5.3 GREENHOUSE GAS MANAGEMENT ASSESSMENT

This section presents the results of the assessment of potential effects and cumulative effects on greenhouse gas (GHG) management resulting from the Woodfibre Liquefied Natural Gas (LNG) Project (Project). The processes used to select GHG management as a valued component (VC), assessment boundaries, and existing conditions relevant to GHG management are described. Assessment findings, including evaluation of Project-related interactions and likely adverse effects, proposed approaches to mitigation, identification of likely residual and cumulative adverse effects, and determination of adverse effects significance, are also presented, along with monitoring and follow-up programs to be undertaken with respect to GHG.

The information and analyses in this section for climate change support the assessment in **Section 12.0 Effects of the Environment on the Project.**

5.3.1 Greenhouse Gas Management Scoping and Rationale

This section provides an overview of the GHG management 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.

5.3.1.1 Overview and Regulatory Setting

This section provides a climate change and GHG emission assessment for the Project, following the federal guidance document for practitioners to use when incorporating climate change issues into environmental assessments (EAs). The federal guidance document was developed by the Federal-Provincial Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA) to incorporate climate change into the assessment through the following considerations (FPTCCCEA 2003):

- How will potential changes in climate affect the infrastructure associated with the Project?
- How will the operation of the Project contribute to GHG emissions, and are those contributions in keeping with sector, provincial, and federal targets and norms?
- Will the GHG emissions from the Project affect climate change (i.e., the Project's contribution to climate through emissions of GHGs)?

The influence of potential changes in climate affecting the Project infrastructure is evaluated using the FPTCCCEA (2003). The future climate is evaluated using the Pacific Climate Impact Consortium (PCIC) Regional Analysis Tool (PCIC 2014), which provides climate change projections from the Intergovernmental Panel on Climate Change (IPCC). The climate change projections are based on socio-economic emission scenarios that provide different future concentrations of GHGs (Nakicenovic and Swart 2000).

The annual GHG emissions from the Project will be estimated for the Project operation phase, using the methodology described in the reporting regulations in the *Greenhouse Gas Reductions Target Act (Cap and Trade)*, SBC 2008 Chapter 32, the *Greenhouse Gas Industrial Reporting and Control Act,* Bill 2, 2014 (first reading), and other commonly accepted methods where a methodology is not provided in the reporting regulations. When considering the reporting requirements, or comparison to provincial or federal values, the provincial regulatory reporting guidance is followed. When considering a comparison to global GHG emissions, the Global Reporting Initiative guideline is used. **Table 5.3-1** presents relevant reference material that forms the basis of GHG emission estimates for the Project. Additional descriptions of this material are presented in **Appendix 5.3-1 Greenhouse Gas Methodology**.

Table 5.3-1 Applicable Guidelines for Estimation of Greenhouse Gas Emissions

Guideline	Program	Source	Date
The Greenhouse Gas Protocol/A Corporate Accounting and Reporting Standard	Multiple Programs (e.g., Global Reporting Initiative (GRI), ISO14001	World Business Council for Sustainable Development/World Resources Institute (WBCSD and WRI 2004)	April 2004
Final Essential Requirements of Mandatory Reporting	Western Climate Initiative	Western Climate Initiative (WCI 2011)	December 2011 (December 2013 Addendum)
Technical Guidance on Reporting Greenhouse Gas Emissions	Greenhouse Gas Reporting Program	Environment Canada 2013b	November 2013
British Columbia *Reporting Regulation* – Guidance Document	B.C. Reg. 272/2009	MOE (MOE 2009)	August 2011

For the purposes of accounting and reporting, GHG emissions are typically classified as Scope 1, Scope 2, or Scope 3, and are defined as follows:

Scope 1 – Direct GHG emissions: Carbon emissions occurring from sources that are owned or controlled by Woodfibre LNG Limited (Proponent or WLNG) (e.g., emissions from combustion in owned or controlled boilers, furnaces and vehicles, process and fugitive emissions)

Scope 2 – Indirect GHG emissions: Carbon emissions from the generation of purchased electricity, heat or steam consumed by the Proponent

Scope 3 – Other indirect GHG emissions: Carbon emissions that are a consequence of the Proponent's activities, but occur from sources not financially or operationally controlled by Proponent (e.g. emissions from waste, the extraction and production of purchased materials, and employee travel to and from work) (ISO 2006).

The government of British Columbia (BC) has set targets in the *Greenhouse Gas Reduction Targets Act* (Bill 44) SBC 2007, c. 42. There are no Federal targets that have been passed into law. It is not possible to project the number of facilities contributing to the provincial GHG emissions in the future, or how the *Greenhouse Gas Reduction Targets Act*, will be implemented to deal with the target. A simple comparison of the Project's GHG emissions to the provincial target is therefore inappropriate, and existing provincial GHG emissions will be used. Additionally, the government of BC has set an emission compliance target, in the form of emission intensity, specific to LNG facilities in the *Greenhouse Gas Industrial Reporting and Control Act*. The Project's GHG emission intensity will be compared to the compliance target for LNG facilities.

5.3.1.2 Selection of Valued Component

The selection of GHG management as a VC followed a process as set out in **Section 4.3 Issues Scoping and Selection of Valued Components.**

Greenhouse gas management is selected as a VC since the proposed liquefied natural gas (LNG) facility and associated shipping activities have the potential to emit GHGs, which will need to be managed over the lifetime of the Project. The Project GHG emissions will contribute to sector, provincial, and national targets and norms. The Project GHG emissions may also contribute to potential changes in the climate through changes in the levels of GHG emissions in the atmosphere. While the impact of a changing climate on the Project infrastructure is considered an intermediate component (IC), it is addressed as part of this VC and in **Section 12.0 Effects of the Environment on the Project.**

5.3.1.3 Indicators

One indicator is selected for GHG management – Project GHG emissions – which will be reported in accordance with the provincial *GHG Reporting Regulation* (MOE 2011a). In addition, Project GHG emissions are used for comparison to the sector, provincial, and national targets and norms, and to assess the influence of the Project on climate change. **Table 5.3-2** presents a summary of the key indicators and further rationale for selection.

Table 5.3-2 Key Indicators for Greenhouse Gas Management

Indicator	Rationale for Selection
Project GHG Emissions	Direct Project GHG emissions (Scope 1), will need to be reported in accordance with the provincial *GHG Reporting Regulation* (MOE 2011a). Direct Project GHG emissions (Scope 1 only) are used for comparison to provincial and national levels. Both Direct and Indirect Project GHG emissions (all scopes) are used to assess the influence of the Project on climate change.

Note: GHG emission scopes are defined in **Section 5.3.1.1** and relate to the GHG emission sources included according to the regulatory guidance.

5.3.1.4 Assessment Boundaries

This section presents the spatial and temporal boundaries of the assessment of GHG management, as well as administrative or technical boundaries that may apply.

5.3.1.4.1 Spatial Boundaries

Spatial boundaries for GHG management are not defined since climate change and GHG emissions are, by nature, both regional and global. Boundaries for GHG management correlate with the inventory boundaries that currently apply to GHG management, which are identified in the provincial and federal GHG policy, regulations, and legislation (refer to **Section 5.3.1.1**). When characterizing the current and future climate, as well as changes in climate, however, emphasis is placed on defining the conditions that correspond to the area defined in **Section 5.2 Atmospheric Environment (Air Quality)** as the regional assessment area (RAA), which is an area approximately 50 km x 40 km, centred on the Project area.

The local assessment area (LAA) and RAA for GHG are defined in **Table 5.3-3**.

Table 5.3-3 Spatial Boundary Definitions for Greenhouse Gas Management

Spatial Boundary	Description of Assessment Area
Local Assessment Area	Spatial boundaries will not be defined, as climate change and GHG emissions are, by nature, both regional and global. Boundaries for GHG management correlate with the provincial and federal GHG policy, regulations, and legislation. Emphasis is placed on defining the current and future climate conditions that correspond to the area defined by the air quality RAA.
Regional Assessment Area	
Cumulative Effects Assessment Area	

5.3.1.4.2 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 temporal boundaries established for the EA of GHG management encompass these Project phases.

5.3.1.4.3 Administrative Boundaries

The administrative boundaries that currently apply to GHG management define the scope of the inventory and are defined by the provincial and federal GHG policy, regulations, and legislation, as described in **Section 5.3.1.1**.

5.3.1.4.4 Technical Boundaries

There were no technical boundaries identified for GHG management.

5.3.2 Existing Conditions

This section describes the existing conditions of the GHG management VC, as well as the surrounding environment and factors influencing GHG management. Completion of the assessment of Project-related effects requires characterization of the current and future climate conditions, as well as current GHG emissions data.

5.3.2.1 Introduction

The Project site is located approximately 7 km west-southwest of Squamish, BC on the west side of Howe Sound. The existing conditions characterize the current climate in the region, project climate trends into the future, and quantify the current GHG emissions at the provincial, federal, and global scales. In order to appropriately assess how climate is projected to change and understand the comparison of Project-related GHG emissions against current and future values, it is necessary to understand the existing conditions for GHG management.

5.3.2.2 Background Information

Greenhouse gas management in the Project area has been studied for many years. Previous studies include the following:

- meteorological observations near the Project area (Environment Canada 2014b)
- annual provincial GHG inventory reports (MOE 2014b)
- annual federal GHG inventory reports (Environment Canada 2013a)

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 Interactions with 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.

5.3.2.3 Desktop and Field Studies

In 2013, the Proponent initiated environmental studies on GHG management to support Project planning and assessment, as well as facilitate future Project management. Building on available information, these studies were designed to address known data gaps. No desktop and field studies were undertaken with respect to GHG management, as there were no known data gaps and all required information was readily available using the sources presented in **Section 5.3.2.2**.

5.3.2.4 Description of Existing Conditions

This section presents the existing conditions pertaining to GHG management as it relates to the Project. The methodology used for the assessment is provided, along with a description of the data utilized by other disciplines. This section also presents the rationale for climate station selection, and provides a characterization of the existing climate as well as an analysis of climate trends.

5.3.2.4.1 Methodology

To understand how the climate has been changing, and may change in the future, climate trends were analyzed as follows:

- describing the current climate using available long-term (30-year) data
- documenting how the climate has changed over the past 30 years in the Project region
- discussing the range of future climate projections (2040 through 2069 and 2070 through 2099)
- presenting a climate risk matrix

Describing the current climate in the region surrounding the Project involved selection of the most representative climate station and documenting the current climate and climate trends for the selected station. The current climate conditions were defined using climate normals data, which are long-term (usually 30-year) averages of observed climate data. The standard period recommended by Environment Canada for establishing climate normals is a 30-year period from 1981 through 2010. Current climate trends are used to document how the climate has changed over the 30-year period in the Project area. Current climate trends are characterized using the climate data with the existing climate data being used to identify apparent trends, and assessing whether these apparent trends are statistically significant.

The projected ranges of future climate were described using the outputs from general circulation models (GCMs) accepted by the IPCC for various emission scenarios developed by the IPCC. The GCM projections are accessed for the Project area using the PCIC Regional Analysis Tool (PCIC 2014). The Regional Analysis Tool provides multiple emissions scenarios for multiple models to provide an indication of the range of possible future climate conditions. To provide context for the GHG emissions associated with the Project, existing GHG emissions are taken from the publicly available provincial and national inventory reports (there are no calculations associated with these values).

5.3.2.4.2 Data Utilized by Other Disciplines

Meteorology refers to the day-to-day or hour-to-hour variations in parameters such as wind, precipitation, or temperature and can be broadly described as weather. Climate, on the other hand, represents the expected values for these meteorological parameters. The climate of an area is described using climate normals, which are typically observatory averages calculated over a 30-year period. This report focuses on the expected climate for the Project area, the weather variability, and the future projections of the climate and weather variability.

Other disciplines areas comprising the Project's effects assessment use climate and meteorology data in their characterizations of existing conditions, and in their predictions and assessments of effects. Because each discipline has a different purpose for using climate or meteorology data, the station selected, the type of data used, and the way in which it is used, can vary among the disciplines. A comparison of meteorology and climate data used in this Application for an Environmental Assessment Certificate (Application) is provided in **Table 5.3-4**.

