5.8 Climate Change

5.8.1 Introduction

This section of the Environmental Assessment Certificate (EAC) Application/Environmental Impact Statement (EIS) (hereafter referred to as the EA.) has been prepared by Golder Associates Ltd. (Golder). It addresses the effects of the Proposed BURNCO Aggregate Project (hereafter referred to as the 'Proposed Project') identified in the construction, operation, reclamation and closure phases on VCs related to climate change. Consideration has been given to Proposed Project specific mitigation measures proposed to mitigate any identified effects of the Proposed Project to acceptable levels and any residual effects have been characterized.

5.8.2 Regulatory and Policy Setting

This section provides a climate change and GHG emission assessment for the Proposed Project, following the federal guidance document for practitioners to use when incorporating climate change issues into 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 Proposed Project?
- How will the operation of the Proposed 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 Proposed Project affect climate change (i.e., the Proposed Project's contribution to climate through emissions of GHGs)?

The influence of potential changes in climate affecting the Proposed Project infrastructure is evaluated using the FPTCCCEA guidance document (FPTCCCEA 2003). The future climate is evaluated using the Pacific Climate Impact Consortium (PCIC) Regional Analysis Tool (PCIC 2016), 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 levels of GHG emissions (Nakicenovic & Swart 2000).

The annual GHG emissions from the Proposed Project will be estimated for the Proposed Project operation phase, using the methodologies described in the *Greenhouse Gas Emission Reporting Regulation* (*BC GHG Reporting Regulation*; Government of BC 2015), the *Final Essential Requirements of Mandatory Reporting* (WCI 2009), and other commonly accepted methods where a methodology is not provided in the *BC GHG Reporting Regulation*. Table 5.8-1 presents relevant reference material that forms the basis of GHG annual emission estimates for the Proposed Project. Additional descriptions of this material are presented in Volume 4, Part G – Section 22.0: Appendix 5.8-B.

Table 5.8-1: Applicable References for Estimation of Greenhouse Gas Emissions

Reference	Program	Source	Date
Greenhouse Gas Industrial Reporting and Control Act	British Columbia Legislation	Government of BC, 2014	November 2014
Greenhouse Gas Emission Reporting Regulation	Provincial Greenhouse Gas Reporting Program	Government of BC, 2015	December 2015
Final Essential Requirements of Mandatory Reporting Amended for Canadian Harmonization	Western Climate Initiative	Western Climate Initiative, 2010	December 2010 (December 2011 Amendment and December 2013 Addendum)
Technical Guidance on Reporting Greenhouse Gas Emissions	Federal Greenhouse Gas Reporting Program	Environment Canada, 2015a	November 2015
The Greenhouse Gas Protocol/A Corporate Accounting and Reporting Standard	Multiple Programs (e.g., Global Reporting Initiative, ISO14001)	World Business Council for Sustainable Development/World Resource Institute, 2004	April 2004 (February 2013 Amendment)

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 the company (e.g., emissions from combustion in owned or controlled boilers, furnaces and vehicles, and process and fugitive emissions).

Scope 2 – Indirect GHG emissions:

> Carbon emissions from the generation of purchased electricity, heat or steam consumed by the company.

Scope 3 – Other indirect GHG emissions:

> Carbon emissions which are a consequence of a company's activities, but occur from sources not financially or operationally controlled by the company (e.g., emissions from waste, the extraction and production of purchased materials, and employee travel to and from work) (ISO 2006).

The provincial and federal reporting regulations and the various GHG reporting programs vary in which emissions sources require reporting. The GHG Protocol (WBCSD/WRI 2004) requires reporting of Scope 1 (direct emissions from site) and Scope 2 (emissions from on-site energy consumption) emissions only. Scope 1 and Scope 2 emissions are typically the focus of most corporate inventories, although many organizations choose to account for other activities such as employee travel and downstream emissions from waste. Both the *BC Reporting Regulation* and the Federal reporting program require reporting of direct facility emissions, but do not require reporting of emissions associated with electricity consumption, marine vessels and emissions related to deforestation. Within this assessment, all significant sources of GHG emissions have been identified and quantified. Given the nature of gravel extraction operations, Scope 1 emissions will be the most significant and therefore were the primary focus of the GHG inventory. Emissions associated with marine vessels, both maneuvering in the vicinity of the Proposed Project (Scope 3) and vessel travel between the Proposed Project and the existing BURNCO facility in Langley (Scope 3) were included. In addition, emissions associated with electricity consumption (Scope 2) and land clearing at the Proposed Project site (Scope 3) have been considered.

The government of BC has set targets in the *Greenhouse Gas Reduction Targets Act* (Government of BC 2007) to reduce GHG emissions from 2007 levels by at least 33% by 2020 and 80% by 2050. Canada has a legislated target of reducing emissions by 30% below the 2005 baseline emissions by 2030 (Environment Canada 2015b). However, guidance documents on how these provincial and federal targets will be reached or how the different sectors will be treated (e.g., to avoid carbon leakage) has not been released.

5.8.3 Assessment Methodology

This section provides a description of the assessment methodology used in preparing the EA, related to climate change.

Please refer to Volume 2, Part B - Section 4.0 for a full description of the assessment methodology and scope including: selection of value components, establishing boundaries, describing existing conditions, identification of Proposed Project VC interactions, identifying mitigation measures, evaluating residual effects and assessing cumulative effects.

5.8.3.1 Value Component (VC) Selection and Rationale

This section describes the VCs and measureable indicators identified for this assessment related to climate change. The VCs identified reflect issues and guidelines, potential Aboriginal concerns, issues identified by the BC EAO and CEA Agency, First Nations, other stakeholders, professional judgment and key sensitive resources, species or social and heritage values. The identified candidate climate change VC was carried forward in the effects assessment (e.g. no climate change VCs were excluded from the assessment). Additional details regarding the methods used to select VCs is provided in Part B, Volume 2 – Section 4.2.4.

Table 5.8-2 provides a summary of identified VCs, rationale for their inclusion in the assessment, and measurable Indicators that will be considered.

Table 5.8-2: Value Components and Measurable Indicators: Climate Change

Value Component	Rationale	Measurable Indicators
Climate Change	The Proposed Project will result in GHG emissions. Changes in climate have the potential to affect the Proposed Project, as well as altering the potential effects of the Proposed Project on the environment.	GHG emissions

5.8.3.2 Assessment Boundaries

5.8.3.2.1 Spatial Boundaries

Defining the geographic extent of the study areas is a key element of an EA. However, for the climate change/GHG discipline, spatial boundaries will not be defined since climate change/GHG is, by nature, a regional/global issue. This assessment will describe the historical climate trends and the future climate projections across spatial boundaries used across all disciplines. Similarly, the impacts of the Proposed Project on climate change and the effects of climate change on the Proposed Project are all within these spatial boundaries.

