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# Workforce Air Quality Health Plan

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# 1. Introduction

## 1.1. Purpose

LNG Canada Development Inc. (LNG Canada) is committed to avoiding, reducing or controlling adverse effects to the environment occurring as a result of the LNG Canada Export Terminal (the Project) in Kitimat, British Columbia (BC), Canada, in the traditional territory of the Haisla Nation. To help ensure this, a series of Environmental Management Plans related to specific aspects of the Project have been developed to avoid, manage or mitigate potential environmental effects.

The Workforce Air Quality Health Plan is developed to comply with Condition 19, Human Health – Workforce Accommodation Centre, of the Environmental Assessment Certificate (EAC) for the Project (E15-01).

JGC Fluor BC LNG Joint Venture (JFJV) is providing Engineering, Procurement, and Construction (EPC) services to the Project. JFJV has engaged Stantec Consulting Ltd. (Stantec) to support the development of this Workforce Air Quality Health Plan (herein "Plan"), as subject matter experts for air quality and human health risk.

A list of acronyms used in this Plan is provided in Appendix A.

## 1.2. Objective

The objective of this Plan is to:

- Present baseline data and other findings from the Human Health Risk Assessment (HHRA) completed by LNG Canada (supported by Stantec) regarding the potential effects of air quality on workers residing at the workforce accommodation centre (WAC), also known as Cedar Valley Lodge (CVL) (which will also apply to those working within CVL).
- Identify mitigation measures to reduce the potential risks posed by air emissions to the health of residents of the CVL to an acceptable level.
- Identify measures to monitor and report on the effectiveness of the mitigations set out in the Plan.
- Provide an adaptive management plan, which includes the development of additional and/ or alternative mitigation measures to address the effects of air quality on the health of residents of the CVL, as required.
- Act as a reference document for Project personnel when planning or conducting specific Project activities.

Revision 0 of this Plan was approved by the BC Environmental Assessment Office (EAO) on February 25, 2020. Herein contains the updates to the notification system, per the direction of EAO to LNG Canada on June 8, 2022.

## 1.3. Exclusions

This Plan does not:

- Absolve Project Contractors from undertaking their own due diligence in relation to environmental requirements for air quality associated with the activity being undertaken.
- Replace design standards or best management practices specific to an engineering discipline. Rather, the intent of this Plan is to complement the design standards and best practices. Should a conflict arise, the most stringent requirement out of the design standard, best management practice, or this Plan should prevail.
- Apply to areas outside of CVL (shown as the "Certified Accomodation Area", in Figure 1); as the work-site is regulated under *Workers Compensaton Act* and *Occupational Health and Safety Regulation* (B.C. Reg 296/97) (under WorkSafeBC jurisidiction).
- Include health management requirements for the Project; as these are addressed in other Project documents.

- Provide indepth details on the environmental management requirements related to air quality; as these are addressed in other Project documents.

## 1.4. Project Description

The purpose of the Project is to convert natural gas into liquefied natural gas (LNG) and contribute to the development of an LNG export industry in BC, Canada. The Project site covers an area of approximately 430 hectares (ha) in the District of Kitimat in northwest BC (refer to Figure 1).

Construction of the Project is scheduled to occur in two phases; Phase 1 includes construction of the first two LNG Trains (Trains 1 and 2), utilities, LNG Storage Tank 1 and shipping Berth 2. Phase 2 would include up to two additional LNG Trains, LNG Storage Tank 2 and shipping Berth 1 (if sanctioned by LNG Canada).

### 1.4.1. Scope of Work

The focus of this Plan is the health of the Project workforce when in residence (at CVL), as it relates to exposure to the local air quality. This Plan will also apply to other personnel located within CVL (i.e. those operating CVL facilities). CVL is located west of the LNG facility and stockpile area, and north of the temporary construction facilities and neighboring industrial facility (refer to Figure 1; illustrated by the "Certified Accommodation Area").

It is anticipated that CVL will be operational for approximately ten (10) years (2020 to 2024 for Phase 1; 2025 to 2030 for Phase 2). CVL will house a workforce population of 4,500 people at any given time during Phase 1 or Phase 2 construction, with the potential to expand to 7,500 workers.

During Phase 1 construction, the workforce could be exposed to atmospheric contaminants from existing sources and Phase 1 construction activities. During Phase 2, the construction workforce could be exposed to atmospheric contaminants from existing sources, Phase 1 operations and Phase 2 construction activities.

A HHRA was undertaken to evaluate the potential risk to off-duty workers at CVL associated with inhalation exposures of contaminants of potential concern (COPC) released to ambient air from operations at the Project, existing emission sources, diesel emissions and fugitive dust emissions on the Haul Road and fugitive dust emissions from the permanent soil stockpile. The HHRA also assessed other exposure pathways, such as dermal contact and ingestion of soils at CVL. A summary of HHRA and findings are provided in Section 5. The outcomes from the HHRA are the basis of the mitigation measures identified in Section 6; and monitoring program presented in Section 7.


**Figure 1: Project Site (EAC Amendment #4)**

## 1.5. Environmental Aspect Definition

The main focus of this Plan is on local air quality as it relates to the personnel residing in CVL. The COPC from construction activities, existing facilities, and LNG Canada Phase 1 facility operations that the workforce may be exposed to (and hence were considered in the HHRA) were:

- Sulphur dioxide ($SO_2$)
- Nitrogen dioxide ($NO_2$)
- Respirable particulate matter ($PM_{2.5}$)
- Diesel Particulate Matter (DPM)
- Metals
- Volatile organic compounds (VOC)
- Polycyclic aromatic hydrocarbons (PAH)
- Hydrogen fluoride (HF)

Construction of the Project will result in direct emissions (e.g. heavy equipment exhaust) and fugitive emissions (e.g. dust from the soil stockpile and roads).

# 2. Related Documents

Table 1 contains a list of all the Project documents referred to within this Plan. Any changes to these documents may need to be reflected in this Plan, as applicable.

**Table 1: Related Project Documents**

| Document Name | Document Number |
|---|---|
| Air Quality Management Plan | L001-09800-HE-7180-1904 |
| Community Impact Management Plan | L001-00000-AA-5880-2101 |
| Construction Environmental Management Plan | L001-09800-HE-7180-1901 |
| Health Services and Medical Emergency Response Strategy | C000-000-HH-5798-0002 |
| Sediment and Erosion Control Plan | L001-09800-HE-7180-1917 |

# 3. Roles and Responsibilities

Every worker is responsible for the protection of the environment, and to accept responsibility for their own safety and fitness to work, and the safety of others. This section outlines the key roles and responsibilities related to the implementation of this Plan.

## 3.1. Workforce

- Attend orientation prior to the commencement of work.
- “Opt-into” notifications related to air quality where they choose to do so (applicable for Low and Moderate Health Risk Alerts, refer to Table 5 for further details).
- Subcontractors responsible for ensuring all their workers are informed and are implementing the health, safety and environmental (HSE) requirements for the Project; including addressing HSE topics at tail-gate meetings.

## 3.2. JFJV

- Provide EPC services to the Project, including overseeing construction and operation of CVL.
- Ensure compliance with applicable regulatory and permit requirements.
- Lead the orientiation program for all workers, including development of content.
- Ensure that all workers and subcontractors are aware of and comply with applicable HSE, socioeconomic and regulatory requirements, as well as the HSE expectations, commitments, obligations and requirements for the Project.
- Provide on-site medical staff for the workforce.
- Assign personnel responsible for overseeing the implementation of notifications related to this Plan.
- Involved in the establishment and operation of the on-site ambient air quality monitoring station.
- Share information with Northern Health Authority for non-emergency events.
- Develop and undertake annual reviews of management plans associated with the EAC.
- Participate in quarterly social management roundtable (SMR) meetings, which includes discussion on housing and accommodation, and community health.
- Report agreed to Project metrics to LNG Canada on monthly basis.
- Lead the Community Feedback Process.
- Advise LNG Canada on HSE matters related to the Project.

## 3.3. LNG Canada

- Meet regularly with JFJV to discuss Project progress, while higlighting and discussing potential environmental and health issues.
- Lead the SMR meetings, which includes discussion on housing and accommodation, and community health.
- Involved in the establishment and operation of the on-site ambient air quality monitoring station.
- Implementation of assurance programs for compliance.
- Provide appropriate representation in the Kitimat Air Quality Roundtable, once established.