Table 5.3-4 Comparison of Climate Data used by Discipline

Discipline	Type of Meteorology/Climate Data Used	Rationale for the Consideration of Meteorology/Climate Data	Application and Use of Meteorology/ Climate Data
Section 5.2 Atmospheric Environment (Air Quality)	Wind speed, temperature, and precipitation from the Port Mellon and Squamish Airport meteorological monitoring stations	An air dispersion model is used in the air quality assessment to predict changes to air quality. The meteorological data used in the model is based on one year's worth of mesoscale meteorological data.	Meteorology from the two stations in the RAA is considered when validating the dispersion model's meteorological data set.
Section 5.15 Freshwater Fish and Fish Habitat and **Section 5.9 Water Quantity**	Temperature and precipitation data from Squamish Airport Station (Station No. 10476F0). Intensity-Duration-Frequency data from Clowhom Falls (Station No. 1041710).	Predicted water flows on Mill Creek are required for assessment of effects upon fish and fish habitat as a result of the water supply intake placement. Site characterization was not used in models or other assessment calculations.	Precipitation data is used in determining Mill Creek flow regime and prediction. Site characterization was not used in models or other assessment calculations.
Section 5.10 Marine Water Quality – **Appendix 5.10-2 Near field Mixing Simulation of Diffuser** and **Appendix 5.10-3 Marine Thermal Analysis: Far-field Modelling Report**	Wind, relative humidity, and air temperature data at Squamish Airport (Station No. 10476F0) and Pam Rocks (Station No. 10459NN) from National Climate Data and Information Archive River discharge data for Squamish River (Station No. 08GA022), Cheakamus River (Station No. 08GA043), Mamquam River (Station No. 08GA075), and Stawamus River (Station No. 08GA076) from Environment Canada Solar radiation data from Vancouver-Nanaimo Ferry Ocean Networks Canada Venus Project platform Water level (tide) data for Pt. Atkinson (Station No. 7795) from Fisheries and Oceans Canada (DFO)	Meteorological and climatological data was used as input to model the cooling water plume and resultant temperature change in Howe Sound.	Data was used as inputs into the thermal plume model.

Note: N/A – not applicable.

5.3.2.4.3 Climate Station Selection

For the purposes of this assessment, selection of climate station was based on specific recommendations from Environment Canada's Canadian Climate Change Scenarios Network (CCCSN), which is the Government of Canada's interface for distributing global climate change scenarios and adaptation research. This network provides useful guidance for selecting a climate station to represent an area of interest and how climate data should be used when calculating trends (CCCSN 2009). The following CCCSN criteria were selected for consideration:

- length of record (minimum 30 years of data)
- availability of a continuous record
- proximity to the area of interest

In addition to utilizing the CCCSN criteria, the study team also considered the following selection factors to identify the station(s) that best represent the Project site meteorologically:

- age of observations compared to the currently accepted normal period
- latitude
- elevation of station
- geographic siting

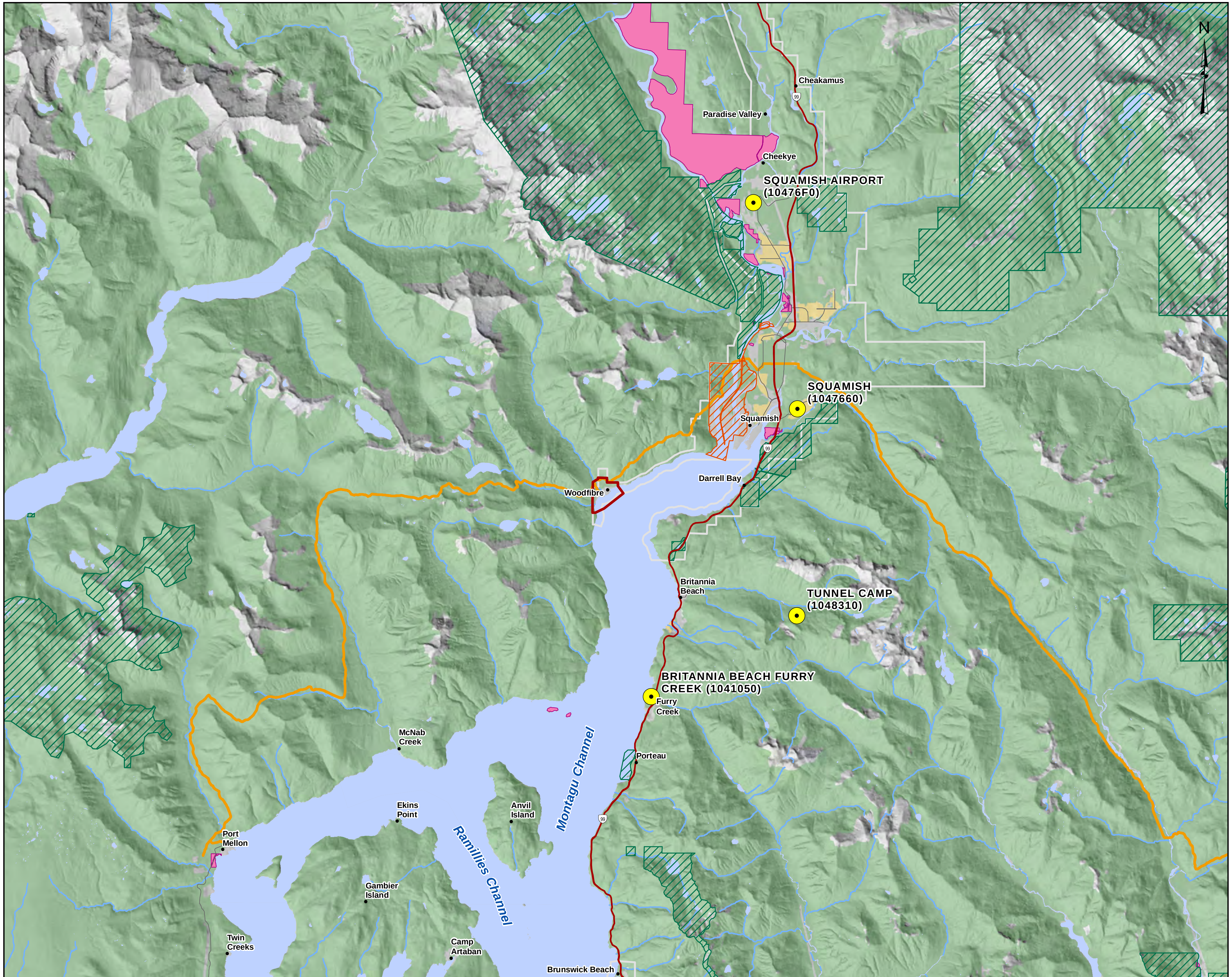
There are 14 climate stations within 20 km of the Project; however, 10 of these stations did not provide a sufficient length of data in their records. The four remaining stations (**Table 5.3-5**) were considered as possible sources of data for characterizing the current climate and climate trends.

Given the number of climate stations that fall within the boundaries of the study area of interest, it is often not practical, from a detailed analysis perspective, to use all of the available climate stations within the study area. The available climate data from each station must be compared to, and pass, the selection criteria outlined above. Data from most climate stations is constrained by low numbers of observations, a limited life span for the station (data quantity), and varying data quality.

Table 5.3-5 Climate Stations Considered For Characterizing Current Climate

Station Name	Climate Station ID	Latitude	Longitude	Elevation [m]	Distance to Project Centroid [km]	Data Availability
Britannia Beach Furry Cr	1041050	49°35'02"	123°13'25"	9	9.4	1913 – 2000
Squamish	1047660	49°42'00"	123°08'00"	31.1	10.9	1959 – 1996
Tunnel Camp	1048310	49°37'00"	123°08'00"	670.6	11.6	1924 – 1974
Squamish Airport	10476F0	49°46'59"	123°09'39"	53.7	15.3	1982 – 2014

The climate assessment completed for the Project used data from one climate station, namely Squamish Airport, to describe current climate conditions, climate variability, and longer-term trends. Squamish Airport climate station is the station closest to the Project, and provides the longest dataset available that falls within the desired normal period (1981 through 2010). The remaining three stations were excluded based on their geographic siting and age of the data collected. For these reasons, Squamish Airport was selected to describe the current climate and current climate trends. The selected climate station is shown in **Figure 5.3-1**.



LEGEND

- PROJECT AREA
- PARK / PROTECTED AREA
- SKEWLWIL'EM SQUAMISH ESTUARY
- FOREST AREA
- URBAN AREA
- INDIAN RESERVE
- MUNICIPAL BOUNDARY
- HIGHWAY
- ARTERIAL ROAD
- FORTIS BC PIPELINE
- WATERCOURSE
- CLIMATE STATION

REFERENCE

PARKS/PROTECTED AREAS AND 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 LTD.
WOODFIBRE, HOWE SOUND, B.C.

TITLE

SELECTED CLIMATE STATION TO CHARACTERIZE CURRENT CLIMATE

Golder Associates

PROJECT NO. 13-1422-0006			PHASE No. 6030	
DESIGN	JK	17 Sep. 2014	SCALE: 1:170,000	REV. 0
GIS	RH	14 Oct. 2014		
CHECK	JLK	16 Oct. 2014		
REVIEW	FSC	16 Oct. 2014		

FIGURE 5.3-1

PATH: N:\CAD-GIS\VAN\2013\13-1422\13-1422-0006 - Woodfibre\Mapping\MXD\Air\WOODFIBRE_ATMOSPHERIC_ENVIRONMENT_Air_Quality_FIGURE_05_3_1_Climate_Station.mxd Date: 10/17/2014 Time: 9:55:26 AM

Available daily meteorological data from the Squamish Airport station were collected for the period from 1981 through to 2010. Once the data set passed the quality assurance – quality control process (e.g., data checks, ranges, missing data), they were prepared for development of the long-term averages and trend analysis.

The percentage of missing data at Squamish Airport station between 1981 and 2010 is approximately 7% for both temperature and precipitation. There are large data gaps at Squamish Airport from 1981 to the beginning of 1982, and from late summer to early fall of 1991. The remaining years all have less than 10% of data missing. Only observations of total precipitation are available for Squamish Airport for the period of interest; the split of precipitation between rainfall and snowfall is not available for a long enough period of time. Only eight years of rainfall and snowfall observations are available, between 1984 and 1990, which does not meet the CCCSN criteria outlined above.

5.3.2.4.4 Current Climate and Current Climate Trends

The climate normals and current climate trends in climate were calculated for Squamish Airport climate station. Both annual and seasonal normals and trends were calculated for the mean temperature; total precipitation was also factored into this calculation. The analysis resulted in three information outcomes for each climate parameter as follows:

- climate normal
- climate trend
- statistical significance of the trend

The climate normal is calculated as the average of a given climate parameter over the selected period; the climate trend is calculated as the average change in the climate parameter per decade (i.e., the decadal trend or change). The trends, calculated using Sen's Slope Estimates (Sälmi et al 2002), are tested for significance at the 90th, 95th, 99th, and 99.9th percentile levels using the Mann-Kendall Test (Sälmi et al 2002). A trend that is not assessed to be significant at the 90th percentile is classified as being not significant. In these cases, the direction of the trend is very likely present, but the magnitude of the trend may be difficult to decipher from the noise. A trend that is assessed to be significant at the 99.9th percentile indicates there is a 99.9% probability that the direction of the trend is correct. A trend that is assessed to be zero is classified as no apparent trend. The normals and trends for each of the climate indices are summarized in **Table 5.3-6** and presented in more detail in **Appendix 5.3-2 Historical Climate Analysis**.