For a full description of the spatial boundaries of the Proposed Project please refer to Volume 2, Part B – Section 4.0.

5.8.3.2.2 Temporal Boundaries

Based on the Proposed Project schedule, the temporal boundaries for the climate change assessment are as follows:

- Project construction – up to 2 years;
- Project operations – 16 years; and
- Project reclamation and closure – on-going and 1 year beyond operations.

GHG emissions are expected to be intermittent in nature throughout the construction period, depending on the schedule of activities. The emission activities that would occur during the construction phase of the Proposed Project would be land clearing of the material processing area and land clearing for year one of the aggregate pit. However, the pit will be expanded progressively over the operational life of the Proposed Project and each year land will need to be cleared to accommodate the pit growth. Therefore, GHG emissions associated with the annual land clearing activities to expand the pit are incorporated in the operation phase's emission activities.

It is expected that the Proposed Project operation phase would result in the largest GHG emissions from the three phases (construction, operations and reclamation and closure). GHG emissions during the operational phase will result from propane combustion for welding, fuel combustion in on-site vehicles, fuel combustion in tugboats, electricity consumption, and land clearing. Although land clearing does not release GHG emissions directly, it has been included since the land clearing activity results in the loss of a carbon sink.

GHG emissions during the reclamation and closure phase are expected to be similar to those during the construction phase. It is difficult to know what kind of technologies and associated emissions rates can be expected as far into the future as the decommissioning would occur.

Due to the fact that intermittent nature of emissions associated with the construction and reclamation and closure phases of the Proposed Project and due to the fact that annual land clearing activities associated with pit expansion are incorporated in the operation phase's emission activities, the climate change assessment temporal boundaries were limited to the Proposed Project's operational phase.

For a full description of the temporal boundaries of the Proposed Project please refer to Volume 1, Part A – Section 2.2.

5.8.3.2.3 Administrative Boundaries

No administrative boundaries have been identified for determining the impact of climate change on the Proposed Project or the impact of the Proposed Project on climate change (through GHG emissions).

5.8.3.2.4 Technical Boundaries

No technical boundaries have been identified for determining the impact of climate change on the Proposed Project or the impact of the Proposed Project on climate change (through GHG emissions).

5.8.3.3 Assessment Methods

5.8.3.3.1 Existing Conditions

Two baseline conditions were considered in support of the climate change effects assessment: climatological environment, and GHG emission environment.

For the climatological environment, the historical and future changes in climate were characterized. The IPCC Fourth Assessment Report provides the physical science basis for how climate has been changing due to natural and anthropogenic influences (Solomon et al., 2007). To understand how the climate has been changing, and may change in the future for the Proposed Project region 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 Proposed Project region; and
- Discussing the range of future climate projections (2040 through 2069 and 2070 through 2099).

Describing the current climate in the region surrounding the Proposed 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 and Climate Change Canada (formerly 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 region of the Proposed Project. 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 Proposed Project Area using the PCIC Regional Analysis Tool (PCIC 2016). The Regional Analysis Tool provides multiple emissions scenarios for multiple models to provide an indication of the range of possible future climate conditions.

The existing GHG environment was based on publically available information on provincial (BC) and federal GHG emissions for the 2013 reporting year, and global emissions for 2012. Existing provincial and federal emissions are provided for both the 'Mining and Upstream Oil and Gas Production' sector, and as a total over all sectors.

5.8.3.3.2 Identifying Project Interactions

The requirement of the FPTCCCEA guidelines to consider climate change is addressed through the following considerations:

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

The assessment also describes how climate change may affect the Proposed Project infrastructure, and identifies the aspects of the Proposed Project that may need further assessment due to a potentially changing climate. A qualitative assessment of how the changing climate may affect Proposed Project aspects has been completed by identifying interactions between the proposed infrastructure and selected climate factors.

The review of historical climate data and analysis of future climate projections presented in this assessment follows accepted practices for undertaking EAs.

In addition, the annual GHG emissions from the Proposed Project were estimated for a worst case operating year and these emissions were compared to the provincial and national emissions to assess the relative contribution of the Proposed Project on a Canadian basis. The contribution of Proposed Project-related GHG emissions to climate change is evaluated by comparing the Proposed Project GHG emissions to the projected changed in global GHG emissions assumed in the future climate forecasts by the IPCC.

5.8.3.3.3 Evaluating Residual Effects

Potential Proposed Project-related residual effects were characterized as the basis for determining the significance of potential residual adverse effects for climate change. The characterization of effects was undertaken following application of appropriate mitigation measures.

Potential residual effects were characterized using the following standard residual effects criteria:

- **Context** – the current and future sensitivity and resilience of climate change to change caused by the Proposed Project;
- **Magnitude** – the expected size or severity of the residual effect;

- **Extent** – the spatial scale over which the residual physical, biological and/or social effect is expected to occur;
- **Duration** – the length of time the residual effect persists;
- **Reversibility** - indicating whether the effect is fully reversible, partially reversible or irreversible; and
- **Frequency** – how often the residual effect occurs.

The criteria defined in Table 5.8-3 have been used to characterise and determine the significance of potential effects for the climate change VC. 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 irreversible 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 irreversible; therefore, any emission of GHGs has an adverse effect. This is why, when considering climate change and GHGs, the only applicable residual effect criterion is magnitude.

Please refer to Volume 2, Part B - Section 4.0: Assessment Methods of this EA. for a description of the criteria used to characterise potential effects for all disciplines.

The likelihood of potential residual effects occurring was also characterized for each VC using appropriate quantitative or qualitative terms. To derive a likelihood rating that indicates the probability of a certain effect to occur, implementation of mitigation measures were considered. For example, the likelihood of a certain effect is low, if there is a low potential of the event leading to the effect to occur, or if there are effective controls in place that can eliminate or reduce the magnitude or frequency of the effect. The following criteria were used to define likelihood:

- **Low** - likelihood of occurrence (0 to 40%) – Residual effect is possible but unlikely;
- **Medium** - likelihood of occurrence (41 to 80%) - Residual effect may occur, but is not certain to occur; and
- **High** - Likelihood of occurrence (81% to 100%) - Residual effect is likely to occur or is certain to occur.

5.8.3.3.4 Evaluating Significance of Residual Effects

The significance of potential residual adverse effects will be determined for each VC based on the residual effects criteria and the likelihood of a potential residual effect occurring, a review of background information and available field study results, consultation with government agencies, First Nations, and other experts, and professional judgement.

The determination of significance of residual adverse effects is rated as negligible-not-significant, not significant, or significant, which are generally defined as follows:

- **Negligible-Not Significant:** The basis for determining that effects are negligible will be provided in the Application for each VC. Negligible effects will not be carried forward to the cumulative effects assessment
- **Not significant:** Effects determined to be not significant are residual effects greater than negligible that do not meet the definition of significant. Residual effects that are not significant will be carried forward to the cumulative effects assessment.
- **Significant:** The basis for determining that a residual effect is significant will be provided in the Application for each VC. Significant residual effects will be carried forward to the cumulative effects assessment.