## 3.4. Northern Health Authority

- Participate in SMR meetings for community health.
- Engage with JFJV and LNG Canada related to information sharing for non-emergency events.
- Appoint representative to be the focal point for information sharing.
- Be an external resource for supporting health issues associated with the workforce.
- Have the ability to "Opt-In" to the Moderate Health Risk Alert notifications from the on-site ambient air quality monitoring station (refer to Table 5 for further details; and Section 7.5.2 for protocol).

## 3.5. Ministry of Environment and Climate Change Strategy

- Review air quality monitoring data provided by JFJV in the semi-annual reports (refer to Table 6 for further details).
- Advise LNG Canada and JFJV on changes to the Kitimat $SO_2$ Alert Pilot Program.
- Have the ability to "Opt-In" to the Moderate Health Risk Alert notifications from the on-site ambient air quality monitoring station (refer to Table 5 for further details).

# 4. Regulatory, Project and Stakeholder Requirements

## 4.1. Introduction

The Project is to be designed, constructed and operated in alignment with the following key considerations:

- Compliance with the Approval conditions that are documented in the Permits
- Compliance with the Regulatory requirements
- Alignment to the Project Stakeholder Commitments

Information on each of these considerations is provided in the following section.

## 4.2. Project Approvals and Conditions

There are various approvals and permits that have been obtained or will be obtained throughout the Project. The key approval condition relevant to this Plan is EAC Condition 19 that states:

*Prior to developing a workforce air quality health plan the Holder must, in consultation with MOH, MOE and WorkSafe BC, complete a human health risk assessment regarding the potential effects of air quality on workers residing at the workforce accommodation centre, to the satisfaction of EAO. The assessment must consider all criteria air contaminants assessed in the Holder's Application for an EAC.*

*The Holder must develop, in consultation with MOE[i], MOH, and OGC[ii], a workforce air quality health plan that must:*

- Include the results of baseline data and the human health risk assessment to support monitoring;
- Identify mitigation measures to reduce the risks posed by air emissions to the health of residents of the workforce accommodation centre to an acceptable level;
- Include measures to monitor and report on the effectiveness of the mitigation set out in the plan; and
- Provide an adaptive management plan, which includes the development of additional and/or alternative mitigation measures to address the effects of air quality on the health of residents of the workforce accommodation centre, as required.

*The Holder must provide the plan to EAO no less than 60 days prior to the Holder's planned date to establish the workforce accommodation centre. The Holder must not establish the workforce accommodation centre until the plan is approved by EAO. Once approved, the Holder must provide the final plan to MOE and MOH. The Holder must implement the plan to the satisfaction of EAO.*

## 4.3. Regulatory Framework

Regulations for development and operation of workforce accommodations to support industrial development in Canada fall under federal, provincial and municipal jurisdictions.

The following section outlines the roles of the four jurisdictions plus reference to supporting industry best practice and guidelines.

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[i] Now known as the BC Ministry of Environment and Climate Change Strategy (ENV)
[ii] Now known as the BC Energy Regulator (BCER)

### 4.3.1. International

Global issues are recognized through International Law; therefore, many legally binding International Agreements (through treaties, conventions, declarations, protocols, etc.) have been developed. These agreements cover a range of environmental issues, including marine, atmospheric pollution and biodiversity protection. This Plan does not consider shipping or marine related activities.

No International Agreements have been identified in this Plan related to the health of the Project workforce when housed at CVL as it relates to exposure to the local air quality.

### 4.3.2. Federal

The Federal government has authority over public crown land, which includes national parks, Federal wildlife reserves, navigable waters, and First Nations Reserves. Federal legislation and regulations regulate the activities of all Canadians on Federal lands. Health Canada is "*responsible for helping Canadians maintain and improve their health. It ensures that high-quality health services are accessible, and works to reduce health risks*" (Health Canada, 2019). Health Canada has guidance related to undertaking HHRA and toxicity reference values (TRVs).

Canadian Ambient Air Quality Standards (CAAQS) were established under the *Canadian Environmental Protection Act, 1999;* and are the driver for air quality management across Canada (Canadian Council of Ministers of the Environment (CCME), 2019). CAAQS have been developed for $PM_{2.5}$, ozone ($O_3$), $SO_2$ and $NO_2$. CAAQS are reviewed every five years to ensure they are adequate to protect human health and the environment.

### 4.3.3. Provincial

Although the Federal government provides an overview on how to enhance and preserve the environment and human health, it delegates the responsibility to each province to protect its local environment and address specific issues that may negatively affect it.

The Project is located in the province of BC. The BC Ministry of Health (MOH) has "*overall responsibility for ensuring that quality, appropriate, cost effective and timely health services are available for all British Columbians*" (BC MOH, 2019). BC has five regional health authorities; Northern Health Authority is the provider for the northern half of BC including Kitimat. The *Public Health Act, Industrial Camps Regulation (BC Reg. 70/2012)* regulates the construction and operational requirements for industrial camps. The only requirement specific to workforce health related to air quality is in Part 2 (Construction and Facilities), Division 1 (Location and Construction), Section 6 (Ventilation): "An operator must ensure that rooms are sufficiently ventilated to prevent the accumulation of condensation and disagreeable odours".

The BC Ministry of Environment and Climate Change Strategy (ENV) uses a suite of ambient air quality criteria that has been developed provincially and nationally to inform decisions in the management of air contaminants (BC ENV, 2021). The BC ambient air quality objectives (AQOs) are used to gauge current and historical air quality and guide decisions on environmental impact assessments and authorizations. The BC ENV have stated that the BC AQOs are to be used to characterize air quality and potential air quality impacts in areas where people live or where other sensitive receptors are likely to be found (BC ENV, 2016). These objectives (Table 2) are collectively referred to as "regulatory criteria".

**Table 2: Regulatory Criteria**

| Criteria Air Contaminants (CAC) | Averaging Interval | Air Quality Objective ($\mu g/m^3$) | Notes |
|---|---|---|---|
| $SO_2$ | 1-hour | 183 | Based on 3-year average of the annual 99th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 99th percentile (the fourth highest) of those 365 values for each year, then average the three annual values. |
| | Annual | 13 | Based on the average of 1-hour concentrations averaged over one year. |
| $NO_2$ | 1-hour | 113 | Based on 3-year average of the annual 98th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 98th percentile (the eighth highest) of those 365 values for each year, then average the three annual values. |
| | Annual | 32 | Based on the average of all 1-hour average concentrations over a single calendar year. |
| $PM_{2.5}$ | 24-hour | 25 | Based on annual 98th percentile of daily average, average over one year |
| | Annual | 8 | Annual average, average over one year. |
| Note: There are also BC AQO for formaldehyde, $O_3$, Particulate Matter with an aerodynamic diameter of 10 micrometers or less ($PM_{10}$), total suspended particulates, carbon monoxide (CO) and total reduced sulphur. Refer to the Information Sheet published by BC ENV for further information on those components (BC ENV, 2021). | | | |

In response to concerns by the public and recommendations from the Environmental Appeal Board, the BC ENV has initiated a pilot project in Kitimat to alert the public of periods of elevated $SO_2$ levels (BC ENV, 2019). BC ENV has stated that "*the health guidance was developed in consultation with the BC Centre for Disease Control, the Ministry of Health and Northern Health Authority. Different sets of health advice were established for moderate (36-70 ppb* [parts per billion]*), high (71-185 ppb) and very high (>185 ppb) levels of $SO_2$. The health advice was based on guidance established by Health Canada for the Air Quality Health Index and by the Island Health Authority in its Health Risk Guide developed for the James Bay Sulphur Dioxide Monitoring Program*" (BC ENV, 2019).

The James Bay Sulphur Dioxide Monitoring Program was developed as air quality monitoring within Victoria's Inner Harbour had found relatively high, short-term peaks of $SO_2$ may occur in association with the cruise ships at Ogden Point (Island Health, 2019).

### 4.3.4. Municipal

The purpose of the municipal governments is to provide governance, services, and facilities that are necessary or desirable, to develop and maintain safe and viable communities. These powers are delegated through the provincial government (BC).

