80,000	REV. 1
GIS	RH	07 Jan. 2015		
CHECK	JR	07 Jan. 2015	FIGURE 5.2-5	
REVIEW	SC	07 Jan. 2015		

PATH: \\golder.gds\gal\Vancouver\CAD-GIS\VAN\2013\13-1422\13-1422-0006 - Woodfibre\Mapping\MXD\Air\WOODFIBRE_ATMOSPHERIC_ENVIRONMENT_Air_Quality_Contours_DDP.mxd Date: 1/7/2015 Time: 3:05:15 PM