The rationale and determinations of the significance of potential residual effects on VCs are provided in Section 5.8.7.

5.8.3.3.5 Describe Level of Confidence

The level of confidence for each predicted effect is discussed to characterize the level of uncertainty associated with both the significance and likelihood determinations. Level of confidence is typically based on expert judgement and is characterized as:

- Low: Limited evidence is available, models and calculations are highly uncertain, and/or evidence about potential effects is contradictory.
- Moderate: Sufficient evidence is available and generally supports the prediction.
- High: Sufficient evidence is available and most or all available evidence supports the prediction.

Table 5.8-3 Criteria for Characterizing Potential Residual Effects: Climate Change

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Climate Change	The IPCC have linked observed changes in the climate system to observed increases in anthropogenic GHG concentrations (Solomon et al, 2007). Historic changes in climate reflect the effects of past GHG emissions, as well as natural variations. Future GHG emissions are projected to have further effects on climate; however, changes in climate are not highly sensitive to changes in emissions.	**Negligible:** Effects from changing climate on Proposed Project infrastructure are below the design thresholds; and/or predicted contribution of GHGs of <1% to the Canadian contribution and <0.001% to the global contribution; **Low**: Effects from changing climate on Proposed Project infrastructure are below the design thresholds; and/or predicted contribution of GHGs of <2% to the Canadian contribution and <0.01% to the global contribution; **Moderate**: Effects on Proposed Project infrastructure from changing climate are approaching design thresholds; and/or predicted contribution of GHGs of >2% to the Canadian contribution and >0.01% to the global contribution; or **High**: Effects on Proposed Project infrastructure from changing climate are above design thresholds; and/or predicted contribution of GHGs of >1% to the global contribution.	**Regional:** Effect is limited to the Proposed Project Area (air quality RSA); or **Beyond Regional:** Effect extends beyond the Proposed Project Area.	**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; or **Long-term** – Predicted climate effects could affect the decommissioning phase, and/or predicted contribution of GHGs will extend into the decommissioning phase.	**Fully Reversible**: Predicted climate effects on Proposed Project infrastructure are reversed after a distinct event, and/or the effect is reversed when the contribution of GHGs ceases; **Partially Reversible:** Predicted climate effects on Proposed Project infrastructure are partially reversed after a distinct event, and/or the effect is reversed when the contribution of GHGs ceases; or **Irreversible**: Predicted climate effects on Proposed Project infrastructure are not reversed after a distinct event and/or the effect will not be reversed when the contribution of GHGs ceases.	**Low:** Predicted climate effects on Proposed 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 Proposed Project; **Medium:** Predicted climate effects on Proposed 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 Proposed Project; or **High:** Predicted climate effects on Proposed 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 Proposed Project.

5.8.4 Baseline Conditions

Two baseline conditions were considered in support of the GHG management effects assessment: climatological environment, and GHG emission environment. The climatological environment considers historical climate trends and future climate change in Sections 5.8.4.2 and 5.8.4.3. The baseline GHG emissions are described in Section 5.8.4.4.

5.8.4.1 Traditional Ecological and Community Knowledge Incorporation

TEK/CK information was gathered from a Project-specific study undertaken by *Skwxwú7mesh* (Squamish Nation) and from publicly-available sources.

TEK/CK sources were reviewed for information that could contribute to an understanding of climate change. The main sources of this information include:

- Occupation and Use Study (OUS) undertaken by Skwxwú7mesh (Traditions 2015 a,b)
- An expert report produced on behalf of Tsleil-Waututh Nation for another project (Morin 2015)
- Regulatory documents for other projects in close proximity to the Proposed Project Area (e.g., Eagle Mountain – WGP 2015 a,b; PMV 2015; WLNG 2015).

TEK/CK sources available at the time of writing provided no specific information on climate change.

5.8.4.2 Historic Climate Trends

Historical climate trend analysis relies on the use of climate normals, which are long-term (30-year) averages of observed climate for set periods of time. An analysis and summary of the current climate conditions for the region for the 1981 through 2010 (the currently recognized climate normal period by Environment and Climate Change Canada), and the longer period of 1971 through 2010 where data is available, was conducted. Historic climate data earlier than 1971 have not been considered in this assessment. Using the climate normal data, historical climate trends are characterized to identify apparent trends in the climate data, and assess whether those apparent trends are statistically significant or not. These trends provide an indication of how climate has been changing over the 30-year current climate period.

5.8.4.2.1 Climate Station Selection

For the purpose of this assessment, climate station selection was based on specific recommendations from Environment and Climate Change Canada's Canadian Climate Change Scenarios Network (CCCSN), which is the Government of Canada's interface for distributing climate change scenarios and adaptation research. The CCCSN 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 criteria used to select the station were based on the following selection CCCSN factors:

- The length of record (minimum 30 years of data);

- A continuous record;
- Records are up to date; and
- Proximity to the area of interest.

There may be a number of climate stations that fall within the boundaries of the study area of interest. As a result, 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 are constrained by low numbers of observations, a limited life span for the station (data quantity), and varying data quality.

The climate assessment completed for the Proposed Project used data from one climate station to describe historic climate conditions, climate variability, and longer-term trends. Based on the CCCSN criteria and the defined study area, the selected station was Gibsons Gower Point (49.383° N 123.533° W), located approximately 24 km south-southwest of the Proposed Project. The elevation of the station is 34 m above sea level (masl) and the Environment and Climate Change Canada climate ID is 1043152. The location of the Gibsons Gower Point with respect to the Proposed Project is shown in Figure 5.8-1.

Available daily meteorological data from the station were collected for the period from 1971 through to 2010. Once the dataset passed the QA/QC process (e.g., data checks, ranges, missing data), they were prepared for developing the long term averages and trend analysis. The percentage of missing data at Gibsons Gower Point station between 1981 and 2010 is approximately 0.7% for temperature and 0.3% for total precipitation. All years have less than 10% of data missing and therefore meet the CCCSN criteria outlined above.

5.8.4.2.2 Background to Trend Analysis

Traditionally, the review of changing climate considers past meteorological records to provide guidance for predicting future conditions. Historic climate trends at Gibsons Gower Point were assessed using data from the climate data archives (Environment Canada 2013). All available information from 1971 through 2010 was assessed.

Potential trends in temperature and precipitation are evaluated by fitting a model to the data using the Sen’s nonparametric model. The statistical significance of the observed trends is determined using the Mann-Kendall test (Salmi et al. 2002). The Mann-Kendall test is applicable to the detection of a monotonic trend of a time series with no seasonal cycle. The analysis uses a two-tail test to determine statistical significance at the 90th, 95th, 99th and 99.9th percentile levels. A trend that is not determined to be significant at the 90th percentile is classified as being “not significant.” A trend that is determined to be significant at the 99.9th percentile level indicates that there is a 99.9% probability that the direction of the trend is correct. This methodology was developed by the Finnish Meteorological Institute and is widely used to assess climate changes predicted from meteorological data.