The Project is located in the District of Kitimat, which is a member municipality of the Regional District of Kitimat-Stikine government. The Kitimat Municipal Code and Kitimat Official Community Plan include the land-use planning and building requirements for developments within Kitimat. The District of Kitimat is responsible for issuing Burning Permits (for open burning); and have committed to working with the province for issues pertaining to air quality and health, given the concerns related to air quality in the community (i.e. Kitimat Terrace Clean Air Coalition).

## 4.4. Commitments, Statements and Considerations

Commitments, statements and considerations have been made to external stakeholders as part of the regulatory approval process for the Project as well as community engagements. Commitments are often sourced from EAC, approvals, permit conditions, contractual agreements with Aboriginal Groups, responses to statements of concern from stakeholders, and minutes from public meetings.

Appendix B identifies the commitments, statements and considerations relevant to workforce health related to air quality as part of the Environment Assessment (EA) application. Refer to the actual Project Stakeholder Commitments Register for the complete list of commitments.

# 5. Human Health Risk Assessment Summary

This HHRA Summary is comprised of three sections:

- Section 5.1 describes the air quality work that was performed in support of the HHRA, and refers the reader to the relevant documents for first-hand information.
- Section 5.2 summarizes the work done and findings regarding the potential human health risks associated with exposures to contaminants in the air and soil, for off-duty workers housed at CVL (which will also apply to those operating within CVL).
- Section 5.3 summarizes the correlation from outoor to indoor air quality.

## 5.1. Summary of Construction Dispersion Modelling

To support the HHRA focused on CVL, LNG Canada engaged Stantec to complete dispersion modelling of construction-related emissions, existing emission sources, and LNG facility Phase 1 operations emissions (Stantec, 2019a).

The intent of this Plan is to document aspects of the CALPUFF dispersion modelling methodology, and other topics not covered by previous reports. It is not intended to repeat content readily available elsewhere including detailed existing or baseline air quality and climate data; emissions from existing and approved sources locally; and Project emissions and their effects. This information is available in the 2014 Air Quality Technical Data Report (Stantec, 2014) and other documents referenced herein.

General findings of the dispersion assessment are presented herein including the uncertainty in the dispersion modelling and confidence in the results. Refer to the complete report issued by Stantec for details of the emission inventory, the model methodology, and model predictions that support the HHRA (Stantec, 2019a).

This dispersion modelling follows a similar methodology employed in the Air Quality Technical Data Report filed as part of the EA Application (Stantec, 2014). It was designed to follow the requirements of the HHRA Work Scope (Stantec, 2019b) approved by the BC EAO EAC Condition 19 Working Group. The results of the Base Case modelling of existing emission sources in Kitimat is taken directly from the original work supporting the EA Application. New dispersion modelling was conducted to depict construction; many of the same input parameters employed in the original work were used in the updated modelling (refer to the complete report issued by Stantec for further details, Stantec, 2019c).

Stantec prepared a memorandum outlining the construction emission inventory, which described dispersion modelling scenarios aligned with Project Phases 1 and 2 (Stantec, 2019c). They are:

- Phase 1 Construction: This phase overlaps with maximum material handling and fugitive dust generation during peak construction activity before LNG facility Phase 1 start-up. Construction modelling includes both direct emissions (e.g. heavy equipment exhaust) and fugitive emissions (e.g. dust from the soil stockpile and roads). To correctly portray emissions from these activities spatially, a number of area sources were established. They include work sites, haul and service roads, and the soil stockpile area. Phase 1 construction dispersion modelling output is added to the Base Case dispersion modelling output from the original EA. The Base Case includes emissions from existing industrial emission sources in Kitimat; the Kitimat LNG Project (not yet operational); and, emissions from all marine vessels associated with existing industry and LNG Canada.
- Phase 2 Construction: This phase overlaps with operational emissions from the LNG facility Phase 1 operations and the lesser emissions from the remainder of Phase 2 construction. Phase 2 construction dispersion modelling output is added to the Base Case dispersion modelling output from the original EA plus Phase 1 operations dispersion modelling output from the original EA.

As outlined in Section 1.5, there were eight COPC considered in the HHRA: $SO_2$, $NO_2$, $PM_{2.5}$, DPM, metals, VOC, PAH, and HF. Three COPC have BC AQO, as discussed in Section 4.3.3 (Table 2), which were addressed in the dispersion modelling.

Table 3 presents the Phase 1 construction results, both in isolation and with the addition of the Base Case predictions.

Table 4 presents the Phase 2 construction results, both in isolation and with the addition of the Base Case plus LNG Facility Phase 1 Operations predictions. Generally, the Phase 2 Construction effects are substantially less than those of Phase 1 Construction as a significant amount of site preparation activities that would support construction of Phase 2 are undertaken during Phase 1.

Results below describe the location of the "maximum" concentrations as being either "in CVL" or "in Kitimat Region". The maximums within CVL alone are pertinent to this Plan. The maximum concentrations in the Kitimat Region are included to demonstrate that maximum predicted concentrations in the Kitimat Region always exceed CVL. The locations of the maximum concentrations are indicated in Figures C-1 through C-6. (Phase 1 Construction) and C-7 through C-12 (Phase 2 Construction) in Stantec 2019a.

Table 3 shows specifically that:

- Within CVL, Phase 1 Construction predicted maximum concentrations for $SO_2$ and $NO_2$ are less than the regulatory criteria; and $PM_{2.5}$ is greater than the regulatory criteria. Addition of the Base Case substantially increases the $SO_2$ predictions to concentrations which exceed regulatory criteria, but not $NO_2$ and $PM_{2.5}$; which infers that $SO_2$ emissions are nearly all from the Base Case (i.e. a neighbouring industrial facility); where $NO_2$ and $PM_{2.5}$ are mainly from Phase 1 construction activities.
- Regionally, all the predicted maximum concentrations exceed the regulatory criteria with the exception of Phase 1 Construction $SO_2$. Addition of the Base Case substantially increases the $SO_2$ predictions to concentrations which exceed regulatory criteria, but not $NO_2$ and $PM_{2.5}$.

Table 4 shows specifically that:

- Within CVL, Phase 2 Construction predicted maximum concentrations for $SO_2$ and $NO_2$ are less than the regulatory criteria, and 24-hour $PM_{2.5}$ is greater than the regulatory criteria (the annual average is less than the regulatory criteria). Addition of the Base Case and LNG Facility Phase 1 Operations substantially increases the $SO_2$ predictions to concentrations which exceed regulatory criteria, but not $NO_2$ and $PM_{2.5}$.
- Regionally, all the predicted maximum concentrations exceed the regulatory criteria with the exception of Phase 1 Construction $SO_2$. Addition of the Base Case and LNG Facility Phase 1 Operations increases the $SO_2$ predictions to concentrations which exceed regulatory criteria, but not $NO_2$ and $PM_{2.5}$.

**Table 3: Phase 1 Construction Alone and Phase 1 Construction plus the Base Case Predicted Concentrations**

| COPC | Averaging Period | Phase 1 Construction Predicted Concentrations (µg/m$^3$) | | Phase 1 Construction + Base Case Predicted Concentrations (µg/m$^3$) | | Regulatory Criteria (µg/m$^3$) |
|---|---|---|---|---|---|---|
| | | Maximum in CVL[e] | Maximum in Kitimat Region | Maximum in CVL | Maximum in Kitimat Region | |
| $SO_2$ | 1-hour [a] | 1.13 | 66.2 | **822** | **2,101** | 183 |
| | Annual [b] | 0.05 | 2.84 | **17.7** | **32.5** | 13 |
| $NO_2$ | 1-hour [c] | 89.0 | **885** | 89.0 | **885** | 113 |
| | Annual [b] | 10.3 | **74.2** | 11.0 | **74.2** | 32 |
| $PM_{2.5}$ | 24-hour [d] | **51.9** | **917** | **53.6** | **917** | 25 |
| | Annual [b] | **12.2** | **376** | **13.6** | **377** | 8 |

NOTES:

[a] Achievement for 1-hour $SO_2$ is based on the annual 99$^{th}$ percentile of daily 1-hour maximum averaged over three consecutive years for consistency with the BC AQOs. One year of predictions precludes use of a 3-year average.