Table 5.3-6 Climate Normals and Current Climate Trends – Squamish Airport Climate Station

Climate Indices	Squamish Airport (1981 to 2010)		
	Normals	Decadal Change	Level of Statistical Significance
Total Precipitation [mm (equiv.)]	2,319.1	-11.2	<90%; not statistically significant
Spring Total Precipitation [mm (equiv.)]	486.8	+6.4	<90%; not statistically significant
Summer Total Precipitation [mm (equiv.)]	173.9	-6.4	<90%; not statistically significant
Fall Total Precipitation [mm (equiv.)]	782.2	+16.7	<90%; not statistically significant
Winter Total Precipitation [mm (equiv.)]	876.2	-14.8	<90%; not statistically significant
Number of Periods of More Than 10 Days with No Rain [#]	3.4	+0.0	No apparent trend
Length of Dry Spells [days]	18.3	-1.3	<90%; not statistically significant
Average Annual Temperature [°C]	9.5	+0.0	No apparent trend
Average Spring Temperature [°C]	9.3	-0.2	<90%; not statistically significant
Average Summer Temperature [°C]	17.1	+0.3	Significant at the 90th percentile
Average Fall Temperature [°C]	9.4	+0.0	No apparent trend
Average Winter Temperature [°C]	2.2	+0.2	<90%; not statistically significant
Number of Periods of More Than 3 Days with Tmax > 30°C [#]	0.8	+0.0	No apparent trend
Length of Heat Waves [days]	3.8	+0.0	No apparent trend
Maximum Daily Temperature [°C]	34.3	+0.4	<90%; not statistically significant
Number of Days with Freeze-Thaw Cycle	34.7	+5.0	Significant at the 90th percentile
Number of Period of More Than 3 Days With Tmin < -15°C [#]	0.0	+0.0	No apparent trend

Note: refer to **Appendix 5.3-2 Historical Climate Analysis** for definition of climate indices.

The analysis of Squamish Airport climate station shows no apparent temperature trends annually and in the fall. Both winter and summer temperatures show increasing trends, while spring temperatures are decreasing. Only the summer temperature trend is statistically significant, at the 90th percentile. The total annual precipitation, as well as summer and winter precipitation, show decreasing trends. The spring and fall precipitation both show increasing trends. None of the precipitation trends analyzed are statistically significant above the 90th percentile. For the annual period, these current climate trends indicate a current climate that is likely similar and slightly drier than previous periods (e.g., a normal period centered on the 1970s).

5.3.2.4.5 Future Climate Change

As an international body, the IPCC provides a common source of information relating to emission scenarios, provides third-party reviews of models, and recommends approaches to document future climate projections. In 1988, the IPCC was formed by the World Meteorological Organization and the United Nations Environment Program to review international climate change data. The IPCC is generally considered to be the definitive source of information related to past and future climate change as well as climate science. Periodically, the IPCC issues assessment reports summarizing the most current state-of-climate science. The fourth assessment report (AR4) (Solomon et al. 2007) represents the most current complete synthesis of information regarding climate change. The fifth assessment report (AR5) is currently in publication but has not been officially released. Any concerns identified using AR4 will still likely be concerns using AR5; however, a straightforward comparison between the reports is challenging due to the changes in emission scenarios and models in AR5.

5.3.2.4.5.1 Approach for Describing Future Climate

Climate modeling involves the mathematical representation of global land, sea, and atmosphere interactions over a long period of time. These GCMs have been developed by various government agencies, but they share a number of common elements described by the IPCC (Solomon et al. 2007). The IPCC does not run the models, but acts as a clearinghouse for the distribution and sharing of the model forecasts.

The IPCC data was accessed through the Regional Analysis Tool (PCIC 2014) developed by the PCIC, a regional climate service centre based at the University of Victoria, BC. Since the model outputs are susceptible to inter-decadal variability, the model outputs are provided in 30-year blocks identified by the centre decade. The following two blocks of climate forecast data were used to assess the range of projections for future climate for the Project:

- **2050s** – 2041 through 2070
- **2080s** – 2071 through 2100

These are the standard forecast data sets for the 21st century, and both the 2050s and the 2080s will reflect the Project decommissioning and post-closure (retirement) phases. While the majority of the Project time occurs during the 2020s (2010 through 2039), this climate projection data will not be assessed, as climate changes will not have been completely manifested. Instead, since the operation phase of the Project (minimum 25 years) will extend past 2039, climate is more appropriately described by the 2050s. Any projected changes in climate during the 2020s will be smaller than the changes projected for the 2050s, and the 2050s will be representative of the conditions near the end of operation and for conditions during decommissioning. The 2080s reflect a bounding condition should the operational lifetime of the Project be extended beyond the minimum 25 years. By using the projected climate change for the 2050s and 2080s, the period when the Project phases will be most sensitive to Project climate change occurrences is included; the projected changes for the 2020s are already included.

Given the large grid size of a GCM projection, as described in **Section 5.3.2.4.5.5**, the data are representative of area averages and are not necessarily representative of a specific location contained within the grid box. Murdock and Spittlehouse (2011) recommend that analyses involving GCM projections be based on descriptions of future climate that have been presented in the context of change from the accepted baseline period (i.e., the models use the 1961 through 1990 period as the baseline). Since the models may have an absolute bias, the predicted future climate is compared to the predicted baseline using the same model. Also, because the models are most effective at describing projections of change, projected changes from a modeled baseline are typically described as a deviation from baseline, either in degrees Celsius (°C) for temperature, or percent (%) for precipitation. The resulting change from the modeled baseline can then be used to estimate the future climate conditions in the context of the actual current climate for the Project, as described in **Section 5.3.2.4**.

The current climate was analyzed for the period from 1981 through 2010, a normal period occurring 20 years after the modeled baseline of 1961 through 1990. In order to account for the difference in modeled baseline and current climate, the projected changes in climate were scaled before being applied to the current climate normals. The scaling approximated a constant decadal rate of change by dividing the projected model change by the number of decades since the modeled baseline period (i.e., eight decades between the baseline and the 2050s). This scaling was then multiplied by the number of decades between the current climate normal and the desired future climate period (i.e., six decades between current climate normal and the 2050s). The scaled changes are presented as changes in ^{o}C and changes in mm of precipitation for the current climate.

5.3.2.4.5.2 General Circulation Models

Climate simulations produced by these general circulation models vary because each model uses a different combination of algorithms to describe and couple the earth's atmospheric, oceanic, and terrestrial processes. The GCMs used in this analysis have been validated against observations, and the interpretation of their results have been peer-reviewed by the IPCC and others. Rather than selecting a single model, the climate change projections from all available models from AR4 (i.e., 136 unique sets of modeling results) using the PCIC Regional Analysis Tool were included in the analysis. This ensemble approach was used to delineate the probable range of results and better capture the actual outcome (an inherent unknown).

In the case of climate models, projections are not made at a location, but for a series of grid cells in the scale of hundreds of km in size. The PCIC Regional Analysis Tool provides GCM projections for a series of defined regions. For this assessment the PCIC-defined Metro Vancouver Region was used because it encompasses the Project area. The PCIC Regional Analysis Tool was then used to select the appropriate grid information from the various GCMs in the ensemble.

5.3.2.4.5.3 Climate Scenarios

Global climate models require extensive inputs in order to characterize the physical and social developments that could alter climate in the future. In order to represent the wide range of the inputs possible to global climate models, IPCC has established a series of socio-economic scenarios that help define the future levels of global GHG emissions. While the IPCC identifies many scenarios, the following three are available from the PCIC Regional Analysis Tool, namely A1B, A2, and B1:

- **Scenario A1B** — The A1 family of scenarios describes a future world of very rapid economic growth, with a global population that peaks in mid-century and declines thereafter, along with the rapid introduction of new and more efficient technologies. The A1 family includes three groups of scenarios that describe alternative directions in the energy system. The A1B group is distinguished by a balance across all sources of energy – green and fossil.
- **Scenario A2** — The A2 scenario family describes a world with an underlying theme of self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is regionally oriented, and per-capita economic growth and technological change are more fragmented and slower than for other scenarios.
- **Scenario B1** — The B1 scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter (similar to the A1 scenarios). The B1 family has rapid change in economic structures toward a service and information economy, with reductions in raw material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

These three socio-economic scenarios have been described more fully by IPCC in the Special Report on Emission Scenarios (SRES) (Nakicenovic and Swart 2000). The IPCC considers each of the scenarios as equally likely to occur. The PCIC Regional Analysis Tool used to provide information for this assessment is based on the SRES emissions scenario combinations provided by the IPCC (PCIC 2014). Data used in this assessment relates to the A1B, A2, and B1 scenarios.

5.3.2.4.5.4 Longer-term Effects of Climate Change

Longer-term effects of climate change on these factors (beyond 2100) are highly dependent on the emissions scenario (A1B, A2, B1, etc.) being considered, and are not provided by the PCIC. As a result, these results are not discussed, as they are beyond the likely lifespan of the Project and are too variable to be considered reliable at this time.

5.3.2.4.5.5 Understanding Climate Projections and Their Limitations

General circulation models have inherent limitations that are important to bear in mind when evaluating variability and the rate of climate change, (i.e., when comparing future projections to historical observations). These limitations are dependent on the research institution's approach to overcoming model uncertainty. Since no one model or climate scenario can be viewed as completely accurate, the IPCC recommends that climate change assessments use as many models and climate scenarios as possible. For this reason, the multi-model ensemble approach described above was used to account for these uncertainties and limitations.

Spatial Scales

Due to limitations on computing power, the GCM outputs are limited to grid cells of 1 to 2.5 degrees (^{o}) (approximately 110km – 275km) and a small number of vertical layers in both the atmosphere and the ocean. These grid cells represent a mathematically defined '*region*' rather than a specific geographic location and are different for many models. Although the appropriate grid cells were selected to represent the Project location, and the data extracted from the appropriate grid cell, this scale is much larger than that of most weather processes such as convective thunderstorms. In addition, local changes in topography cannot be represented at this scale.

Temporally, the GCM simulations are run at monthly time scales, and only monthly average temperature and precipitation are available as outputs.

The process of downscaling is a method to overcome the spatial and temporal scale limitations. Downscaling may decrease uncertainty for regions where the regional topography or geography is complex compared to the GCM grid-scale, or where diurnal fluctuations in local meteorology are important. While this technique can improve comparisons between historical observations and simulations of past climate for a specific GCM, it does not address uncertainty in the models, as noted in the following sections.

Unpredictable Events

Climate model simulations represent average conditions and typically do not consider the influence of inherently unpredictable stochastic or episodic events (e.g., volcanic eruptions, earthquakes, tsunamis). In other words, events of a certain magnitude tend to occur at a certain frequency; however, their actual magnitude and timing is unknown and currently not predictable within a specific GCM's outputs.

Although large events are rare, they have the potential to invalidate climate model projections both globally and regionally. For example, the 1991 eruption of Mount Pinatubo is well known to have decreased the average planetary surface temperature by approximately 1°C for at least one year; this change represents a significant offset to predictions of approximately 3°C of warming over the next century. The Pinatubo eruption ranks as a “6 out of 8” on the logarithmic-based volcanic explosivity index, and events such as Pinatubo have return periods on the order of 100 years. Larger events have return periods of 1,000 years or more; however, their plumes can reach altitudes of greater than 40 km and inject sufficient amounts of sulphur into the stratosphere to suppress global temperature from years to decades (Robock et al. 2009).

Changes to Collective Understanding of the Processes

The earth’s system processes and feedbacks are very complex, and therefore have to be approximated in GCM model simulations. In these instances, mathematical parameterizations of these processes are required to reduce the computational burden within the simulations. Each of these independent processes that drive climate change can be assigned a rank based on the current level of scientific understanding (LOSU). The contribution of aerosols in the GCMs is an example of this uncertainty. Aerosols were ranked as very low LOSU in the 2001 IPCC report and were upgraded to a medium-to-low LOSU in the 2007 IPCC report (Forster et al. 2007).

In addition, new discoveries can change the inputs to the GCMs and the interrelationship of these drivers within each GCM. For example, the 1988 discovery of *Prochlorococcus* spp. (cyanobacteria), the most abundant photosynthetic organism (i.e., a photosynthetic picoplankton) in the ocean, led to a change in the understanding of ocean biology, the carbon cycle, and atmospheric carbon dioxide (CO_2) (Chisholm et al. 1988). Similarly, the 2001 discovery of ubiquitous atmospheric N_2-fixation by the marine cyanobacterium *Trichodesmium* spp. (i.e., also called sea sawdust) changed the understanding of the effects of ocean biology and our understanding of the earth’s nitrogen cycle (Berman-Frank et al. 2001).