5.8.4.2.3 Result of Trend Analysis

The historic trends in climate were computed for the Gibsons Gower Point dataset for the annual and seasonal mean temperature and total precipitation. The trend analysis returns two pieces of information for each climate indices: the climate average and the climate trend. The climate average is calculated as the average of a given climate index over the selected period and the climate trend is calculated as the average change in the climate index per year. The decadal trend (change per decade) is calculated from the yearly trend (change per year).

Data from Gibsons Gower Point meteorological station (for the 40 year period from 1971 through 2010) were used for describing the current climate and historic climate trends in the Proposed Project region. The analysis of the data summarized in Table 5.8-4 show statistically significant increasing trends for temperatures in all seasons and a decreasing trend for precipitation in summer.

Table 5.8-4: Gibsons Gower Point Trend Analysis Results

Climate Indices	1971 to 2010 Average	1971 to 2010 Trend (Change per year)	1971 to 2010 Trend (Change per decade)	Level of Statistical Significance
Total Precipitation [mm (equiv.)]	1337.8	-2.91	-29.1	not statistically significant, no apparent trend
Spring Total Precipitation [mm (equiv.)]	290.5	-0.66	-6.6	not statistically significant, no apparent trend
Summer Total Precipitation [mm (equiv.)]	148.8	-1.28	-12.8	significant at the 90th percentile
Fall Total Precipitation [mm (equiv.)]	405.4	+0.52	+5.2	not statistically significant, no apparent trend
Winter Total Precipitation [mm (equiv.)]	493.1	-1.80	-18.0	not statistically significant, no apparent trend
Average Annual Temperature [°C]	10.3	+0.03	+0.3	significant at the 99.9th percentile
Average Spring Temperature [°C]	9.4	+0.03	+0.3	significant at the 95th percentile
Average Summer Temperature [°C]	16.7	+0.04	+0.4	significant at the 99.9th percentile
Average Fall Temperature [°C]	10.5	+0.02	+0.2	significant at the 95th percentile
Average Winter Temperature [°C]	4.4	+0.04	+0.4	significant at the 99.9th percentile

5.8.4.3 Future Climate Change

As an international body, the IPCC provides a common source of information relating to GHG 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 (WMO) and the United Nations Environment

Program (UNEP) 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.

5.8.4.3.1 Approach for Describing Future Climate

Climate modelling 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 share a number of common elements described by the IPCC (Solomon et al., 2007). The IPCC does not run the models, but does act as a clearinghouse for the distribution and sharing of the model forecasts.

The IPCC data was accessed through the Regional Analysis Tool (PCIC 2016) 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 Proposed Project:

- 2040 to 2069 (noted as 2050s); and
- 2070 to 2099 (noted as 2080s).

These are the standard forecast data sets for the 21st century and both the 2050s and the 2080s will be reflective of the Proposed Project decommissioning and post-closure (retirement) phases. While the majority of the Proposed Project time occurs during the 2020s (2011 through 2040), this climate projection data will not be assessed, as climate changes will not have been completely manifested. Instead, since the post-closure phase of the Proposed Project (anticipated to begin in 2036) will extend past 2040, 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 during post-closure. The 2080s reflect a bounding condition should the operational lifetime of the Proposed Project be extended beyond the anticipated 16 years. By using the projected climate change for the 2050s and 2080s, when the Proposed Project phases most sensitive to climate change occur, the projected changes for the 2020s are already included.

Given the large grid size of a GCM projection, as described in Section 5.8.4.3.2, the data are representative of area averages and not necessarily representative of a specific location contained within the grid box. Murdock and Spittlehouse (Murdock & 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 modelled 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 modelled baseline can then be used to estimate the future climate conditions in the context of the actual current climate for the Proposed Project described in Section 5.8.4.2.

The current climate was analysed for the period from 1971 through 2010, occurring 20 years after the modelled baseline of 1961 through 1990. In order to account for the difference in modelled 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 modelled 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 ˚C and changes in millimetres (mm) of precipitation for the current climate.

5.8.4.3.2 General Circulation Models (GCMs)

Climate simulations produced by these GCMs 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 interpretations of their results have been peer reviewed by the IPCC and others. Rather than selecting a single model, the climate change projections from all the available models from AR4 (i.e., 136 unique sets of modelling 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 to 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 kilometres 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 Proposed Project Area. The PCIC Regional Analysis Tool was then used to select the appropriate grid information from the various GCMs in the ensemble.

5.8.4.3.3 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, namely A1B, B1, and A2, are most common scenarios used for impact assessment.

- Scenario A1B — the A1 family of scenarios describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and 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 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). Although IPCC has not stated which of these scenarios are most likely to occur, the A2 scenario most closely reflects the current global socio-economic situation. In relation to the A2 scenario, scenarios A1B and B1 result in lower long-term GHG emissions over the next century. 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 2016). Data used in the assessment relates to the A1B, A2 and B1 scenarios.

5.8.4.3.4 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. Therefore these results are not discussed, as they are well beyond the likely lifespan of the Proposed Project and are too variable to be considered at this time.

5.8.4.3.5 Understanding Climate Projections and their Limitations

GCMs 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 institutions' 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.

5.8.4.3.5.1 Spatial Scales

Due to limitations on computing power, the GCM outputs are typically limited to grid cells of 1° to 2.5° (approximately 110 – 275 km) 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 Proposed 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.

5.8.4.3.5.2 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 and 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 Mt. Pinatubo is well known to have decreased the average planetary surface temperature by approximately 1°C for at least one year; 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).

5.8.4.3.5.3 Changes to our Understanding of the Processes

The Earth's system processes and feedbacks are very complex and therefore have to be approximated in the 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,* the most abundant photosynthetic organism in the ocean, led to a change in the understanding of ocean biology, the carbon cycle, and atmospheric CO_2 (Chisholm et al 1988). Similarly, the 2001 discovery of ubiquitous atmospheric N_2-fixation by the marine cyanobacterium *Trichodesmium* changed the understanding of the effects of ocean biology and our understanding of the earth's nitrogen cycle (Berman-Frank et al. 2001).

5.8.4.3.6 Climate Projections for Proposed Project Region

The future climate for the Proposed 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 modelled baseline period used by PCIC is 1961 through 1990, which differs from the current climate period of 1971 through 2010 used in Section 5.8.4.2. It is important to note that this modelled baseline is not necessarily representative of the local conditions and does not correspond to the observed data but, as outlined in Section 5.8.4.3.1, is used by the GCM projections to estimate changes in climate. This 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 are presented in this assessment.

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.