[b] Achievement for annual $SO_2$, $NO_2$, and $PM_{2.5}$ is based on the average of all 1-hour average concentrations over a single calendar year for consistency with the BC AQOs.

[c] Achievement for 1-hour $NO_2$ is based on the annual 98$^{th}$ percentile of daily 1-hour maximum averaged over three consecutive years for consistency with the BC AQOs. One year of predictions precludes use of a 3-year average.

[d] Achievement for $PM_{2.5}$ is based on annual 98$^{th}$ percentile of daily average, averaged over three consecutive years.

[e] The maximum in CVL is based on the 100 receptors employed in the HHRA (refer to Section 5.2.4.2; Stantec, 2019d)

Source for regulatory criteria (refer to Table 2): BC ENV, 2021. **Bold** indicates an exceedance of the regulatory criteria.

**Table 4: Phase 2 Construction Alone and Phase 2 Construction plus the Base Case plus LNG Facility Phase 1 Operations Predicted Concentrations**

| COPC | Averaging Period | Phase 2 Construction Predicted Concentrations (µg/m$^3$) | | Phase 2 Construction + Base Case + LNG Facility Phase 1 Operations Predicted Concentrations (µg/m$^3$) | | Regulatory Criteria (µg/m$^3$) |
|---|---|---|---|---|---|---|
| | | Maximum in CVL[e] | Maximum in Kitimat Region | Maximum in CVL | Maximum in Kitimat Region | |
| $SO_2$ | 1-hour [a] | 0.34 | 13.7 | **826** | **2,116** | 183 |
| | Annual [b] | 0.02 | 0.87 | **17.9** | **32.9** | 13 |
| $NO_2$ | 1-hour [c] | 78.9 | **356** | 79.4 | **356** | 113 |
| | Annual [b] | 6.42 | **45.1** | 7.95 | **45.4** | 32 |
| $PM_{2.5}$ | 24-hour [d] | **29.0** | **237** | **30.9** | **238** | 25 |
| | Annual [b] | 6.21 | **94.9** | 7.74 | **95.5** | 8 |

| COPC | Averaging Period | Phase 2 Construction Predicted Concentrations (µg/m$^3$) | | Phase 2 Construction + Base Case + LNG Facility Phase 1 Operations Predicted Concentrations (µg/m$^3$) | | Regulatory Criteria (µg/m$^3$) |
|---|---|---|---|---|---|---|
| | | Maximum in CVL[e] | Maximum in Kitimat Region | Maximum in CVL | Maximum in Kitimat Region | |

NOTES:
Achievement for each parameter and time averaging interval is as described in the Notes section of

Table 3. Source for regulatory criteria (refer to Table 2): BC ENV, 2021. **Bold** indicates an exceedance of the regulatory criteria.

An assessment of isopleth maps and an exercise to attribute effects to specific emissions sources shows that in both Phase 1 and Phase 2 Construction:

- For $SO_2$, emissions from existing industrial sources contributes nearly all of the ground-level $SO_2$ observed within CVL and in the Kitimat region at large.
- For $NO_2$ and $PM_{2.5}$, emissions from construction sources contributes nearly all of the ground-level $NO_2$ and $PM_{2.5}$ observed within CVL and in the Kitimat region at large. The Haul Road from the Sandhill Materials Quarry is the largest contributor given its proximity to CVL.

An exercise to assess confidence in the results shows that:

- There is a high degree of confidence in the ability of the model to faithfully depict the effects of the Base Case (point source) emissions of $SO_2$. Emission quantity and source behaviour from point sources are well known, and the model faithfully reproduces actual conditions.
- There is little confidence in the ability of the model to faithfully depict the effects of the Construction Case (area source) emissions of nitrogen oxides ($NO_X$) and $PM_{2.5}$. There is a fair degree of uncertainty in both emission quantities, the $NO_X$ to $NO_2$ conversion process, and the ability of the model to characterize the emission dispersion with area sources. Uncertainty tends strongly to overprediction to maintain conservatism in the results.

As a result it was concluded that with respect to the HHRA, the predictions for $SO_2$ can be relied upon with a high degree of confidence. The predicted concentrations for $NO_2$ and $PM_{2.5}$ cannot be relied upon. They are likely four times greater than that which will be measured at CVL during Phase 1 and 2 Construction. Given the high degree of over prediction, it is recommended that the HHRA account for the fourfold over prediction bias in the risk estimates for all COPC modelled, with the exception of $SO_2$ (refer to the HHRA for further explanation, Stantec 2019d).

## 5.2. Summary of the Human Health Risk Assessment

The EA Application for the Project included a HHRA that assessed potential changes in health risk to people in Kitimat and Kitamaat Village from inhalation exposures to $SO_2$, $NO_2$, CO and $PM_{2.5}$ (LNG Canada 2014a, b). Workers housed at CVL during the construction phase of the Project were not included in the assessment. During the review and approval process of the EA Application, regulatory agencies requested that potential human health risks be evaluated for workers housed at CVL (EAC Condition 19). To address this request, LNG Canada engaged Stantec to undertake a HHRA to assess the potential human health risks associated with exposures to contaminants in the air and soil, for workers housed at CVL.

### 5.2.1. Problem Formulation

#### 5.2.1.1. Contaminants of Potential Concern (COPC)

The identification of COPC for the HHRA was completed in consultation with regulatory agencies in accordance with the EAC Condition 19 Working Group (which includes the BC ENV, BC MOH, Health Canada, Northern Health Authority, British Columbia Oil and Gas Commission [BC OGC] and WorkSafeBC) as well as consideration of commitments made by LNG Canada as identified in the EAO Assessment of Application for Amendment 1, LNG Canada Export Terminal Project, Environmental Assessment Certificate 15-01 (August 5, 2016). As outlined in Section 1.5, there were eight COPC considered in the HHRA: $SO_2$, $NO_2$, $PM_{2.5}$, DPM, metals, VOC, PAH, and HF.

### 5.2.2. Receptor Identification

Human receptors include male and female adult workers between the ages of 20 and 65, who are housed at the CVL during Phase 1 and Phase 2 construction periods. Sensitive receptors are those individuals with asthma, chronic obstructive pulmonary disease (COPD) etc. No infants, toddlers, children or adults typically above the age of 65 will live at the CVL. Adult workers will be exposed to COPC in the air and soils while housed at CVL.

The HHRA assumed that workers would be present at the CVL for 24-hours a day, 365 days per year to account for the potential that construction and project management staff could be housed in CVL on a continuous basis rather than on a the 3-week work rotation basis anticipated for the workforce. This assumption also addresses the personnel working within CVL.

#### 5.2.2.1. Conceptual Site Model

The CVL covers an area of 33.6 ha and consists of residential buildings, office buildings, entertainment and recreation centers, a food services building, snow storage area, a bus parking area and a sports field. The majority of the CVL site is covered by buildings or pavement, with the sports field being the only location where surface soils are present. Surface areas of CVL that are not covered by buildings, pavement or the sports field (which will be turfed), will remain as uncovered aggregate material. There are no planned vegetable gardens, and planter boxes, if present in the future, are used for flowers. Groundwater at the site is not and will not be used as potable water.

The HHRA also evaluated the potential health risk to workers at CVL associated with inhalation and direct contact (incidental soil ingestion, dermal contact with soil) exposures to COPC released to ambient air from operations at the Project, existing emission sources (including fugitive dusts from existing facilities), diesel emissions, and fugitive dust from trucks on the haul road and fugitive dust emissions from the proposed stockpile. A summary of the exposure pathways considered in the HHRA is provided in the conceptual site model (CSM) shown in Figure 2.