5.3.2.4.5.6 Climate Projections for Project Region

The future climate for the Project site has been described using the climate projections for the Metro Vancouver Region defined in the PCIC Regional Analysis Tool. The data were obtained from PCIC for all the available AR4 scenarios. The historic modeled baseline period used by PCIC is 1961 through 1990, which differs from the current climate period of 1981 through 2010 used in **Section 5.3.2.4.3**. It is important to note that this modeled baseline is not necessarily representative of the local conditions and does not correspond to the observed data but, as outlined in **Section 5.3.2.4.5.1**, is used by the GCM projections to estimate changes in climate. This assessment presents the data obtained for the historic baseline period (1961 through 1990), as well as the A1B, A2, and B1 socio-economic scenarios for the 2050s (2040 through 2069) and 2080s (2070 through 2099), time periods from PCIC.

A scatter plot analysis is widely used for describing future climate projections and illustrates the distribution of the future climate conditions predicted by the models. The figures illustrate the projected change in temperature on the vertical axis and the projected change in precipitation on the horizontal axis. The resulting scatter plots are divided into four quadrants, with values in the upper right quadrant, representing change to a warmer and wetter climate, while values in the lower left quadrant represents a change to a cooler and drier climate. In addition, the current climate trends are added to the scatter plot figures to illustrate whether the models are predicting changes that are consistent with current climate observations, or whether future trends are different.

The model projections generally fall in the upper right quadrant of the plots, suggesting a future climate that will be warmer and wetter; however, some of the model projections suggest a future climate that will be warmer and drier, and these forecasts are most similar to the observed current climate trends at Squamish Airport climate station (**Table 5.3-6**). As per **Table 5.3-6**, the annual climate trends for temperature and precipitation were not found to be statistically significant. Comparisons of the future climate projections for the Project area for the 2050s and the 2080s periods, as well as the change in climate that would occur if the observed current climate changes continue forward into the future (i.e., the black diamond on the scatter plot graphs), are shown as scatter plots on **Figure 5.3-2**. For reference, the current climate normal is where the axes intersect. The current climate trend shown in the figure is calculated using the Squamish Airport climate station data.

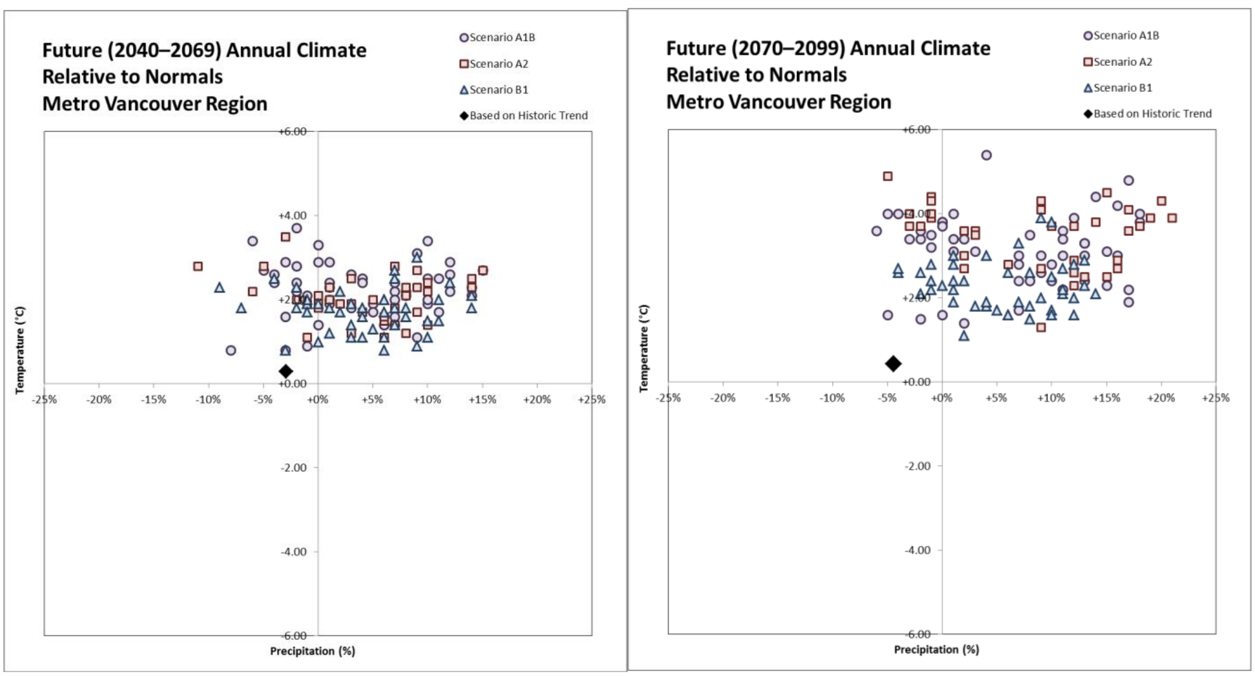


Figure 5.3-2 Scatter Plots Showing the 2050s and 2080s Annual Projections for the Project Area

In general, the climate in the Project region is projected to be warmer and possibly wetter for the 2050s and 2080s time horizons when compared to the current climate period. This is a change from the trends currently observed at Squamish Airport. It is not unusual for current climate trends to differ from the projected future trends. The projected current climate trends do not account for changes in the anthropogenic forcing or variations in the observed record between the current climate conditions and projected future climate conditions. The mean of the projected annual temperature and precipitation for all models and the three SRES scenarios are provided in **Table 5.3-7**.

Table 5.3-7 Summary of Projected Climate Change for the Project Area

Special Report on Emission Scenario	Time Period	Annual Average Temperature (°C)	Total Annual Precipitation (mm[equiv.])
A1B	1981 – 2010 Climate	+9.3	+2267.6
	2050s	+10.9 (+1.6)	+2317.2 (+49.6)
	2080s	+11.8 (+2.5)	+2370.1 (+102.5)
A2	1981 – 2010 Climate	+9.3	+2267.6
	2050s	+10.9 (+1.5)	+2322.0 (+54.4)
	2080s	+12.2 (+2.8)	+2361.9 (+94.3)
B1	1981 – 2010 Climate	+9.3	+2267.6
	2050s	+10.6 (+1.3)	+2318.8 (+51.2)
	2080s	+11.2 (+1.9)	+2349.4 (+81.8)
All Scenarios	1981 – 2010 Climate	+9.3	+2267.6
	2050s	+10.8 (+1.5)	+2319.0 (+51.4)
	2080s	+11.7 (+2.4)	+2361.4 (+93.8)

Note: Scaled projected changes, relative to the current climate, are provided in brackets. The All Scenarios projected changes are based on PCIC outputs and are not an average of the three SRES Scenarios listed above.

5.3.2.4.6 Baseline Greenhouse Gas Emissions

The GHG emission intensity compliance target for LNG facilities in BC, and the GHG emissions for BC and Canada are provided in **Table 5.3-8**. The GHG emission intensity compliance target was obtained from the *Greenhouse Gas Industrial Reporting and Control Act* in the schedule of regulated operations and emission limits. Baseline information for Canada was obtained from the *National Inventory Report 1990 – 2012: Greenhouse Gas Sources and Sinks in Canada* (Environment Canada 2014a) for submission to the United Nations Framework Convention on Climate Change. Baseline information for BC was obtained from the *British Columbia Greenhouse Gas Inventory Report 2012* (MOE 2014a). Both provincial and national emissions are provided for the 2012 reporting year. Global emissions are considered from two sources: the IPCC (Nakicenovic and Swart 2000), representing the 2010 global GHG emissions, and the World Resources Institute (WRI), representing the 2011 global GHG emissions. The IPCC value represents the maximum 2010 GHG emission levels globally, based on a projection consistent with the SRES scenarios of the 2000 GHG emissions levels used by the IPCC. The WRI value uses the United Nations Framework Convention on Climate Change data, complemented with data from a variety of non-governmental sources (WRI 2014). The WRI global GHG emissions is used for comparison to project GHG emissions to targets, whereas the IPCC global GHG emissions will be used to assess the effect of Project-related GHG emissions on climate change.

A comparison of the Project-related GHG emissions to the annual GHG emissions for BC, Canada, and globally has been undertaken using the values provided in **Table 5.3-8**.

Table 5.3-8 Baseline Greenhouse Gas Emissions

Source	GHG Emission Intensity Compliance Target (t CO_2e/ t LNG)[1]	GHG Emissions (kt CO_2e)[1]
BC (LNG Facilities)	0.16	-
BC (All Sectors 2012)	-	61,500
Canada (All Sectors 2012)	-	699,000
Global (Allali et al. 2007)	-	20,894,000
Global (WRI 2011)	-	43,816,734

1. Note: t CO_2e / t LNG – tonnes of carbon dioxide equivalent per tonne of liquefied natural gas produced
2. Note: kt CO_2e – kilo tonnes of carbon dioxide equivalent

5.3.3 Assessment of Project-related Effects

This section describes the methods for characterizing potential effects, identifies the potential interactions between Project activities, and provides the mitigation measures proposed to avoid and reduce potential adverse effects to GHG management. Residual effects and their significance are also characterized in this section.

5.3.3.1 Assessment Methodology

The potential residual effects of the Project are assessed following the methodology outlined in **Section 4.0 Environmental Assessment Methods**. Potential interactions between the Project activities and GHG management 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 residual effects characteristics and significance are provided for the GHG management in the following sections.

5.3.3.1.1 Residual Effects Characterization

Definitions for ratings applied to residual effects criteria are developed with specific reference to GHG management and presented in **Table 5.3-9**.

Table 5.3-9 Criteria Used to Characterize Residual Effects on Greenhouse Gas Management

Criteria	Description	Definition of Rating
Magnitude	Expected size or severity of the residual effect	**Low** – effects from changing climate on Project infrastructure are below the design thresholds; and/or predicted contribution of GHGs of <50% of the GHG emission intensity compliance target, <1% to the Canadian contribution, and <0.001% to the global contribution. **Moderate** – effects on Project infrastructure from changing climate are approaching design thresholds; and/or predicted contribution of GHGs of <100% of the GHG emission intensity compliance target, >2% to the Canadian contribution, and >0.01% to the global contribution. **High** – effects on Project infrastructure from changing climate are greater than the GHG emission intensity compliance target, or predicted contribution of GHGs of >1% to the global contribution.
Geographic Extent	Spatial scale over which the residual effect is expected to occur	**Regional** – effect is limited to the Project area (air quality RAA). **Beyond Regional** – effect extends beyond the Project area.
Duration	Length of time over which the residual effect is expected to persist	**Short-term** – Predicted climate effects could affect the construction phase, and/or predicted contribution of GHGs will cease after the construction phase. **Medium-term** – Predicted climate effects could affect the operation phase, and/or predicted contribution of GHGs will cease after the operation phase. **Long-term** – Predicted climate effects could affect the decommissioning phase, and/or predicted contribution of GHGs will extend into the decommissioning phase.
Frequency	How often the residual effect is expected to occur	**Infrequent** – Predicted climate effects on Project infrastructure occur only in very infrequent events (1 in 100 years) and/or predicted contribution of GHGs occurs less than 25% of the time during one phase of the Project. **Frequent** – Predicted climate effects on Project infrastructure could occur on an annual basis, and/or predicted contribution of GHGs occurs more than 25% but less than 75% of the time during two phases of the Project. **Continuous** – Predicted climate effects on Project infrastructure could occur on an annual basis and/or predicted contribution of GHGs occurs more than 75% of the time during three phases of the Project.
Reversibility	Whether or not the residual effect can be reversed once the physical work or activity causing the effect ceases	**Reversible** – Predicted climate effects on Project infrastructure are reversed after a distinct event, and/or the effect is reversed when the contribution of GHGs ceases. **Non-reversible** – Predicted climate effects on Project infrastructure are not reversed after a distinct event and/or the effect will not be reversed when the contribution of GHGs ceases.
Ecological Context	Refers primarily to the sensitivity and resilience of the VC to change caused by the project	Not applicable to GHG management.