Figure 5.8-2 scatter plots show Comparisons of the future climate projections for the Proposed Project Area for the 2050s and the 2080s periods, as well as the change in climate that would occur if the observed current climate trend continue forward into the future (i.e., the black diamond on the scatter plot graphs). For reference, the current climate normal is where the axes intersect. The current climate trend shown in Figure 5.8-2 is calculated using the Gibsons Gower Point climate station data.

The scatter plots indicated that 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. The warmer and drier forecasts are most similar to the observed historical climate trends at Gibsons Gower Point climate station (Table 5.8-4), which when extrapolated as shown as the black diamond on the plots, indicate a warmer drier climate.

The mean of the projected annual temperature and precipitation for all models and the three SRES scenarios are summarized in Table 5.8-5.

Table 5.8-5: Summary of Projected Climate Trend Deviations from Observed Historic Values

SRES Scenario	Time Period	Annual Average Temperature [°C]	Total Annual Precipitation [mm(equiv.)]
A1B	1971 - 2010 Climate	+10.3	+1337.8
	2050s	+11.8 (+1.5)	+1368.1 (+30.3)
	2080s	+12.7 (+2.4)	+1393.2 (+55.3)
A2	1971 - 2010 Climate	+10.3	+1337.8
	2050s	+11.9 (+1.6)	+1367.1 (+29.3)
	2080s	+12.8 (+2.5)	+1398.3 (+60.5)
B1	1971 - 2010 Climate	+10.3	+1337.8
	2050s	+11.8 (+1.5)	+1369.9 (+32.1)
	2080s	+13.1 (+2.8)	+1393.5 (+55.6)

SRES Scenario	Time Period	Annual Average Temperature [°C]	Total Annual Precipitation [mm(equiv.)]
All Scenarios	1971 - 2010 Climate	+10.3	+1337.8
	2050s	+11.6 (+1.3)	+1368.0 (+30.2)
	2080s	+12.1 (+1.9)	+1386.1 (+48.3)

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

In general, the majority of the projections predict that climate in the Proposed 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 historical trends currently observed at Gibsons Gower Point that indicate a warmer but drier future climate. 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.

5.8.4.4 Baseline GHG Emissions

The baseline for the GHG environment was based on the provincial and federal GHG emissions for the 2013 reporting year, and global emissions for the 2013 reporting year. The baseline GHG emissions are provided in Table 5.8-6. Provincial and federal GHG emissions are provided for both the 'Mining and Upstream Oil and Gas Production' sector, and as a total over all sectors. Baseline information for British Columbia was obtained from the *British Columbia Greenhouse Gas Inventory* (BC MoE 2016). Baseline information for Canada was obtained from the *National Inventory Report 1990-2013: Greenhouse Gas Sources and Sinks in Canada* (Environment Canada 2015c), prepared by Environment and Climate Change Canada for submission to the United Nations Framework Convention on Climate Change. Global emissions were taken from the World Resources Institute (WRI) Climate Data Explorer (WRI 2016).

Table 5.8-6: Baseline Greenhouse Gas Emissions

Source	GHG Emissions (kt CO2e/yr)
BC (2013)[1]	64,000
BC (2013 Mining and Upstream Oil and Gas Production total)[2]	8,770
Canada (2013) [2]	726,000
Canada (2013 Mining and Upstream Oil and Gas Production total) [2]	93,600
Global (2012)[3]	44,815,540

Sources:
[1]BC MoE 2016
[2]Environment Canada 2015c
[3]WRI 2016

5.8.5 Potential Effects of Changing Climate

While a changing climate can have an effect on the Project and other valued components assessed, climate is not itself considered a valued component. This assessment only evaluates Proposed Project-related greenhouse gas emissions, as outlined in the Application Information Requirements. The potential effects of a changing climate on the Proposed Project are discussed in this section, identifying how potential changes in climate may affect the infrastructure associated with the Proposed Project as required by the Application Information Requirements, but are not evaluated as part of the effects assessment.

While the projected climate normals for the 2050s and the 2080s show similar trends than presented in the current climate trends (i.e., warmer, although wetter compared to drier in the historical trends (Figure 5.8-2)), 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 Proposed Project. A qualitative assessment of how the changing climate may affect Proposed Project aspects has been completed by identifying interactions between the proposed infrastructure and selected climate factors. Given the coastal location of the Proposed Project, how potential future sea level rise as a result of changing climate may affect the Proposed Project has also been considered.

5.8.5.1 Project Specific Climate Factors

Based on the climate parameters and climate data analyzed, climate factors have been developed to further analyse the potential climate infrastructure interactions for the Proposed Project region. The climate factors include changes to rainfall, 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 5.8.4.3.6. 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 5.8-7.

Table 5.8-7: 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.
	Amount of rain	Increasing	An increase is projected for the amount of rain (Canadian Council of Ministers of the Environment, 2003).
			Total annual precipitation will increase but precipitation in the key seasons may decrease and the intensity of rain may increase (Canadian Council of Ministers of the Environment, 2003; Lemmen et. al., 2008)

Climate Factor Description		Trend	Comments on Future Trends
			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	High temperatures	Increasing	The multi-model ensemble suggests temperatures are increasing, leading to the possibility for higher temperatures.
	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.
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., 2008) and an increase in winter flooding (Parry et. al., 2007).

5.8.5.2 *Future Sea-Level Rise*

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 Proposed Project is located on the shore of Howe Sound, therefore changes in sea level and coastal erosion dynamics have the potential to affect the Proposed 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 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 cm and a high predicted eustatic sea-level rise of 100 ± 30 cm. The tide gauge closest to the Proposed Project, where sea-level predictions were made in the study, was Point Atkinson (49.333° N 123.250° W), located approximately 30 km south-southeast of the Proposed Project (shown on Figure 5.8-1). The predicted RSL_{2100} using the mean sea-level rise was 18 cm, with a possible range of 6 to 30 cm. The predicted RSL_{2100} using the high predicted sea-level rise was 88 cm, with a possible range of 57 to 118 cm.

Since the Proposed Project is expected to be completed by 2035 it is expected that rising sea levels of this amount will have little direct impact on the Proposed Project operation phase. The Proposed Project closure plan consists of removing surface infrastructure and site reclamation including a ground and surface water-fed lake (the pit lake), and therefore it is expected that the predicted rising sea level will have little impact on Proposed Project closure.

5.8.5.3 Potential Climate Infrastructure Interactions

With the exception of the long term management of the Proposed Project Area during the post-closure/reclamation phase, most facilities and infrastructure associated with the Proposed Project have an estimated operational lifetime of around 16 years. Table 5.8-8 presents a climate risk matrix which provides a summary of the potential climate-facility/infrastructure interactions by physical work or activity associated with the Proposed Project.