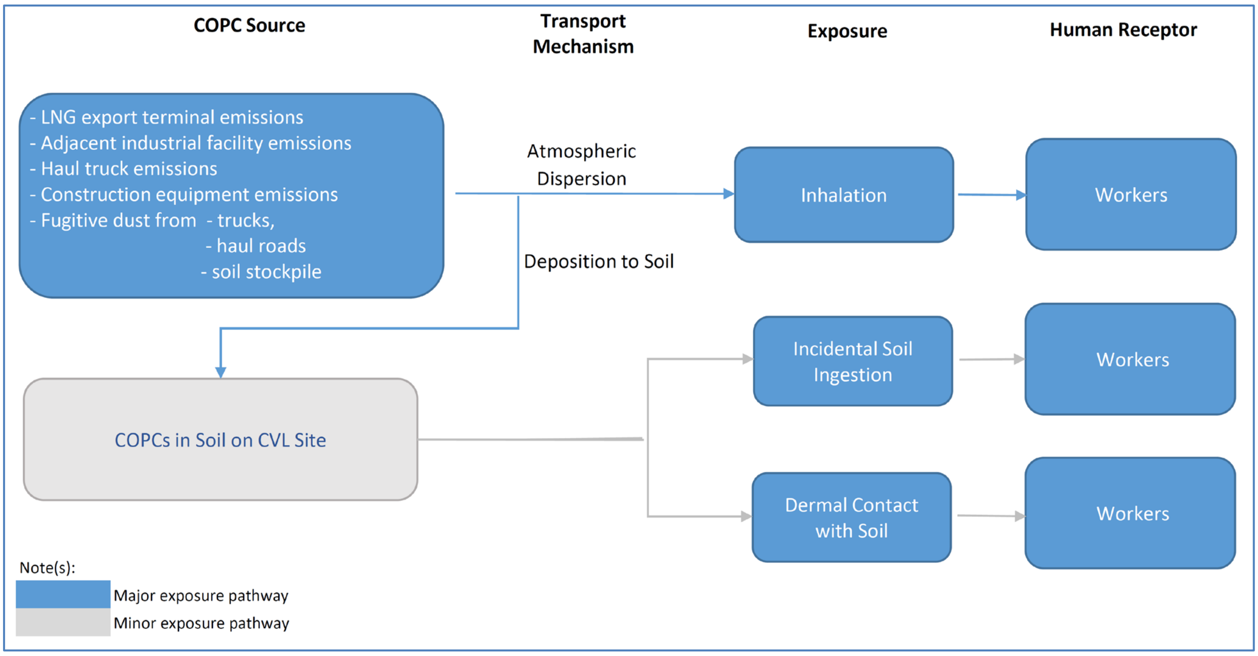


**Figure 2: Conceptual Site Model**

### 5.2.3. Toxicity Assessment

The assessment of potential human health risks associated with exposures to COPC is based on a comparison between the predicted exposures and the exposure limits established by regulatory agencies such as Health Canada and the United States Environmental Protection Agency (US EPA). The Toxicity Assessment section of the HHRA outlines the selection process used to identify the exposure limits used to evaluate the potential human health risks associated with exposures to the predicted COPC concentrations in air and soil at CVL. Exposure limits for short-term exposures (e.g. 1-hour, 24-hour) and long-term exposures (e.g. annual average) are provided for each of the COPC and are presented in the HHRA.

### 5.2.4. Exposure Assessment and Risk Characterization

#### 5.2.4.1. Health Risks Associated with Direct Contact Exposures

Dust, generated by activities on neighboring sites (fugitive dust from adjacent industrial facilities, stockpile soil, and construction and haul road activities), will deposit on the CVL property. Deposited dust will not accumulate on areas of CVL covered by pavement or buildings. Dust deposited on aggregate will be washed into the interstitial spaces between the aggregate by rain and melting snow and will not accumulate at the surface. Soil on the sports field, which will be turfed, is the only location on the CVL property where dust may accumulate in surface materials. Workers using the sports field could come into contact with COPC that accumulate in the soil beneath the turf on the field as a result of dust deposition.

The HHRA evaluated the potential human health risks associated with direct contact exposures to PAH and metals in soil. Risk estimates were based on the assumption that workers would have access to soil on the sports field 365 days per year, even though the sports field will be turfed and direct access to the soil beneath the turf is expected to be limited. The HHRA further assumed that workers would be housed at CVL for a full 5-year period during Phase 1 construction and a second 5-year period during Phase 2 construction. The risks were calculated using the maximum predicted COPC concentrations in soil after ten (10) years of deposition.

Although direct contact with COPC in soil is a complete exposure pathway, the HHRA showed that even after ten (10) years of dust deposition on the sports field, COPC concentrations would be below the BC ENV soil quality guidelines for residential properties. Although these results indicate that COPC concentrations in soil represent a negligible human health risk for workers, the HHRA included a quantitative assessment of these risks.

The potential human health risks for workers housed at CVL were below the risk acceptability benchmarks for non-carcinogenic and carcinogenic compounds. Based on these results the HHRA concluded that the predicted COPC concentrations in soil represent a negligible human health risk for workers housed at CVL.

#### 5.2.4.2. Health Risks Associated with Inhalation Exposures

The assessment of potential human health risks associated with inhalation exposures to COPC relied on the results of air dispersion modelling. The major sources of $SO_2$ are stack emissions from the adjacent industrial facility (refer to Section 5.1). Dispersion modelling is specifically designed to predict atmospheric concentrations from a point source (such as a stack). As a result, there is good agreement between modelled and measured $SO_2$ concentrations and the $SO_2$ results were used without adjustment. However, due to a number of factors (Stantec, 2019d), the modelled concentrations of $NO_2$, $PM_{2.5}$, DPM, PAH, metals and VOC are considered overly conservative. To account for this over prediction, forensic modeling was used to evaluate the accuracy of the CALPUFF model predictions compared to ambient measurements. The forensic modelling showed that predictions of $PM_{2.5}$ are greater than four times that measured locally. Given these results, the modelled results for $PM_{2.5}$, $NO_2$, DPM, PAH, VOC and metals bound to $PM_{2.5}$ used in the assessment of inhalation risks have been adjusted (i.e., divided by four) to account for this over-prediction. In keeping with the regulatory requirement of presenting the risk results based on the reported air quality modelling data, the HHRA presents the estimated human health risks associated with both the unadjusted and adjusted modelling results.

The predicted COPC concentrations in air used in the HHRA were based on air quality modelling results for 100 receptor locations within the CVL footprint. The HHRA evaluated potential risks associated with the maximum predicted COPC concentration from the 100 receptor locations and the 95% upper confidence limit of the mean (95% UCLM) concentrations. Basing risk estimates on the maximum concentration assumes that a worker remains at the location of the maximum predicted concentration 100% of the time and provides overly conservative worst-case estimates of the potential human health risks that could be experienced by workers housed at CVL. The 95% UCLM concentration better reflects the exposures that workers could experience while moving around the CVL site. Therefore, the 95% UCLM concentrations were used to estimate the potential exposures and risks that may be experienced by workers housed at CVL.

Several risk acceptability benchmarks were applied in the HHRA in evaluating the potential human health risks for workers housed at CVL. In determining the potential human health risks associated with exposures to non-carcinogenic chemicals, a risk acceptability benchmark of 1.0 was applied to contaminants where inhalation is the predominant route of exposure. A risk acceptability benchmark of 1.0 is also applied when assessing the risks associated with short-term (24-hour) inhalation exposures to COPC where short-term exposure limits are available (metals and VOC). The contaminants where a risk acceptability benchmark of 1.0 has been applied include: $SO_2$, $NO_2$, DPM and $PM_{2.5}$ and short-term (24-hour) exposures to metals and VOC. For long-term or chronic exposures to metals, PAH, VOC and HF, where other routes of exposure may contribute to the exposures experienced by workers over the long-term, a risk acceptability benchmark of 0.2 was applied in assessing the potential human health risk associated with exposures to these chemicals. The results of the HHRA, based on the 95% UCLM concentrations are summarized below. For additional information on assumed length of exposures, the metrics in question, or other details please refer to the full HHRA documentation (Stantec, 2019d).

##### *5.2.4.2.1. Hydrogen Fluoride (HF)*

The predicted human health risks associated with inhalation exposures to HF, using measured HF concentrations, were below the risk acceptability benchmark of 0.2 established by Health Canada and BC ENV. Therefore, inhalation exposures to HF represent a negligible human health risk for workers housed at CVL.

##### *5.2.4.2.2. Volatile Organic Compounds (VOC)*

The predicted human health risks associated with inhalation exposures to non-carcinogenic VOC using both the unadjusted and adjusted 95% UCLM concentrations for non-carcinogenic VOC, were below the risk acceptability benchmark of 0.2 established by Health Canada and BC ENV. The predicted human health risks associated with inhalation exposures to carcinogenic VOC, using both the unadjusted and adjusted 95% UCLM concentrations of carcinogenic VOC, were below the cancer risk acceptability benchmark of $10^{-5}$ (0.00001) established by BC ENV and Health Canada. Therefore, inhalation exposures to non-carcinogenic and carcinogenic VOC represent a negligible human health risk for workers housed at CVL.