In applying these effects characteristics criteria further, it can be shown that some residual effects criteria do not vary due to the long-term (i.e., duration) and global nature (i.e., regional extent) of climate change and GHGs. Projections in climate change are considered to be continuous and non-reversible due to natural and anthropogenic drivers. With the complex, global nature of this assessment process, only the adverse effects of climate change were considered. The effect of GHG releases are continuous, lasting well beyond when the contribution of GHGs ceases, thus making the effect non-reversible; therefore, any emission of GHGs has an adverse effect. This is why, when considering climate change and GHGs, the only applicable residual effects criterion is magnitude.

5.3.3.1.2 Definition of Significance

The level of each residual effect has been rated as negligible, not significant, or significant, as follows:

Negligible (N) — Effects determined to be negligible are those that have a low-magnitude effect and context where the impact of climate change on Project infrastructure or the contribution of Project GHG emissions are not measurable (<100% GHG emission intensity compliance target, <1% of the Canadian contribution and <0.001% of the global contribution). Negligible effects are not carried forward to the cumulative effects assessment

Not significant (NS) — Effects determined to be not significant are those that are greater than negligible and do not meet the definition of significant. These effects have a low or moderate magnitude and have a measurable effect. Not-significant effects are carried forward to the cumulative effects assessment.

Significant (S) — Effects determined to be significant are those that have a high magnitude (contribution of GHGs of >1% to the global contribution). Significant effects are carried forward to the cumulative effects assessment.

5.3.3.1.3 Likelihood

Likelihood refers to whether or not a residual effect is likely to occur. This may be influenced by a variety of factors, such as the likelihood of a causal disturbance occurring or the likelihood of mitigation being successful (EAO 2013). For the effects assessment on GHG management the likelihood of each residual effect occurring is presented in terms of unlikely or likely, and are defined qualitatively as follows:

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

5.3.3.1.4 Confidence and Risk

The level of confidence for each residual effect prediction takes into consideration any uncertainty associated with each prediction. Confidence levels are defined below. 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.

- **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

5.3.3.2 Potential Interactions of the Project and Proposed Mitigation

Potential interactions between the Project activities and GHG management, and mitigation measures proposed to avoid or minimize the interactions are presented in the following sections.

5.3.3.2.1 Potential Interactions

Potential interactions between Project activities and GHG management during the construction, operation, and decommissioning phases of the Project are identified in **Table 5.3-10**. The following criteria have been used to indicate the degree of the effect from the interaction between GHG management and each activity:

- No interaction is predicted.
- Minor interaction is predicted (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.

A rationale for the assessment of interactions rated as having no or minor interaction is presented in **Table 5.3-10**. Interactions with potential effects to be carried forward are discussed in **Section 5.3.3.2.1**. **Table 5.3-10** includes an assessment of the interactions related to Project GHG emissions. Interactions related to the effect of a changing climate on the Project are assessed in **Table 5.3-12**.

Project components could be affected by climate change during the operation and decommissioning phases, but not during construction as climate change occurs over many years. For example, increased rainfall with time could place additional burdens on the water management systems at the Project site. Project activities during all stages of the Project have the potential to cause direct or indirect GHG emissions. Direct GHG emissions are those resulting from fuel combustion or Project processes, while indirect emissions refer to GHGs caused by generation of electricity supplied to the Project, such as purchased electricity. **Table 5.3-10** also highlights those Project activities for which there will be no interaction, either because they do not result in GHG emissions or the activities are not considered susceptible to climate change.

Table 5.3-10 Potential for Interactions between Project-related Activities and GHG Management

Project Activities and Physical Works	Valued Component Interaction	Nature of Interaction and Rationale for Interaction Rating
Phase: Construction		
All construction activities	See below	
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	Carried forward	Potential for GHG emissions
Site clearing	No interaction predicted	Brownfield site with minimal clearing required
Blasting where required to accommodate Project infrastructure	Carried forward	Potential for GHG emissions
Demolition of infrastructure not required for the Project	Carried forward	Potential for GHG emissions
Upgrades to existing buildings and infrastructure, including site administration and safety facilities	No interaction	Negligible potential for GHG emissions
Installation of stormwater and erosion and sediment control measures	Carried forward	Potential for GHG emissions
Construction of Mill Creek water intake, pipeline, and water storage tank	Carried forward	Potential for GHG emissions
Installation of batch plant	Carried forward	Potential for GHG emissions
Upgrading and construction of onsite roads	Carried forward	Potential for GHG emissions
Construction and upgrading of small craft floats	Carried forward	Potential for GHG emissions
Waste material disposal at permitted offsite and onsite landfills	Carried forward	Potential for GHG emissions
Construction of electrical substations and transformers and cables and powerlines	Carried forward	Potential for GHG emissions
Construction of land-based civil works, including foundation excavation, cast-in-place concrete, and structures	Carried forward	Potential for GHG emissions
Construction of the foundation and uploading dock for land-based LNG facility, including natural gas piping. Transfer of the LNG facility to its foundation	Carried forward	Potential for GHG emissions
Construction of FSO jetty, including pile driving and shoreline modifications, to accommodate structural infrastructure, including possible dredging, and permanent mooring of FSO	Carried forward	Potential for GHG emissions
Connection of utilities (e.g., electrical, controls, gas, water) to LNG facility and FSO	No interaction predicted	Negligible potential for GHG emissions
Installation of seawater cooling system, including inlet and outlet structures	No interaction predicted	Negligible potential for GHG emissions
Re-vegetation of areas of the Green Zone	No interaction predicted	Negligible potential for GHG emissions

Project Activities and Physical Works	Valued Component Interaction	Nature of Interaction and Rationale for Interaction Rating
Operation Phase		
All operation activities	See below	
Commissioning of equipment for startup	No interaction predicted	Negligible when considering annual emissions
Delivery of natural gas via piping from the from the FortisBC natural gas metering station to the LNG facility	Carried forward	Potential for GHG emissions
Pre-treatment and liquefaction of natural gas at the LNG facility	Carried forward	Potential for GHG emissions
Storage and offloading of LNG at the FSO	Carried forward	Potential for GHG emissions
Mooring of LNG carriers at the FSO for LNG transfer	Carried forward	Potential for GHG emissions
Shipping within Howe Sound (approximately 40 LNG carriers per year) in established shipping lanes	Carried forward	Potential for GHG emissions
Patrolling of Control Zone around LNG facility, FSO	Carried forward	Potential for GHG emissions
Extraction of water from Mill Creek	No interaction predicted	Negligible potential for GHG emissions
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	Potential for GHG emissions
Decommissioning		
All decommissioning activities	See Below	
Dismantling of equipment and buildings that will not continue to serve a purpose	Carried forward	Negligible potential for GHG emissions
Removal of LNG facility and FSO from the Project area	Carried forward	Potential for GHG emissions, including vehicle emissions, likely less than for construction phase.

5.3.3.2.2 Potential Effects

Based on the interactions presented in **Table 5.3-10**, the potential effects are described in the following sections. Three potential adverse effects are considered:

- the potential effect of a changing climate on the Project
- the potential effect of the Project-related GHG emissions on sector, provincial, and federal targets and norms
- the potential effect of Project-related GHG emissions on climate change

The assessment also describes how climate change may affect the Project infrastructure, and identifies the aspects of the Project that may need further assessment due to a potentially changing climate. The review of historical climate data and analysis of future climate projections presented in this assessment follows accepted practices for undertaking EAs.

The contribution of Project-related GHG emissions during the operation phase and how these contributions compare to sector, provincial, and federal targets and norms are evaluated by estimating the GHG emissions associated with the Project and comparing them to the GHG emission intensity compliance target for LNG facilities to assess the relative contribution on a sector/provincial basis, and the provincial and national GHG emissions to assess the relative contribution of the Project on a Canadian basis.

The contribution of Project-related GHG emissions to climate change is evaluated by comparing the Project GHG emissions to the projected changed in global GHG emissions assumed in the future climate forecasts by the IPCC.

5.3.3.2.2.1 Potential Effects of Changing Climate on the Project during Operation and Decommissioning

Climate Change

While the projected climate normals for the 2050s and the 2080s show different trends than presented in the current climate (i.e., warmer and wetter compared to warmer and drier (**Figure 5.3-2**), climate change may result in a climatological environment that is different from the current climatological environment (e.g., changes in the intensity and frequency of precipitation). Such changes may affect future operations, and may affect the operation of infrastructure associated with the Project. A qualitative assessment of how the changing climate may affect Project aspects and components has been completed by identifying interactions between the proposed infrastructure and selected climate factors.

Based on the climate parameters and climate data analyzed, climate factors have been developed to further analyze the potential climate infrastructure interactions for the Project region. The climate factors include changes to precipitation (i.e., focused on rainfall), along with temperature and extreme events (e.g., storms). These factors are further subdivided into specific event-type factors that describe long-term changes such as increasing winter temperatures, or extreme events such as increased storms that have the potential for lightning, high winds, and intense precipitation. The climate factors are based on the future climate projections presented in **Section 5.3.2.4.4**. Where climate projections are not available, literature values are referenced to discuss the projected change in climate. For example, the monthly time scale of climate model projections is not able to capture changes in the frequency of rain events, and thus literature is referenced. The climate factors, climate factor trend, and justification for the trend are provided in **Table 5.3-11**.

Table 5.3-11 Climate Factor Trends

Climate Factor Description		Trend	Comments on Future Trends
Precipitation	Drought	Increasing	An increase in drought is projected to be likely (Allali et al. 2007; Solomon et al. 2007).
			The multi-model ensemble suggests increasing temperatures and precipitation. Depending on the distribution of the precipitation, this could lead to more drought events.
	Increased precipitation	increasing	The multi-model ensemble suggests a slight increase in the amount of seasonal and annual precipitation.
	Amount of rain	Increasing	An increase is projected for the amount of rain (CCME 2003).
			Total annual precipitation will increase but precipitation in the key seasons may decrease and the intensity of rain may increase (CCME 2003, Lemmen et al. 2008).
			The multi-model ensemble suggests a slight increase in the amount of seasonal and annual precipitation.
	Frequency of heavy rain fall events	Increasing	An increase in the frequency of rain events is projected to be very likely (Allali et al. 2007; Solomon et al. 2007).
	Amount of rainfall per event	Increasing	An increase in the amount of rainfall per rain event is projected to be very likely (Allali et al. 2007; Solomon et al. 2007).
	Changes in snowfall	Unknown	The multi-model ensemble suggests an increase in the amount of winter precipitation but does not differentiate between snow and rain.
	Changes in snowpack	Decreasing	Reduced snow cover is expected with projected increased winter temperatures leading to projected reduced snowpack (Lemmen et al. 2008).
			The multi-model ensemble suggests an increasing trend in winter temperatures, which may cause a decrease in the snowpack.
Temperature	Freeze-thaw	Increasing	The multi-model ensemble suggests a slight increase in the amount of winter precipitation and winter temperatures
			Freeze-thaw events are projected to increase for much of Canada but the trends are weakest in BC (CCME 2003).
	High temperatures	Increasing	The multi-model ensemble suggests temperatures are increasing, leading to the possibility for higher temperatures.
	Low temperatures	Decreasing	Warmer and/or fewer cold days and nights are projected over most land areas (Allali et al. 2007, Solomon et al. 2007).
			The multi-model ensemble suggests temperatures increases for all seasons indicating low temperature events will decrease in frequency.
	Warmer winter	Increasing	The multi-model ensemble suggests temperatures increases for winter.
			An increasing trend in warmer winters is projected (Lemmen et al. 2008).
	Heat waves	Increasing	An increase in heat waves is considered to be very likely, with an increased number, intensity, and duration (Allali et al. 2007, Solomon et al. 2007).
			The multi-model ensemble suggests higher temperatures, allowing for the possibility of increase in heat waves.