Table 5.8-8: Climate Risk Matrix

Activity Description	Description of Potential Interaction with Climate Change
Construction	
All activities in the construction phase	The timescale of activities is too short (approximately two years), and will occur in the near future (2016-2017) therefore considerable climate-infrastructure interaction impacts are not expected.
Operations	
All activities in the operation phase	The timescale of activities means that the operational phase is predicted to be completed by 2034 or 2035, which is considered too short for considerable climate-infrastructure interaction impacts.
Reclamation and Closure	
Removal of land based Proposed Project infrastructure	The timescale of activities means that the closure/reclamation phase is predicted to be completed in 2034 or 2035, which is considered too short for considerable climate-infrastructure interaction impacts.
Removal of marine based infrastructure	
Final remediation works including vegetation and landscaping	
Final completion of the aggregate pit lake and landscaping	The predicted future changes in temperature, rain and mixed events (e.g., storms) may impact the rate at which the aggregate pit refills with water. Changes to climate may impact species found in the area.

5.8.5.4 Project Considerations due to Changing Climate

The influence of a changing climate on Proposed Project infrastructure was evaluated through an understanding of the current climate at the Proposed Project site, and how the climate is projected to change in the future. The effect of the effect of the changing climate on Proposed Project infrastructure was then evaluated using the climate risk matrix.

Only Proposed Project components during the reclamation and closure phase could be affected as climate change will take many years to occur. For example, future changes in temperature, rainfall and storm events may impact the rate at which the aggregate pit refill with water.

The Proposed Project will consider the potential for climate factors such as extreme weather events, increased precipitation and temperatures, while designing Proposed Project infrastructure to minimize potential impacts of a changing climate on the Proposed Project.

5.8.6 Effects Assessment

The effects assessment considers the potential effect of GHG emissions released from the Proposed Project to influence climate change. As discussed above the potential effect of changing climate on the Proposed Project is not carried through the effects assessment because it is not a potential impact of the Proposed Project.

5.8.6.1 Potential Project Related Effects

Proposed Project activities that emit GHG emissions are considered to have a potential effect. Only one sub-component has been identified under the GHG and climate change Valued Component (VC): Proposed Project GHG emissions. The following two potential effects related to GHG and climate change have been identified and assessed:

- The comparison of Proposed Project GHG emissions to sectorial, provincial, and federal targets and norms; and
- The effect of Proposed Project GHG emissions on climate change.

The following sections describe the potential effects further.

5.8.6.1.1 Description of Potential Effects of Project GHG Emissions

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

The Proposed Project will have sources that produce the following three GHGs: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The emissions of these GHGs are expressed as tonnes 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 Proposed Project GHG emissions are accepted values of 1, 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 assessment, and associated quantification methodology are summarized in Table 5.8-9. Further detail on the quantification methodology is provided in Volume 4, Part G – Section 22.0: Appendix 5.8-B.

Table 5.8-9: Summary of Greenhouse Gas Emission Sources and Quantification Methodology

Source	Source Category	Scope	Methodology
Welding	On-site stationary fuel combustion sources (Scope 1)	Scope 1	WCI.23 (WCI 2010)
On-Site Vehicles	On-site mobile fuel combustion sources (Scope 1)	Scope 1	WCI.280 (WCI 2010)
Electricity Consumption	Electricity Purchases (Scope 2)	Scope 2	BC Hydro emission factor taken from 2014 BC Best Practices Methodology for Quantifying Greenhouse Gas Emissions (BC MoE 2014b)
Barge Tugboat (maneuvering in the vicinity of the Proposed Project)	Marine Vessel fuel combustion sources (Scope 3)	Scope 3	2005-2006 BC Ocean-Going Vessel Emissions Inventory (The Chamber of Shipping 2007).
Barge Tugboat (travel between the Proposed Project and the Langley BURNCO facility)	Marine Vessel fuel combustion sources (Scope 3)	Scope 3	WCI.280 (WCI 2010)
Land Clearing	Other indirect emissions (Scope 3)	Scope 3	BC Ministry of Forests (Dymond 2014)

5.8.6.1.1.1 Direct GHG Emissions

The estimated direct GHGs from the Proposed Project are presented in Table 5.8-10. The direct emissions consist of on-site vehicle emissions and emissions associated with welding activities. Detailed supporting calculations are provided in Volume 4, Part G – Section 22.0: Appendix 5.8-B.

Table 5.8-10: Direct Proposed Project GHG Emissions from Significant Sources for Maximum Annual Production Rate

Activity	Emissions (tonnes)				
	CO_2	CH_4	N_2O	CO_2e	% of Proposed Project Total
Welding	11.5	0.000182	0.000821	11.7	0.2
On-site Vehicles	1916	0.0957	0.288	2004	38.5
Direct Emissions Total	**1928**	**0.0959**	**0.289**	**2016**	**38.7**

5.8.6.1.1.2 Indirect GHG Emissions

The indirect emissions for the Proposed Project represent emissions associated with purchased electricity, land clearing and marine vessels. The estimated indirect GHGs from the Proposed Project are presented in Table 5.8-11.

The GHG emissions from purchased electricity in CO_2e are calculated based on the GHG consumption intensity factor within the 2014 BC Best Practices Methodology for Quantifying GHG Emissions (BC MoE 2014b). 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 consumption intensity factor is presented in units of CO_2e only, and is not provided for the individual GHGs such as CO_2, CH_4 and N_2O. The GHG emissions from purchased electricity were based on the expected power consumption of the Proposed Project provided by BURNCO. It was assumed that the expected power consumption applied to hours of the day when the Proposed Project will be operational, and that 10% of the operational power consumption level will apply to non-operational hours.

Changes in land use can also be a source of indirect GHG emissions that the IPCC and BC MoE identify for inclusion in emission inventories. The Proposed Project involves land clearing to make way for infrastructure, as well as land clearing for mineral extraction and associated conversion of the land to a lake. These activities will remove a quantity of carbon from storage.

The GHG emissions associated with land clearing have been calculated based on the following assumptions:

- 80% of the existing land area comprises grassland;
- 20% of the existing land area comprises forest land; and
- Land clearing will occur progressively throughout the Proposed Project, and therefore the maximum area to be cleared in one year was used in the calculations (6.9 ha).

The indirect emissions associated with land clearing of forest land (deforestation) were calculated based on equations and emission factors provided by the MoE (BC MoE 2014a). The indirect emissions associated with clearing of grassland were calculated based on equations and emission factors presented in Chapter 6 of Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006).

Emissions associated with the barge tugboat were calculated using the methodology in 2005-2006 BC Ocean-Going Vessel Emissions Inventory (The Chamber of Shipping 2007). Emissions were calculated based on engine power, duration of travel, and fuel-specific emission factors. Vessel maneuvering in the vicinity of the Proposed Project and vessel travel (underway) between the Proposed Project and the BURNCO facility in Langley were both considered in the assessment. Further details on supporting calculations are provided in Volume 4, Part G – Section 22.0: Appendix 5.8-B.