#### *5.2.4.2.3. Metals*

The predicted human health risks associated with long-term (annual average) inhalation exposures to non-carcinogenic metals using the unadjusted maximum concentrations in Phase 1 was marginally above the concentration ratio (CR) risk acceptability benchmark of 0.2 (CR of 0.21) when the CRs for the individual metals are summed. In Phase 2, the unadjusted total CR was below the 0.2 benchmark. Both the unadjusted and adjusted 95% UCLM concentrations for non-carcinogenic metals (both individual and summed), were below the risk acceptability benchmark of 0.2 established by Health Canada and BC ENV. The CR calculated for the maximum concentrations assumes that the maximum concentration of each metal occurs at the same receptor location and that a worker would be present at that location on a continuous basis (24 hours per day 365 days per year). This approach over-predicts that exposures that workers housed at CVL would be likely to experience. Given the over-predictive nature of the Phase 1 maximum concentration CR and the fact that the 95% UCLM concentrations for Phase 1 and Phase 2 (both unadjusted and adjusted) and the maximum unadjusted CR for Phase 2 are below the risk acceptability benchmark of 0.2, long-term inhalation exposures to non-carcinogenic metals represent a negligible human health risk.

The predicted human health risks associated with inhalation exposures to carcinogenic metals, using both the unadjusted and adjusted 95% UCLM concentrations of carcinogenic metals, were below the cancer risk acceptability benchmark of $10^{-5}$ (0.00001) established by BC ENV and Health Canada. Therefore, inhalation exposures to carcinogenic metals represent a negligible human health risk for workers housed at CVL.

In assessing the potential human health risks associated with short-term (24-hour) exposures, a risk acceptability benchmark of 1.0 is applied. The predicted human health risks associated with short-term (24-hour) inhalation exposures to metals using the predicted unadjusted and adjusted maximum and 95% UCLM concentrations are below the risk acceptability benchmark of 1.0 for both the individual metals and the summed CR. Therefore, short-term inhalation exposures to metals represents a negligible human health risk for workers housed at CVL.

#### *5.2.4.2.4. Polycyclic Aromatic Hydrocarbons (PAH)*

The predicted human health risks associated with inhalation exposures to non-carcinogenic PAH using the unadjusted maximum concentrations for non-carcinogenic PAH, were marginally above the risk acceptability benchmark of 0.2 established by Health Canada and BC ENV for Phase 1 and Phase 2 (total CR for non-carcinogenic PAH was 0.25 for Phase 1 and 0.246 for Phase 2). However, the corresponding total CRs using the adjusted data were below the 0.2 benchmark in Phase 1 and Phase 2. The CR associated with the maximum concentrations (unadjusted and adjusted) were below 0.2 for Phase 1 and Phase 2. In addition, the predicted human health risks associated with inhalation exposures to non-carcinogenic PAH using both the unadjusted and adjusted 95% UCLM concentrations for non-carcinogenic PAH, were below the risk acceptability benchmark of 0.2 for Phase 1 and Phase 2 (total CR for summed non-carcinogenic PAH was 0.182 for Phase 1 and 0.177 for Phase 2). The predicted human health risks associated with inhalation exposures to carcinogenic PAH, using both the unadjusted and adjusted maximum and 95% UCLM concentrations of carcinogenic PAH, were below the cancer risk acceptability benchmark of $10^{-5}$ (0.00001) established by BC ENV and Health Canada. Therefore, inhalation exposures to non-carcinogenic and carcinogenic PAH represent a negligible human health risk for workers housed at CVL.

#### *5.2.4.2.5. Diesel Particulate Matter (DPM)*

The assessment of potential human health risks for workers identified CR that exceeded the risk acceptability benchmark of 1.0 based on unadjusted maximum 2-hour average DPM concentrations: CR of 3.31 during Phase 1 and CR of 1.42 during Phase 2. However, these CRs were predicted to occur at a location on the northeastern edge of the CVL property, where workers would not be anticipated to spend any amount of time. Moreover, most of the concentration exceedances were predicted to occur during the winter months (January, February, November, December) when the workers are expected to spend the majority of their time indoors, thus their effective exposure to DPM in outdoor air would be lower than what was assumed in the HHRA. In addition, the CR for Phase 1 and Phase 2 using the adjusted DPM concentrations were below the risk acceptability benchmark of 1.0. There were no exceedances of the risk acceptability benchmark for annual DPM exposures. Therefore, it is reasonable to conclude that inhalation exposures to short-term (2-hour average) and long-term (annual average) DPM concentrations in air, represent a negligible human health risk for workers housed at CVL.

#### *5.2.4.2.6. Particulate Matter ($PM_{2.5}$)*

Fine particulate matter ($PM_{2.5}$) is considered to be a non-threshold contaminant which means that any degree of exposure is associated with some level of health risk. At very low $PM_{2.5}$ concentrations, the health risk is low. The health risk increases as $PM_{2.5}$ concentrations increase. Assessing the potential human health risks associated with exposures to non-threshold contaminants is generally conducted using a risk acceptability benchmark. Although there are potential health risks associated with exposures that occur at levels that are below this benchmark, the risks are considered to be negligible. Risk acceptability benchmarks for non-threshold contaminants that are not carcinogenic have not been formally established by regulatory agencies. In the absence of a defined risk acceptability benchmark, the BC AQOs for $PM_{2.5}$ has been used as the benchmark. Exposures that are below the $98^{th}$ percentile of the daily average or annual average BC AQOs for $PM_{2.5}$ (identified by CR less than 1.0) are considered to represent a negligible human health risk.

The assessment of potential human health risks for workers identified CR that exceeded the risk acceptability benchmark of 1.0 based on the unadjusted maximum daily average $PM_{2.5}$ concentration: CR of 2.11 during Phase 1 at Receptor location 820 and CR of 1.23 during Phase 2 at Receptor location 110. These receptor locations are situated on the northeastern edge of the CVL property. This is not a location where workers would be anticipated to spend any amount of time. Moreover, the concentration exceedances were predicted to occur during the winter months (January and December) while the rest of the year had no exceedances. During winter, the workers are expected to spend most of their time indoors, thus their effective exposure to $PM_{2.5}$ in outdoor air would be lower than what has been assumed in the HHRA. In addition, the CR using the adjusted maximum daily average $PM_{2.5}$ concentrations were below the risk acceptability benchmark of 1.0 for both Phase 1 and Phase 2.

For long-term exposure, based on the unadjusted maximum annual average $PM_{2.5}$ concentration for Phase 1, the CR exceeded the benchmark (CR of 1.7). However, the equivalent CR using the 95% UCLM of the unadjusted annual average concentration was 0.93 and the CR using the adjusted maximum annual average was 0.43. There were no benchmark exceedances for annual $PM_{2.5}$ (based on adjusted and unadjusted concentrations) for Phase 2.

Therefore, it is reasonable to conclude that inhalation exposures to short-term (daily) and long-term (annual average) $PM_{2.5}$ concentrations in air, represent a negligible human health risk for workers housed at CVL. For additional information please refer to the full HHRA documentation (Stantec, 2019d).

#### *5.2.4.2.7. Nitrogen Dioxide ($NO_2$)*

$NO_2$ is a non-threshold contaminant which means that any degree of exposure is associated with some level of health risk. At very low $NO_2$ concentrations, the health risk is low. The health risk increases as $NO_2$ concentrations increase. In the absence of a defined risk acceptability benchmark for $NO_2$, the CAAQS for $NO_2$ has been used as the benchmark. Exposures that are below the 1-hour or annual average CAAQS for $NO_2$ (identified by CR less than 1.0) are considered to represent a negligible human health risk.