Climate Factor		Trend	Comments on Future Trends
Other Events	Increase in extreme events (e.g., storms)	Increasing	Extreme events such as storms are likely to have both increased frequency and intensity (Allali et al. 2007, Solomon et al. 2007). There is a potential increase in spring flooding (Lemmen et al. 2003) and an increase in winter flooding (Parry et al. 2007).
	Lightning	Unknown	Potential for increase inferred from increased frequency and intensity of storms.
	Wind	Variable	Potential for increase inferred from increased frequency and intensity of storms.
			Decrease in surface wind speeds (Blunden and Arndt 2013).
			Weakening of large-scale circulation patterns (Blunden and Arndt 2013).
	Increased rainfall on snowpack	Variable	The projected increases in temperature will decrease the time for snowpack accumulation (Lemmen et al. 2008).
			Projected increases in rainfall, as described above, may lead to more rainfall on snowpack.
			The multi-model ensemble suggests the potential for decreased snowpack due to the increase in temperature and the potential for increased precipitation, meaning the potential for more rainfall on the available snowpack.
	Sea level rise	Increasing	Predicted sea level rise for coastal BC (Thomson et al. 2008).

The facilities and infrastructure associated with the Project have an estimated minimum operational lifetime of 25 years and will be removed during the decommissioning phase. **Table 5.3-12** presents a climate risk matrix, which provides a summary of the potential climate-infrastructure interactions by physical work or activity associated with the Project. This climate risk matrix was provided to all other technical disciplines to identify all possible climate-infrastructure interactions and the climate factors behind the interactions.

Table 5.3-12 Climate Risk Matrix

Physical Work or Activity	Climate Factors	Description of Potential Interaction with Climate Change
Construction Phase		
All activities in the construction phase	None	Timescale too short for significant climate change effects.
Operation Phase		
Building and infrastructure related to the Project activities in the operation phase	Extreme events	Extreme events (e.g. storms) may result in a potential interaction with infrastructure; however, this is accounted for in the infrastructure design and will be addressed through ongoing maintenance.
Electricity use	Temperature	Increased temperature may increase the electrical demand for cooling natural gas.

Physical Work or Activity	Climate Factors	Description of Potential Interaction with Climate Change
Once through cooling system	Temperature	Increased temperature may increase the cooling requirements. The analysis shows that the thermal plume is dilute with relatively small predicted changes on temperature (0.05 °C) that are within the error of analysis. Given the large thermal mass of Howe Sound and the annual and inter-annual mixing processes, the projected climate change for the operating period is not likely to change the significance assessment of the Marine Thermal Analysis.
Stormwater management	Precipitation, extreme events	Precipitation and extreme events may result in a potential interaction during operation; however, this potential effect is accounted for in the infrastructure design.
Power and gas supply system and infrastructure	Temperature, precipitation, extreme events	Temperature, precipitation, and extreme events may result in a potential interaction with operation-phase activities; however, the infrastructure design accounts for this potential effect.
FSO Maintenance	Extreme events and sea-level rise	Extreme events and sea-level rise may result in a potential interaction through increased maintenance of the FSO.
Port Facilities	Extreme events and sea-level rise	Extreme events and sea-level rise may affect the use of the port facilities.
Withdrawal of water from Mill Creek to supply water use at facility	Lack of rain, extreme dry events	Water withdrawal during extreme dry events has the potential cause serious harm to fish and fish habitat. This potential effect will be mitigated through the adoption of a Water Use Plan, which will prescribe the extraction rates and flow thresholds that allow for a minimum instream flow requirement to be achieved. Withdrawal of water may result in effects to the fish and fish habitat of Mill Creek during 7Q10 dry event, and potential low seasonal precipitation will result in less water withdrawal or greater effects (refer **Section 5.15 Freshwater Fish and Fish Habitat** for further details).
Decommissioning Phase		
All activities in the decommissioning phase	None	All infrastructure will be removed or turned over to the new owner, who will assess climate during the design of the future land use.

Note: 7Q10 – the lowest 7-day average flow that occurs on average once every 10 years; FSO – floating storage unit.

Sea-level Change

With melting polar ice due to increased temperatures, it is predicted that sea levels will continue to rise, with a possibility of increased or changing coastal erosion. The Project site is located on the shore of Howe Sound; therefore, changes in sea level and coastal erosion dynamics have the potential to affect the Project directly. A study undertaken by Thomson et al. (2008) presents an examination of the factors affecting relative and absolute sea level in coastal BC, and presents estimates of future sea-level change. The study presents sea-level height by the year 2100 relative to 2007 levels (RSL_{2100}).

The RSL_{2100} was predicted using two eustatic sea level rises by the year 2100, the IPCC-AR4 mean eustatic sea level rise of 30 ±12 centimetres (cm) and a high predicted eustatic sea-level rise of 100 ±30 cm. The tide gauge closest to the Project, where sea level predictions were made in the study, was Point Atkinson (49.333°N, 123.250°W), located approximately 37 km south-southwest of the Project site. The predicted RSL_{2100} using the mean sea-level rise was 18 cm, with a possible range of 6 cm to 30 cm. The predicted RSL_{2100} using the high predicted sea-level rise was 88 cm, with a possible range of 57 cm to 118 cm.

Since the Project is expected to be completed by the 2040s it is expected that rising sea levels of this amount will have little direct effect on the Project operation phase. The Project design considered a sea level rise of 0.5 m over the design life of the Project, conservatively based on the MOE (2011b) *Guidelines for Management of Coastal Flood Hazard Land Use*, which recommends a global sea-level rise of 1.0 m by the year 2100. The sea-level rise considered over the Project lifetime is comparable to the sea-level rise predicted by 2100 at the nearby tide gauges. The Project Closure Plan will comprise the removal of surface infrastructure; therefore, it is expected that the predicted rising sea level will have little effect on Project closure.

5.3.3.2.2.2 Potential Effects of Project Greenhouse Gas Emissions during All Phases

The Project has the potential to emit GHGs throughout all phases. The Project GHG emissions may affect sectorial, provincial, and federal targets, as well as commitments for managing these targets, and may affect climate change.

The Project will have sources that produce CO_2, methane (CH_4), and nitrous oxide (N_2O). The Project is not expected to have sources that produce perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and sulphur hexafluoride (SF_6). The rationale for each contaminant is presented in the following table.

Table 5.3-13 Contaminant Inventory Boundary

Greenhouse Gas	Emitted from the Project	Rationale
Carbon Dioxide (CO_2)	Yes	Expected emissions are predicted as a product of natural gas combustion from several Project sources.
Methane (CH_4)	Yes	
Nitrous Oxide (N_2O)	Yes	
Ozone (O_3)	No	The Project will not have sources that produce ozone, PFCs, or HFCs.
Perfluorocarbons (PFCs)	No	
Hydrofluorocarbons (HFCs)	No	
Sulphur hexafluoride (SF_6)	No	The Project will not have sources that produce SF_6. SF_6 may be contained in electrical equipment onsite, but it will be contained in a sealed system and will not be released to the atmosphere.

The emissions of these GHGs are expressed as tonnes (t) or kilotonnes (kt) of equivalent carbon dioxide (CO_2e), which is calculated by multiplying the annual emissions of each GHG by its 100-year global warming potential (GWP). The GWP of each gas represents the gas's ability to trap heat in the atmosphere in comparison to CO_2. The GWPs that were used to calculate the Project GHG emissions are accepted values of one, 25, and 298 for CO_2, CH_4, and N_2O, respectively. These GWPs are the recommended values provided in IPCC's Fourth Assessment Report (Solomon et al., 2007) and are currently consistent with federal and provincial reporting regulations. The GHG emission sources considered in the construction and operation phases of the Project are summarized in **Table 5.3-14**. The decommissioning phase is assumed to be the same as the construction phase, as presented in the following section related to direct emissions.

Table 5.3-14 Summary of Greenhouse Gas Emissions Sources Considered

Scenario	Source	Source Category	Scope	Methodology
Construction	Marine Vessels	Mobile Combustion	Scope 1/Scope 3	2005 – 2006 BC Ocean-Going Vessel Emissions Inventory (Chamber of Shipping 2007)
	Construction Equipment	Mobile Combustion	Scope 1	National Inventory Report 1990 - 2012: Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2014a)
Operation	Amine Unit Incinerator	Stationary Combustion	Scope 1	Combustion Chemistry using Stoichiometric Mass Balances
	Process Flares (WWGF, LPCF, CDGF and LPWF)	Stationary Combustion	Scope 1	Combustion Chemistry using Stoichiometric Mass Balances
	Hot Oil Heater	Stationary Combustion	Scope 1	Combustion Chemistry using Stoichiometric Mass Balances
	HVAC Units	Stationary Combustion	Scope 1	Combustion Chemistry using Stoichiometric Mass Balances
	Fugitive Natural Gas from Operations	Process Fugitives	Scope 1	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 4 (IPCC 2006)
	Landfill	Landfill Fugitives	Scope 1	LandGEM – landfill gas prediction model
	Marine Vessels	Mobile Combustion	Scope 1/Scope 3	2005 – 2006 BC Ocean-Going Vessel Emissions Inventory (Chamber of Shipping 2007)
	Plant Electrical Demand	Purchased Electricity	Scope 2	National Inventory Report 1990 - 2012: Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2014a)
	Floating Storage and Offloading Unit	Process Fugitives	Scope 1	Combustion Chemistry using Stoichiometric Mass Balances

Note: GHG emission scopes are defined in **Section 5.3.1.1** and relate to the GHG emission sources included according to regulatory guidance.

Scope 1: Direct Emissions

The estimated direct GHGs for the construction and operation phases of the Project are presented in **Table 5.3-15** and **Table 5.3-16**, respectively. For the construction phase, direct emissions only consist of mobile equipment and the existing fugitive emissions from the landfill. For the operation phase, direct emissions represent various stationary fuel combustion sources, process fugitives, landfill fugitives, and mobile equipment.

Table 5.3-15 Construction-phase Direct Emissions

Source	Annual Emissions [kt/year]				
	CO_2	CH_4	N_2O	CO_2e	% of Phase Total
Mobile Combustion	28.0	<0.1	<0.1	28.5	63.7
Landfill Fugitives	1.6	0.6	<.0.1	16.2	36.3
Total	**29.6**	**0.6**	**0.0**	**44.7**	**100.0**

Table 5.3-16 Operation-phase Direct Emissions

Source	Annual Emissions [kt/year]				
	CO_2	CH_4	N_2O	CO_2e	% of Phase Total
Stationary Combustion	85.9	<0.1	<0.1	86.7	67.0
Process Fugitives	0.1	0.9	<.0.1	23.7	18.3
Landfill Fugitives	1.6	0.6	<0.1	16.2	12.5
Mobile Combustion	2.8	<0.1	<0.1	2.8	2.2
Total	**90.3**	**1.6**	**0.0**	**129.4**	**100.0**

The maximum annual GHG emissions scenario for the Project is expected to occur during the operation phase. The only potential emissions for the decommissioning phase would be from mobile equipment; however, the number of vehicles needed for closure is unknown. As such, considering the construction vehicle fleet would be considerably larger than the fleet needed for closure, the direct emissions from the decommissioning phase have been conservatively assumed to be the same as those for the construction phase (i.e., given that similar but less equipment and fuel consumption will be involved).

Scope 2: Indirect Emissions

Carbon emissions from the consumption of purchased electricity, heat, or steam are considered indirect emissions. The Project will use only purchased electricity. The GHG emissions from purchased electricity in CO_2e are calculated based on the GHG consumption intensity factor within the Canada National Inventory Report (Environment Canada 2014a). The consumption intensity factor represents an overall emission factor for GHG emissions from the different types of electrical consumption in the province of BC, and includes unallocated energy and transmission emissions. The majority of the electrical generation in BC is from hydroelectric power, and as a result, has a relatively low GHG emission factor compared to other sources of electrical power. Detailed supporting calculations are provided in **Appendix 5.3-1 Greenhouse Gas Methodology**.