Table 5.8-11: Indirect Proposed Project GHG Emissions from Significant Sources for Maximum Annual Production Rate

Activity	Emissions (tonnes)				
	CO_2	CH_4	N_2O	CO_2e	% of Proposed Project Total
Purchased Electricity	—	—	—	37.2	0.7
Land Clearing	—	—	—	326	6.2
Marine Vessels	2801	0.352	0.0810	2834	54.4
Indirect Emissions Total	—	—	—	**3197**	**61.3**

5.8.6.2 Mitigation

This section provides a description of the proposed in-design mitigation measures specifically related to Proposed Project effects on the VC for GHG and climate change, GHG emissions. The proposed GHG mitigation measure around using electricity instead of fossil fuels to power the main processing operations is consistent with specific actions within the Sea-to-Sky Air Quality Management Plan (SSAQMP) (Sea to Sky Clean Air Society 2007). More specifically, they are consistent with Action 13 of the SSAQMP to promote the use of non-fossil fuel energy sources through the airshed. The measures proposed to reduce GHG emissions are presented in Table 5.8-12.

The mitigation strategy outlined below forms the basis for the commitments that the Proposed Project is making with respect to climate change. A detailed list of all commitments of the Proposed Project are provided in Volume 3, Part F – Section 19.

Table 5.8-12: Identified Mitigation Measures: Climate Change

Potential Effect	Mitigation	Anticipated Effectiveness
GHG Emissions from On-Site gravel extraction, handling, transport around site, processing operations and barge loading	Using electrically as a power source instead of diesel vehicles and diesel stationary combustion. Major extraction and processing equipment such as the dredger, screens and crusher will be powered by electricity. Extracted and processed material will be transferred around the Proposed Project site using a network of conveyors instead of using haul vehicles	Highly Effective - use of electricity as a power source will replace diesel combustion which has a much higher GHG emission intensity
GHG Emissions from On-Site Vehicles	Ongoing routine maintenance of vehicles	Moderately Effective – well maintained vehicles will result in increased fuel efficiency and therefore result in less GHG emissions
GHG Emissions from On-Site Vehicles	Minimize vehicle idling	Highly Effective - avoiding idling will directly avoid diesel/gas combustion
GHG Emissions from Barge Tugboat	Minimize tug idling	Highly Effective - avoiding idling will directly avoid diesel/gas combustion

5.8.7 Residual Effects Assessment

The potential residual effects of the Proposed 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 Proposed Project-related GHG emissions on provincial and national levels and future targets, and the potential effect of Proposed Project-related GHG emissions on climate change.

5.8.7.1 Comparison of Proposed Project GHG Emissions to BC, Canadian and Global Emissions

The residual effect of Proposed Project-related GHG emissions on provincial and national levels based on the Proposed Project's maximum year is assessed through the comparison of currently available emission totals for BC and Canada.

A comparison of the predicted GHG emissions from the Proposed Project to the annual GHG emissions for BC, Canada and globally is provided in Table 5.8-13.

Table 5.8-13: Comparison of Proposed Project GHG emissions to Canadian emissions

Source	Annual GHG Emissions (kt CO_2e/yr)	Proposed Project Total as a Relative Percentage
Stationary Fuel Consumption	0.01	—
Mobile Fuel Consumption	2.00	
Marine Vessels	2.83	
Electricity Consumption	0.04	
Land Clearing	0.33	
Proposed Project Total	**5.21**	
BC (2013)[1]	64,000	0.0081%
BC (2013 Mining and Upstream Oil and Gas Production total)[2]	8,770	0.059%
Canada (2013) [2]	726,000	0.00072%
Canada (2013 Mining and Upstream Oil and Gas Production total) [2]	93,600	0.0056%
Global (2012)[3]	44,815,540	0.00001%

Sources:
[1]BC MoE 2016
[2]Environment Canada 2015c
[3]WRI 2016

As discussed in Section 5.8.3.3.3, the only applicable residual effects criterion is magnitude. Using the effects criteria presented in Table 5.8-3, the magnitude of the GHG emissions on sector, provincial and national levels are negligible during the Proposed Project as the GHG contribution is less than 1% of the Canadian GHG emissions and less than 0.001% of the global emissions. Therefore the significance of the residual effect is considered negligible-not significant. The Proposed Project will likely result in GHG emissions, therefore, the likelihood of effects associated with the Proposed Project GHG emissions is considered high.

When considering the effects of Proposed Project GHG emissions, the level of confidence is considered high and the level of risk is considered low. When calculating the Proposed Project GHG emissions, conservative assumptions were used in the emission quantification, such as the maximum area of land to be cleared in a single year was used in calculating GHG emissions due to land clearing. This conservative approach yields an estimate of the maximum GHG emissions from the Proposed Project. In reality, the Proposed Project GHG emissions will likely be lower than those calculated. Likewise, the risk is considered low if a conservative estimate of the Proposed Project-related GHG emissions produces residual adverse effects that are considered negligible-not significant.

5.8.7.2 Comparison of Proposed Project GHG Emissions to Global Emissions

To evaluate the potential effect of Proposed 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 5.8-14 illustrate how the relatively minor increase in global emissions associated with the Proposed Project would correspond to a change in climate that is unlikely to be measurable.

Table 5.8-14 Comparison of Proposed Project GHG Emissions to Changes used in the IPCC models

Parameter	SRES Scenario A1B	SRES Scenario A2	SRES Scenario B1	Proposed Project
Change in global GHG emissions relative to the 2010 global baseline [a]	+28.7%	+86.0%	+2.0%	+0.00002%
Change in annual temperature for the 2040 to 2069 horizon [b]	+1.5°C			Cannot be measured [c]
Change in annual precipitation for the 2040 to 2069 horizon [b]	+41 mm[equiv]			Cannot be measured [d]

Notes:

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

b Changes were calculated as the difference between the baseline and scenario forecasts for the 2040 to 2069 time horizon.

c On the basis of proportionality, the GHG emissions from the Proposed Project could represent an increase of less than 1×10^{-6} °C in the annual temperature. Such a change would not be measurable.

d On the basis of proportionality, the GHG emissions from the Proposed Project could represent an increase of less than 2×10^{-7} mm/day in the annual precipitation. Such a change would not be measurable.

Using the effects criteria presented in Table 5.8-3, the magnitude of the effect of Proposed Project-related GHG emissions on climate change is negligible and therefore the significance of the residual effect is considered negligible. The Proposed 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 Proposed Project GHG emissions is considered high.

When considering the effects of Proposed Project GHG emissions on climate change, the level of confidence is considered high and the level of risk is considered low. The Proposed 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 the significance is considered negligible-not significant.

5.8.8 Cumulative Effects

VCs that were determined to have not-significant or significant residual effects were carried forward in the cumulative effects assessment. All potential Project-related residual adverse effects were determined to be negligible – not significant and requiring no further consideration. No residual effects were carried forward to a cumulative effects assessment. Additional information on the methods used for the cumulative effects assessment is provided in Volume 2, Part B – Section 4.5.5. The text has been revised to include this additional information.