The assessment of potential human health risks for workers identified a CR that exceeded the risk acceptability benchmark of 1.0 (CR of 1.01) (unadjusted $NO_2$ concentrations during Phase 2), at Receptor location 820 which, as noted in Section 5.2.4.2.6, is located on the northeastern edge of the CVL property. This is not a location where workers would be anticipated to spend any amount of time. In addition, this CR was based on the maximum predicted daily 1-hour maximum $NO_2$ concentration. The equivalent CR using the 95% UCLM daily 1-hour maximum was below the risk acceptability benchmark. The CR for Phase 1 and Phase 2 using the adjusted the daily 1-hour maximum and annual average $NO_2$ are below the risk acceptability benchmark of 1.0. Based on this, it is reasonable to conclude that inhalation exposures to short-term (1-hour) and long-term (annual average) $NO_2$ concentrations in air, represent a negligible human health risk for workers housed at CVL.

The predicted human health risks associated with inhalation exposures to $NO_2$, using both the unadjusted and adjusted 95% UCLM $NO_2$ concentrations, were below the risk acceptability benchmark of 1.0 established by

Health Canada and BC ENV. Therefore, inhalation exposures to $NO_2$ represent a negligible human health risk for workers housed at CVL.

### *5.2.4.2.8. Sulphur Dioxide ($SO_2$)*

The assessment of the potential health risks for workers housed at CVL depends on multiple lines of evidence and weighs the results from the risk characterizations for 1-hour, 10-minute and 5-minute exposures to $SO_2$. The results of the 1-hour $SO_2$ exposure analysis indicates that for more than 95% of the year, 1-hour $SO_2$ concentrations across CVL are below levels where workers (including those with asthma or COPD) would be expected to experience respiratory effects. Concentration ratios for the maximum 99$^{th}$ percentile daily 1-hour maximum and the 95% UCLM daily 1-hour maximum values exceed one (1) suggesting a potential health risk for workers. However, review of the air quality modelling data shows that the 99$^{th}$ percentile daily 1-hour maximum and the 95% UCLM concentrations occur infrequently (less than five (5) hours per year) and are predicted to occur at locations where workers would not be anticipated to spend time. Therefore, the CR based on the maximum 99$^{th}$ percentile daily 1-hour maximum and the 95% UCLM over predict the potential human health risks for workers (including those with asthma or COPD).

The results of the 10-minute $SO_2$ analyses show that the CR calculated for the maximum 10-minute $SO_2$ concentration and the 95% UCLM of the maximum 10-minute $SO_2$ concentrations across all 100 receptor locations within CVL, are more than 10-fold higher than the risk acceptability benchmark of 1.0. These results suggest that exposures to 10-minute $SO_2$ concentrations may represent a potential human health risk for workers. However, further analysis shows that 10-minute $SO_2$ concentrations exceed the Health Canada TRV 4.6% of the time in Phase 1 and Phase 2. The Health Canada 10-minute TRV is based on protecting the most sensitive members of the population, who are unlikely to be present at CVL.

The 10-minute $SO_2$ TRV developed by Health Canada is based on a lowest observable adverse effect concentration (LOAEC) for decreased lung function. The LOAEC was based on controlled inhalation studies where asthmatics were exposed to $SO_2$ for 5 to 10-minute periods at increased ventilation rates (exercising) (Health Canada, 2016). Health Canada selected a LOAEC of 0.4 ppm (1048 $\mu g/m^3$–rounded down to 1,000 $\mu g/m^3$) which represents the lowest $SO_2$ concentration where a statistically significant decrease in lung function was noted in test subjects (Health Canada, 2016). Although effects were seen at lower $SO_2$ concentrations (0.2 ppm or 524 $\mu g/m^3$ rounded to 500 $\mu g/m^3$), Health Canada noted that these effects were not statistically significant, so these results were not used to derive the TRV. It is important to note that the decreased lung function reported in these studies was transitory and lung function returned to normal when exposure decreased (US EPA, 2017). Health Canada applied an uncertainty factor of six (6) to the LOAEC where statistically significant effects were observed (1,000 $\mu g/m^3$) to derive the TRV of 175 $\mu/m^3$, in order to protect the most sensitive members of the population (children and the elderly).

To characterize the potential risks associated with 10-minute exposures to $SO_2$, it is necessary to understand the frequency and duration of the exceedances. A frequency analysis shows that 10-minute $SO_2$ concentrations exceed the LOAEC (1,000 $\mu g/m^3$) infrequently and occur a maximum seven (7) times (seven 10-minute intervals out of the 8,760 hours per year considered) in Phase 1 and eight (8) times (eight hours out of 8,760 hours per year) in Phase 2. The data also show that 10-minute $SO_2$ concentrations exceed 500 $\mu g/m^3$ a maximum 34 times per year in Phase 1 and 34 times per year in Phase 2 (34 10-minute periods per year in Phase 1 and 34 10-minute periods per year in Phase 2).

Members of the general workforce, and workers with asthma or COPD who are not engaged in physical outdoor activity would not be expected to experience decreases in lung function at 10-minute $SO_2$ concentrations that are below the LOAEC. Workers with asthma, who are particularly sensitive to $SO_2$, may be expected to experience decreases in lung function. However, recovery would be expected to occur once exposure levels decrease and/or as the degree of physical activity decreases (US EPA, 2017).

The results of the 5-minute $SO_2$ analyses predict that less than 50 respiratory responses per year (related to $SO_2$ exposure) in each of Phase 1 and Phase 2 would be added to the predicted baseline number of events of 45,000 events per year, an increase of less than 0.1%. It is important to note that the respiratory events considered in the US EPA assessment cover a wide range of responses from small changes in airway resistance at low $SO_2$ concentrations that would not be noticed by the people who experience these events, to more noticeable changes in breathing in response to higher levels of $SO_2$. In addition, the effects-response curve developed by the US EPA is based on exercising asthmatics and is likely to over-predict potential effects in the general workforce.

The Health Canada risk assessment for $SO_2$ (Health Canada, 2016) concluded that the toxicological and epidemiological evidence supports the existence of a causal relationship between $SO_2$ exposure and respiratory morbidity (respiratory effects). However, although associations between short-term exposure to $SO_2$ and other health effects have been noted (non-accidental and cardiopulmonary mortality risks, reproductive effects), and the toxicological and epidemiological evidence may be suggestive of an association, the data are insufficient to establish the existence of causal relationships between exposure to $SO_2$ and these other reported health effects (Health Canada, 2016; US EPA, 2009). It should be noted that the BC MOH and Northern Health Authority consider $SO_2$ to be a non-threshold contaminant which means that any degree of exposure is associated with some level of health risk. At very low $SO_2$ concentrations, the health risks associated with direct respiratory tract effects are low. The health risks increase as $SO_2$ concentrations increase. The potential link between $SO_2$ exposure and the other health effects for which causal relationships have not been established (e.g. cardiopulmonary mortality, reproductive effects) suggests that as $SO_2$ exposures increase the risks associated with these health effects would also increase. The current assessment focuses on the potential for direct respiratory effects to occur in the workforce, because toxicological benchmarks for exposures associated with direct and immediate respiratory effects have been established and can be used to provide quantitative assessments of potential health risks. Equivalent benchmarks for quantifying the health risks for individual workers have not been established for the other health effects (cardiopulmonary mortality, reproductive effects etc.) and thus, quantitative estimates of potential risks for these effects cannot be calculated. However, the likelihood of these indirect health risks would be expected to be lower than the direct respiratory health risks associated with inhalation exposures to $SO_2$.

In addition to indirect health risks, cold and/or dry air has the potential to exacerbate respiratory effects among exercising asthmatics (Linn et al. 1984). However, studies that exposed asthmatics to cold air during exercise suggest that the effect of combined exposures to $SO_2$ and cold air is less than additive, and that the effects are mild even at temperatures as low as -6°C (Linn et al. 1984). Climate data for the District of Kitimat shows that during the winter months (November through March) the lowest minimum average temperature range between 0°C in November to -6.1°C in January[iii]. This data suggests that while exposure to cold air may increase the potential for workers with asthma to experience respiratory effects, the increase in responses associated with combined exposures to $SO_2$ and cold will be infrequent and mild. Dry air is generally defined as a humidity level of 40% or lower. In Kitimat, the relative humidity ranges between an average low of 74% in April to an average high of 87% in December[iv] which are not considered dry air conditions. Therefore, dry air conditions would not be expected to contribute to the respiratory effects experienced by workers with asthma or COPD.