For the construction phase, electricity consumption is assumed to be significantly less than the operation phase, and has therefore not been estimated quantitatively. The indirect GHG emissions from purchased electricity from the operation phases of the Project is presented in **Table 5.3-17**.

Table 5.3-17 Operation-phase Indirect Emissions

Source	Annual Emissions [kt/year]				
	CO_2	CH_4	N_2O	CO_2e	% of Phase Total
Purchased Electricity	12.6	<0.1	<0.1	12.7	100

There are no indirect Project GHG emissions from significant sources for the decommissioning phase, as it was assumed no land clearing would take place and no electricity would need to be purchased.

Scope 3: Other Indirect Greenhouse Gas Emissions

There are other indirect sources (e.g., minor land clearing) that could be associated with the Project, and which are, in accordance with the provincial and federal reporting programs, not included in the inventory boundary and were not included in the assessment. These other indirect sources are considered to be negligible sources of GHG emissions in comparison to the direct emissions from the Project, and have not been quantitatively assessed.

Additionally, some of the marine-related GHG emissions are considered Scope 3, as stated in **Table 5.3-14**. However, a conservative approach suggests these minor GHG contributions have been considered as a Scope 1 direct GHG emission.

Greenhouse Gas Intensity

The GHG intensity value for the Project was estimated by taking the annual Project GHG Scope 1 (excluding landfill and marine) and Scope 2 emissions and dividing it by the corresponding design throughput of LNG. Therefore, at peak capacity the Project will have a GHG intensity of 0.059 t CO_2e per t of LNG.

5.3.3.2.3 Proposed Measures to Mitigate Project-related Effects

5.3.3.2.3.1 Measures to Minimize the Effects of Climate Change on the Project

The main option to minimize the effects of climate change on the Project is incorporation of design measures into the final design for the Project, as described in the following Project Design measures. The effects of climate change on the Project are also considered in **Section 12.0 Effects of the Environment on the Project**.

Project Design Measures to Minimize the Effect of Changing Climate on the Project

The proposed mitigation for effects of a changing climate on the Project during operation is to incorporate the potential for climate change over the lifetime of the Project into the Project design. For example, the Project's infrastructure design such as stormwater management will be designed to account for a projected increase in rainfall, which may cause an increase in the amount of stormwater that needs to be managed and a sea-level rise of 0.5 m over the design life of 25 years. Project infrastructure will be monitored throughout the design life of the Project and measures required to adapt to the changing climate will be identified and implemented as required.

5.3.3.2.3.2 Measures to Minimize Project Greenhouse Gas Emissions

The two main options for the mitigation of Project GHG emissions are the development of best management practices (BMPs) and incorporating mitigation as part of the Project design. These options will be re-evaluated as provincial and federal policies identify, update, and implement new BMPs.

Project Design

The foremost GHG mitigation measure for the Project is mitigation by design, which will reduce emissions through machinery/technology selection, process design, and managing fugitive emissions. This mitigation measure has already been incorporated into the Project (**Section 2.2 Description of the Proposed Project**). The Project will minimize the emission of GHGs, most notably those emissions associated with fuel combustion through the use of electricity from BC Hydro to power the compressors, instead of using natural gas, which is a more GHG-intensive compared to hydro electric power. The use of the electrical-powered compressors is consistent with specific actions within the Sea-to-Sky Air Quality Management Plan (Sea–to-Sky Clean Air Society 2007). More specifically, the use of electricity to power the compressors is consistent with Action 13 of the Sea-to-Sky Air Quality Management Plan, which seeks to promote the use of non-fossil fuel energy sources through the airshed. In addition, the process is designed to use process air for valve actuation, instead of natural gas, thereby further reducing GHG emissions. Operating a brand new facility, the Proponent will generate very small fugitive GHG emissions by using welded joints, instead of flanged connections, where possible. Equipment will minimize fugitive emissions to the environment, eliminate or minimize waste gas stream to vent or flare, and provide safe isolation of equipment for inspection or repair.

Liquefied natural gas production is a highly energy-intensive process, and produces a commodity that is highly exposed to global competition. Liquefied natural gas may be shipped long distances and local demand does not result in high market share. Through shipping, LNG has the potential to reduce GHG emissions globally by providing a recognized fuel substitution method for reducing GHG emissions where there is no local natural gas supply. It is a recognized concern that GHG reduction targets will increase energy costs and potentially compromise the global competitiveness of these energy-intensive, trade-exposed industries (ACEEE 2014), since the energy-intensive, trade-exposed industry may be unable to pass on the costs of reducing their carbon emissions. For these reasons, it is common for GHG legislation to take measures to limit this effect, commonly known as carbon leakage, which represents the movement of production from a regulated jurisdiction to a jurisdiction with less stringent or no GHG regulations or targets.

M5.3-1 – Best Management Practices for Greenhouse Gas Emissions

Woodfibre LNG Limited will develop and implement best management practices reduce GHG emissions. Woodfibre LNG Limited will be compliant with regulations and permitting and associated reporting requirements (see **Section 14.0 Compliance Reporting**). Best management practices will include the following:

- Reduce emissions from mobile equipment (such as through ongoing vehicle maintenance and reducing the idling time of vehicles)
- Develop and implement a leak detection and repair program for Project facilities
- Develop control philosophies to minimize the amount of flared and vented gases, and select chemicals that minimize contributions to global warming

These best mitigation approaches will address regulatory developments on both a provincial and federal level through the incorporation of new processes and operations. Annual compliance reports will track the implementation and success of the BMPs. Compliance will be demonstrated through reporting emissions to the MOE, according to the regulation outlined in **Appendix 5.3-1 Greenhouse Gas Methodology**. Leak detection will follow the recommendations of the American Petroleum Institute (2013), and leak repair will follow the engineering design of the Project.

The potential effects and the proposed mitigation to avoid or reduce the effects are summarized in **Table 5.3-18**.

Table 5.3-18 Summary of Potential Effects and Mitigations for Greenhouse Gas Management

Summary of Potential Effect	Project Design Measure / Mitigation	Mitigation Number
Construction		
Effect of the Project GHG emissions on provincial and national levels	Best Management Practices for greenhouse gas emissions	M5.3-1
Effect of the Project GHG emissions on climate change	Best Management Practices for greenhouse gas emissions	M5.3-1
Operation		
Effects of climate change on the Project	Account for climate change in Project design and create adaptive management plan to identify and adapt to climate change vulnerabilities not accounted for in the Project design.	Project design

Summary of Potential Effect	Project Design Measure / Mitigation	Mitigation Number
Effect of the Project GHG emissions on provincial and national levels	In-design mitigation to reduce contribution of Project GHG emissions(e.g., use of electricity to power the Project)	Project design
Effect of Project-related GHG emissions on provincial and national levels from on-site vehicles	Best Management Practices for greenhouse gas emissions	M5.3-1
Effect of the Project GHG emissions on provincial and national levels from maintenance and blowdown	Best Management Practices for greenhouse gas emissions	M5.3-1
Effect of Project-related GHG emissions on provincial and national levels – fugitive GHG emissions from leaks	Best Management Practices for greenhouse gas emissions	M5.3-1
Effect of the Project GHG emissions on climate change	In-design mitigation to reduce contribution of Project-related GHG emissions (e.g., use of electricity to power the	Project design
Effect of the project GHG emissions on climate change from on-site vehicles	Best Management Practices for greenhouse gas emissions	M5.3-1
Effect of Project-related GHG emissions on climate change from maintenance and blowdown	Best Management Practices for greenhouse gas emissions	M5.3-1
Effect of Project-related GHG emissions on climate change – fugitive GHG emissions from leaks	Best Management Practices for greenhouse gas emissions	M5.3-1
Decommissioning		
Effect of the Project-related GHG emissions on provincial and national levels -GHG emissions from onsite vehicles	Best Management Practices for greenhouse gas emissions	M5.3-1
Effect of the Project-related GHG emissions on climate change – GHG emissions from onsite vehicles	Best Management Practices for greenhouse gas emissions	M5.3-1

Considering the mitigation described in **Section 5.3.3.2.3**, the first adverse effect relating to potential for changing climate to affect the Project is expected to be eliminated through Project design and adaptive management considerations and measures. As a result, the potential effect of a changing climate on the Project infrastructure is not likely to result in a residual adverse effect and is not characterized for significance.

The potential effect of Project-related GHG emissions on provincial and national levels and the effect of Project-related GHG emissions on climate change will remain after mitigation and are considered further in **Section 5.3.3.4**.

5.3.3.3 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 this VC. Residual effects are those effects remaining after implementation of mitigation measures.

This section considers the potential effect of Project-related GHG emissions on provincial and national levels and the potential effect of Project-related GHG emissions on climate change. The assessment approach is outlined in **Section 5.3.3.1**.

Residual Effects of Project-related Greenhouse Gas Emissions against Provincial and National Levels on Targets

The residual effect of Project-related GHG emissions on sector targets during the Project's operation phases is assessed through the comparison of Project GHG intensity value to GHG emission intensity compliance target for LNG facilities. The residual effect of Project-related GHG emissions on provincial and national levels during the Project's construction and operation phases is assessed through the comparison of currently available emission totals for BC and Canada.

A comparison of the Project GHG intensity value to the GHG emission intensity compliance target for LNG facilities is provided in **Table 5.3-19**. The Project GHG intensity value is considered much lower than other proposed LNG projects and can be attributed to the use of electrically powered compressor units. **Table 5.3-19** also presents a comparison to the average of several LNG projects and the proposed Pacific NorthWest LNG project, which is located in northern BC.

Table 5.3-19 Greenhouse Gas Intensities of Other Liquefied Natural Gas Projects

Project	GHG Emission Intensity Compliance Target (t CO_2e per tonne of LNG)	WLNG as a Relative Percentage
Woodfibre LNG	0.059	—
Greenhouse Gas Industrial Reporting and Control Act, Bill 2, 2014, first reading.	0.16	37%
Pacific NorthWest LNG*	0.27	22%
Average from similar projects*	0.33	18%

Note: * - Data obtained from the Pacific NorthWest LNG Environmental Impact Statement and Environmental Assessment Certification Application (Pacific NorthWest LNG 2014).

A comparison of the predicted GHG emissions from the Project to the annual GHG emissions for BC, Canada, and the world is provided for the construction and operation phases in **Table 5.3-20** and **Table 5.3-21**, respectively. The GHG emissions during the Project decommissioning phase are conservatively considered to be similar to but less than those emissions expected during construction.

Table 5.3-20 Comparison of Project-related Construction-phase Greenhouse Gas Emissions to Provincial, Federal, and Global Emissions

Source	Annual Greenhouse Gas Emissions (kt CO_2e/yr)	Project Total as a Relative Percentage
Direct emissions	45	-
Indirect emissions	0	
Project Total	45	
British Columbia (2010)	61,500	0.07%
Canada (2010)	699,000	0.006%
2011 WRI Global	43,816,734	0.0001%

Source: Data for BC and Canada-wide GHG emissions were obtained from the British Columbia Greenhouse Gas Inventory (MOE, 2014b) and National Inventory Report (Environment Canada 2014a). Data for global GHG emissions were obtained from the WRI (2014).

Table 5.3-21 Comparison of Project-related Operation-phase Greenhouse Gas Emissions to Provincial, Federal, and Global Emissions

Source	Greenhouse Gas Emissions (kt CO_2e)	Project Total as a Relative Percentage
Direct emissions	129	-
Indirect emissions	13	
Project Total	142	
British Columbia (All Sectors, 2012)	61,500	0.23%
Canada (All Sectors, 2012)	699,000	0.020%
2011 WRI Global	43,816,734	0.0003%

Source: Data for BC and Canada wide GHG emissions were obtained from the British Columbia Greenhouse Gas Inventory (MOE, 2014b) and National Inventory Report (EC, 2014a). Data for global GHG emissions were obtained from WRI (2014).