5.8.9 Conclusions

The consideration of climate change as reported herein was carried out in accordance with the general guidance document for practitioners prepared by the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA 2003). The evaluation answered the following questions:

- What is the current climate in the region where the Proposed Project is proposed, and how has this historic climate been changing?
- How will the climate in the region where the Proposed Project is proposed change in the future?
- How could the projected changes in climate interact with the infrastructure of the Proposed Project?
- What are the GHG emissions associated with the Proposed Project, how do they compare to provincial, national and international totals, and what is the potential for them to affect climate change?

The current climate for the Proposed Project region was described using data from the Gibson's Gower Point meteorological station for the period 1971 to 2010. The data showed that the historic climate in this region has been increasing in temperature and precipitation levels have generally been decreasing.

The climate projections for the Proposed Project region were based on PCIC's Regional Analysis tool. The tool uses the results of more than 15 GCMs and provides maps, plots and data describing future climate conditions for regions throughout BC. The future climate at the Proposed Project location was forecast to have higher temperatures and generally increased precipitation levels.

Using the historical climate trends and the future climate projections, the effects of climate on the Proposed Project were analysed by developing a climate risk matrix to identifying potential climate infrastructure interactions. Based on this assessment it can be concluded that the effects of a potentially changing climate on the Proposed Project are relatively insignificant.

The direct and indirect GHG emissions associated with the Proposed Project were quantified and compared to the current provincial, national sector and federal totals. The conservative estimate of Proposed Project GHG emissions is only 0.0082% of the BC emissions, 0.00072% of the total national emissions and 0.00001% of global emissions. The contribution of Proposed Project GHG emissions to the provincial and federal totals are considered negligible. Based on the calculation methodology for the Proposed Project GHG emissions, the confidence level is considered to be high. Therefore, the influence of the Proposed Project GHG emissions on totals is considered to be negligible-not significant.

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

Despite the negligible effect on climate, the Proposed Project includes in-design mitigation measures that will reduce GHG emissions that are consistent with specific actions within the Sea-to-Sky Air Quality Management Plan (SSAQMP) (Sea to Sky Clean Air Society 2007).

LEGEND

- Gibsons Gower Point
- Point Atkinson
- Project Area
- Park / Protected Area
- Sensitive Environmental Area
- Vegetation
- Indian Reserve
- Residential Area
- Waterbody
- Highway
- Road
- Resource Road
- Railway
- Ferry
- Watercourse
- Contour (250m)

5,000 0 5,000

SCALE 1:150,000 METRES

PROJECT

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

TITLE

CLIMATE STATIONS AND PROPOSED PROJECT LOCATION

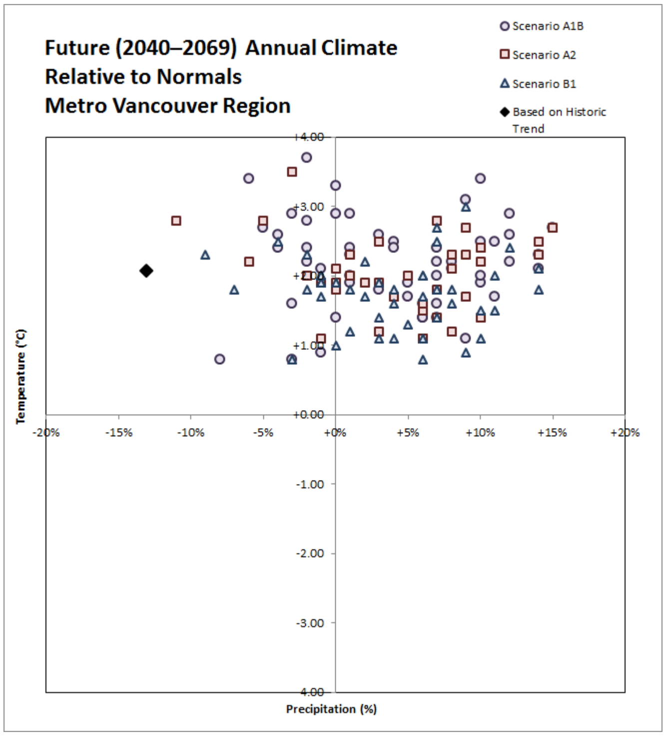
Golder Associates

PROJECT NO. 11-1422-0046			PHASE NO. 4700	
DESIGN	SD	11 Jun. 2013	SCALE AS SHOWN	REV. 0
GIS	DL	29 Mar. 2016		
CHECK	SD	29 Mar. 2016	**FIGURE 5.8-1**	
REVIEW	RW	29 Mar. 2016		

REFERENCE

Parks/protected areas and sensitive areas from the Province of British Columbia. Elevation and indian reserves from Geobase. Base data from CanVec. Projection: UTM Zone 10 Datum: NAD 83

Path: X:\Project Data\BC\McNab\Figures\MXD\Air Quality\EA\BURNCO_AIR_Figure_5_8-1_Project_Location_and_Climate_Stations.mxd



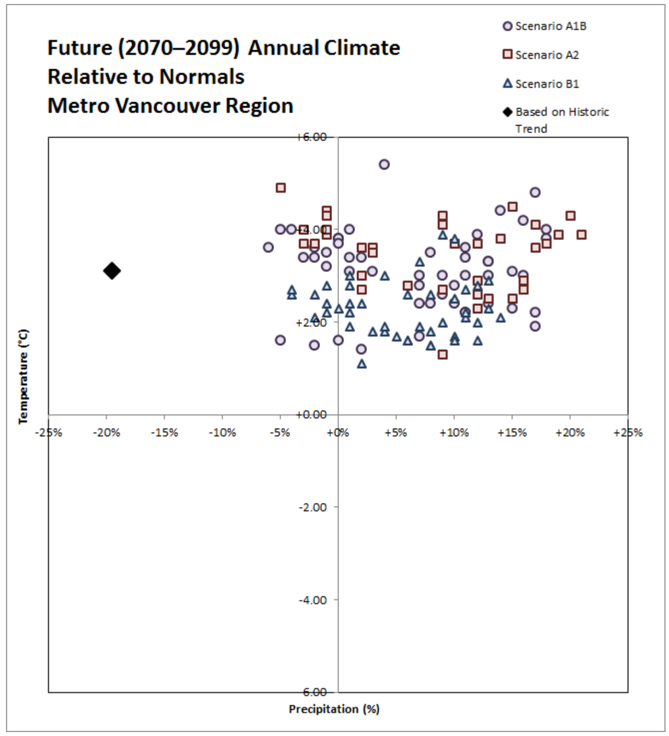


Figure 5.8-2: Scatter Plots Showing the 2050s and 2080s Annual Projections for the Proposed Project Area