Using the effects criteria presented in **Table 5.3-9**, the magnitude of the GHG emissions on sector, provincial and national levels are anticipated to be low during the construction and operation phase. With the implementation of the mitigation measures, the significance of the residual effect is considered negligible, since the magnitude of the effect will remain as low, which is less than the threshold of >1% global contribution for a significant effect. The Project will likely result in GHG emissions during all phases, therefore, the likelihood of effects associated with the Project GHG emissions is considered likely. When considering the effects of Project GHG emissions on targets, the level of confidence is considered high and the level of risk is considered low. When calculating the Project GHG emissions, a worst-case scenario was assumed in which all equipment is running simultaneously at design capacity over the course of a year. This conservative approach yields an estimate of the maximum GHG emissions from the Project. In reality, the Project GHG emissions will likely be lower than the scenarios used for the construction and operation phases, as it is unlikely all equipment will be operating at a sustained full capacity at the same time over an extended period. Likewise, the risk is considered low if a conservative estimate of the Project-related GHG emissions produces residual adverse effects that are considered not significant.

Residual Effects of the Project Greenhouse Gas Emissions on Climate Change

To evaluate the potential effect of Project-related GHG emissions on climate change, it is necessary to understand the changes in climate forecast by the IPCC and the associated changes in GHG emissions that bring those about. Although it is recognized that climate change is not a simple linear mechanism, the data presented in **Table 5.3-22** illustrate how the relatively minor increase in global emissions associated with the Project would correspond to a change in climate that is unlikely to be measurable. As a result, the magnitude of the effect associated with Project GHG emissions on climate is considered negligible.

Table 5.3-22 Comparison of Project-related Greenhouse Gas Emissions to Changes Used in the Intergovernmental Panel on Climate Change Models

Parameter	SRES Scenario A1B	SRES Scenario A2	SRES Scenario B1	Project
Change in global GHG emissions relative to the 2010 global baseline[a]	+28.7%	+86.0%	+2.0%	+0.0003%[c]
Change in annual temperature for the 2040 to 2069 horizon[b]	+1.6°C	+1.5°C	+1.3°C	Cannot be measured[d]
Change in annual precipitation for the 2040 to 2069 horizon[b]	+50 mm(eq)	+54 mm(eq)	+51 mm(eq)	Cannot be measured[e]

Notes: SRES – Special Report on Emission Scenario

[a] These values represent the projected changes in global GHG emissions from the global baseline emissions for 2010 that were listed in the IPCC as 20,894 MT CO_2e (Nakicenovic and Swart 2000).

[b] Changes were calculated as the average of available modeled differences between the baseline (1981 to 2010) and scenario forecasts for the 2040 to 2069 time horizon.

[c] The contribution from Project GHG emissions was calculated using the maximum emissions during peak operations.

[d] On the basis of proportionality, the GHG emissions from the Project could represent a maximum increase of less than 0.0003°C in the annual temperature. Such a change would not be measurable.

[e] On the basis of proportionality, the GHG emissions from the Project could represent a maximum increase of less than 0.008 mm (equivalent) in the annual total precipitation. Such a change would not be measurable.

Using the effects criteria presented in **Table 5.3-9**, the magnitude of the effect of Project-related GHG emissions on climate change is low. With the implementation of the mitigation measures, the significance of the residual effect is considered negligible as the magnitude of the effect will remain as low, which is less than the threshold of >1% global contribution for a significant effect. The Project will likely result in increased GHG emissions during all phases, compared to 2010 IPCC global totals, despite the planned implementation of mitigation measures. As a result, the likelihood of effects associated with the Project GHG emissions is considered likely.

When considering the effects of Project GHG emissions on climate change, the level of confidence is considered high and the level of risk is considered low. The Project-related GHG emissions are sufficiently low magnitude that their effect on climate change cannot be measured; this is supported by the federal guidance, which states that the contribution of an individual project to climate change cannot be measured (FPTCCCEA 2003). As a result, individual effects that are not measurable are, by definition, considered negligible. Likewise, the level of risk is considered low if the federal guidance acknowledges that the contribution of an individual Project to climate change cannot be measured, and is thus considered negligible.

5.3.3.4 Summary of Project–related Adverse Residual Effects and Significance

Two Project-related residual adverse effects remain after the implementation of mitigation measures for GHG management. These residual adverse effects are related to Project GHG emissions, which will still be emitted after the implementation of mitigation, and are listed in **Table 5.3-23** and **Table 5.3-24**.

Table 5.3-23 Summary of Determination of Significance of Adverse Residual Effects for Greenhouse Gas Management

Residual Effect	Significance (significant / not significant)	Likelihood (likely/unlikely)	Level of Confidence (low/moderate/high)
Effect of Project GHG emissions on provincial and national levels	Negligible residual effect	Likely	High
Effect of Project GHG emissions on climate change	Negligible residual effect	Likely	High

Both residual effects were assessed to be negligible, as the magnitude of the effect was low and the Project-related GHG emissions were considered not measurable at 0.02% of the Canadian contribution and 0.0003% of the global contribution. The Project will likely result in increased GHG emissions during all phases, compared to provincial and national levels, and to 2010 IPCC global totals, despite the planned implementation of mitigation measures. Therefore, the likelihood of effects associated with the Project-related GHG emissions is considered likely.

The level of confidence associated with the significance assessments is considered high. When calculating the Project-related GHG emissions, reasonably conservative estimates of the maximum GHG emissions were used, where the actual operation-phase emissions are likely to be lower. Additionally, the federal guidance (FPTCCCEA 2003) states that the contribution of an individual Project to climate change cannot be measured.

Table 5.3-24 Summary of Effects Characteristics and Significance for Greenhouse Gas Management

Potential Adverse Residual Effect	Contributing Project Activity or Physical Works	Mitigation #	Proposed Mitigation Measures	Residual Effects Characterization (see Notes for details)							
				Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological Context	Level of Effect	Likelihood	Confidence
Construction											
Project GHG emissions on targets	Mobile equipment	M5.3-1	Best Management Practices for greenhouse gas emissions	LM	No	ST/CF	I	-	N	L	H
Project GHG emissions on climate change	Mobile equipment	M5.3-1	Best Management Practices for greenhouse gas emissions	LM	No	ST/CF	I	-	N	L	H
Operation											
Project GHG emissions on targets	Various stationary fuel combustion sources, process fugitives, landfill fugitives, and mobile equipment and purchased electricity	M5.3-1	Best Management Practices for greenhouse gas emissions	LM	No	MT/CF	I	-	N	L	H
Project GHG emissions on climate change	Various stationary fuel combustion sources, process fugitives, landfill fugitives, and mobile equipment and purchased electricity	M5.3-1	Best Management Practices for greenhouse gas emissions	LM	No	MT/CF	I	-	N	L	H

Potential Adverse Residual Effect	Contributing Project Activity or Physical Works	Mitigation #	Proposed Mitigation Measures	Residual Effects Characterization (see Notes for details)							
				Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological Context	Level of Effect	Likelihood	Confidence
Decommissioning											
Project GHG emissions on targets	Mobile equipment	M5.3-1	Best Management Practices for greenhouse gas emissions	LM	No	ST/CF	I	-	N	L	H
Project GHG emissions on climate change	Mobile equipment	M5.3-1	Best Management Practices for greenhouse gas emissions	LM	No	ST/CF	I	-	N	L	H

Notes: Table is not completed for positive effects

Magnitude: NM = negligible, LM = low magnitude, MM = moderate magnitude, HM = high magnitude, N/A = no estimate available
Geographic extent: No = none, Site = negligible, LAA = low, RAA = regional, P = provincial
Duration: LT = long term (permanent), MT = moderate term, ST = short term, TT = transient term
Frequency: CF = continuous, FF = frequent, UF = uncommon, RF = rare
Reversibility: R = reversible, I = irreversible, C = change but may fluctuate from positive to negative for the duration
Ecological Context: Not applicable
Level of Effect: N = negligible, NS = not-significant, S = significant
Likelihood: L = likely, U = unlikely
Confidence: L = low, M = medium, H = high

5.3.4 Greenhouse Gas Management Cumulative Effects Assessment

This section describes the assessment of potential cumulative effects associated with GHG management. Cumulative effects result from interactions between Project-related residual effects and incremental effects of all other certain and reasonably foreseeable projects and activities. The effects other projects and activities that have been carried out (past and present projects) are described in the existing conditions for this VC (**Section 5.3.2.4**). The combination of the residual Project-related effects, with the effects of all other certain and reasonably foreseeable projects, along with activities that will be carried out, comprise the total future cumulative effects.

The Project-related residual effects were assessed as negligible, and are therefore not likely to interact cumulatively with other projects. Further, the future climate change assessment outlined in **Section 5.3.2.4.4** is based on the values provided by GCMs and considers the impacts of global emission scenarios prepared by the IPCC. Similarly the GHG assessment in **Section 5.3.2.4.4** compares the Project emissions to the global GHG emissions used in the IPCC emission scenarios. For these reasons, the effects assessment inherently already considers the cumulative effects of other existing and reasonably foreseeable projects. Therefore, an additional cumulative effects assessment is not required.

5.3.5 Summary of Residual Project-related Effects and Residual Cumulative Environmental Effects

This section summarizes the potential residual effects of the Project and potential residual cumulative effects due to interactions with other certain and reasonably foreseeable projects and activities. The assessment of climate change was completed according to the federal guidance document provided by the FPTCCCEA (2003). Both the effect of climate change on the Project and the effect of the Project on climate change were assessed using both climate data and Project-related GHG emissions.

The influence of a changing climate on Project infrastructure was evaluated through understanding what the current climate is at the Project site and how the climate is projected to change in the future. The effect of the changing climate on the Project infrastructure was then evaluated using the climate risk matrix. This evaluation shows that the potential for changing climate to affect the Project is expected to be eliminated through Project design, adaptive management, and BMP considerations. As a result, the potential effect of a changing climate on the Project infrastructure is not likely to result in a residual adverse effect and is not characterized for significance.

5.3.5.1 Residual Effects of Project-related Greenhouse Gas Emissions on Targets

The influence of the Project-related GHG emissions on the target totals was evaluated using a comparison of the Project-related GHG emissions against the current GHG emission intensity compliance target, and provincial and federal totals (i.e., as a proxy for future targets). The worst-case scenario of the operation phase has the largest GHG emissions over all phases of the Project. The contribution of

Project-related GHG emissions during the operation phase provides a low-magnitude effect at 37% of the sector GHG emission intensity compliance target and with approximately a 0.2% increase to provincial totals. The contribution of Project-related GHG emissions during the operation phase to the sector, provincial and the federal totals are considered low in magnitude. Based on the calculation methodology for Project-related GHG emissions, the confidence level is considered to be high. As a result, the influence of Project-related GHG emissions on the target totals is considered to be not significant.

5.3.5.2 Residual Effects of the Project-related Greenhouse Gas Emissions on Climate Change

The influence of Project-related GHG emissions on climate change was evaluated by assessing whether any measurable change in climate could result from the Project-generated GHG emissions. The relatively minor increase in global emissions associated with the Project would correspond to a change in climate that is unlikely to be measurable. This conclusion is supported by guidance from the federal government, which indicates, "…unlike most project-related environmental effects, the contribution of an individual Project to climate change cannot be measured" (FPTCCCEA 2003). The confidence level is considered to be high; therefore, the influence of the Project GHG emissions on climate change is considered to be negligible.

No federal permits or approvals are required for GHG management for this Project to proceed.

5.3.6 Monitoring and Follow-up Programs

Project Design has considered a potentially changing climate, and an Adaptive Management Plan will be developed and implemented to monitor the ongoing ability of Project infrastructure to cope with changes in climate during the operation phase. Project infrastructure that requires adaptive measures to the changing climate can be identified and implemented if necessary.

The Project will result in increased GHG emissions, compared to current sector, provincial, and federal totals during all phases, despite application of identified mitigation measures. The MOE requires reporting of GHG emissions over the 10 kt threshold, as described in **Section 5.3.1.1**. Thus, the Project GHG emissions will be monitored on an annual basis and reported to the MOE as required. In addition, the BMPs documented in this section will be implemented at all stages of the Project to reduce GHG emissions.

5.3.7 References

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