The results of the assessment indicate that inhalation exposures to $SO_2$ in general, represent a minimal but manageable human health risk in areas of CVL where workers (including those with asthma or COPD) could be expected to spend time and engage in outdoor recreational activities. Although there are occasions when $SO_2$ concentrations may reach levels where sensitive members of the workforce may experience respiratory effects, these occasions are few, the effects are reversible and can be easily managed through changes in the levels of outdoor recreational activities. Thus, it is reasonable to conclude that for workers housed at CVL, inhalation exposures to $SO_2$ represent a minimal and manageable human health risk.

## 5.3. Correlation between Outdoor and Indoor Air Quality

The CVL HHRA is based on predicted (or in some instances measured) outdoor concentrations of COPC ($PM_{2.5}$, $SO_2$ and $NO_2$) assuming that indoor concentrations are at most equal to outdoor concentrations. This Plan

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[iii] Kitimat weather by month – available at: https://en.climate-data.org/north-america/canada/british-columbia/kitimat-12036/climate-table

[iv] Average Humidity in Kitimat British Columbia Available at: https://weather-and-climate.com/average-monthly-Humidity-perc,kitimat-british-columbia-ca,Canada

assumes that in instances where there are acute levels of COPC outdoors, sheltering indoors provides a measure of protection. The conservative nature of these assumptions was not questioned in developing the HHRA work plan. The approved HHRA work plan therefore did not address indoor air quality directly.

In subsequent discussions, the EAC Condition 19 Working Group questioned these assumptions and requested a literature review to demonstrate that in the absence of significant indoor sources of COPC (mainly $PM_{2.5}$, $SO_2$ and $NO_2$), the indoor environment provides a quantifiable reduction for both chronic and acute exposures. This section addresses these issues, focusing on the COPC of primary concern.

$PM_{2.5}$ is widely acknowledged as primarily being formed from fuel combustion and chemical / physical reactions in the atmosphere (secondary organics and inorganics, condensation, and coagulation). Indoor activities such as printing and photocopying are minor indoor sources of $PM_{2.5}$. Very little, if any, $PM_{2.5}$ originates from the resuspension of crustal material (fugitive dust). $SO_2$ and $NO_2$ originate largely from industrial and combustion processes, although globally there are substantial biogenic sources of each. Globally there are substantial biogenic sources of $PM_{2.5}$, $SO_2$ and $NO_2$.

Given the combustion sources at CVL (space heating, water heating, cooking) are properly ventilated outdoors, there are no significant sources of $PM_{2.5}$, $SO_2$ and $NO_2$ indoors at CVL. Exposure to $NO_2$ from cooking is not an issue at the CVL dorms as they are isolated from the dining area. There are sinks of $PM_{2.5}$, $SO_2$ and $NO_2$ indoors, in that surfaces and furnishings facilitate natural removal processes such as particle aggregation, and deposition, and some reaction to sulphates and nitrates. Activities such as vacuuming re-suspends $PM_{2.5}$, however this is minor.

Heating, Ventilation and Air Conditioning (HVAC) systems at CVL incorporate filtration for particulate removal and comply with WorkSafeBC guidelines with respect to ventilation and indoor air quality. While filtration is more effective for particle sizes greater that 2.5 microns in aerodynamic diameter, they are somewhat effective in the $PM_{2.5}$ range. Health Canada (2012), in their guidance for fine particulate matter in residential indoor air, recommend identifying and removing sources of particulate matter, and improving ventilation. They note that "identification of potential sources, in most situations, are more informative and cost-effective than indoor air quality testing and comparison of measured values to quantitative guideline values."

Health Canada (2002) conducted a review of the health risks associated with $NO_2$ and $SO_2$ in indoor air following a comprehensive review of the scientific literature respecting the relationship of indoor and outdoor air pollution. Brauer et al. (Health Canada, 2002) conducted an extensive search of bibliographic databases of the medical and scientific literature between 1990 and December 31, 2001. Six thousand plus papers were reviewed by the Authors for relevance, and approximately ten key studies aimed at characterizing the relationship between indoor and outdoor pollutant levels were identified and referenced. The ten key studies were obtained and reviewed. Classic pre-1990 studies were also reviewed, as were studies published after December 31, 2001. The key findings of these studies are summarized below.

***The pre-1990 studies***

- Biersteker, Graff & Nass (1965) studied indoor and outdoor smoke and $SO_2$ concentrations of 60 homes in Rotterdam, Netherlands. On average living rooms contained approximately 80% of the smoke and 20% of the $SO_2$ measured simultaneously outdoors during 24-hour periods.
- Spengler et al. (1979) report on the results of one year's indoor and outdoor monitoring for $SO_2$ and $NO_2$ in six (6) communities with widely varying outdoor levels. Annual average Indoor/Outdoor $SO_2$ ratios are on the order of 0.2 to 0.7. However indoor $NO_2$ levels can exceed outdoor levels by a factor of two, but only if there is an indoor source of $NO_2$ and depending on the type of cooking appliance used. They evaluated the impact of various heating and cooking systems.
- In 1982 the Journal of the Air Pollution Control Association published a critical review of the relationship between indoor and outdoor air quality (Yocom, 1982). In this critical review Yocom (1982) notes that generally $SO_2$ Indoor/Outdoor ratios are between 0.3 to 0.5 in cities with modest to high outdoor $SO_2$ levels. Also, since $NO_2$, once formed, is a relatively reactive molecule Indoor/Outdoor ratios for $NO_2$ tend to be less than 1.0 in the absence of indoor sources of $NO_2$. Yocom cites examples of Indoor/Outdoor ratios for $NO_2$ for non-air-conditioned buildings of between 0.49 and 1.0, and 0.37 for an

air-conditioned house with a sophisticated air cleaning device. Yocum (1982) also noted that the half-life of $NO_2$ is on the order of 0.84 h in the absence of ventilation, illustrating the efficiency of the indoor $NO_2$ removal process.

***The 1990-2001 studies***

- Brauer et al. (1991) used annular denuder-filter pack sampling systems to measure indoor and outdoor aerosols and $SO_2$ in Boston, Massachusetts. They found outdoor levels of $SO_2$ exceeded their indoor concentrations during winter and summer. Winter Indoor/Outdoor ratios were lower than during the summer, probably due to lower air exchange rates during the winter period.

- Lee et al. (1997) studied the indoor and outdoor air quality at two (2) staff quarters at Hong Kong Polytechnic University at Tsim Sha Tsui East (TSTE) and Shatin (ST) in January and February 1996. At TSTE, the $SO_2$ and $NO_2$ Indoor/Outdoor ratios were 0.72 and 0.78, respectively. At ST, the $SO_2$ and $NO_2$ Indoor/Outdoor ratios were 0.91 and 0.97, respectively. The authors speculate that the indoor $SO_2$ was mainly from outdoor sources, while the indoor $NO_2$ came from the outdoors or from indoor sources such as tobacco smoking, gas stoves, burning incense, candles or mosquito coils, and operating a heater. The results suggest that the indoor air pollutants appear to be affected by infiltration of outdoor air as well as by indoor generation.

- Baek, Kim & Perry (1997) studied indoor and outdoor air quality in two (2) cities in Korea (Seoul and Taegu). They passively sampled six (6) residences, six (6) offices and six (6) restaurants in each city during summer 1994 and winter 1994-1995 (24 hour samples). They found that in homes the mean Indoor/Outdoor ratio for $NO_2$ was 1.03, however for offices the mean Indoor/Outdoor ratio for $NO_2$ was 0.71. For restaurants the mean Indoor/Outdoor ratio for $NO_2$ was 1.4. Indoor environments without cooking (offices) have lower Indoor/Outdoor ratios than with cooking (restaurants and homes). (*Note, exposure to $NO_2$ from cooking is not an issue at the CVL dorms as they are isolated from the dining area*).

- Kulkarni and Patil (1998) studied personal exposure levels of $NO_2$ in a mixed residential and industrial area of Mumbai over 2-day periods in winter (February 1996) and summer (April 1996). They found that there is a 37% (winter) and 47% (summer) correlation of personal exposure with indoor and outdoor concentration (Indoor/Outdoor ratios not available). Personal exposure to $NO_2$ was significantly greater in winter than in summer. Respondents staying in smaller houses and/or having outdoor occupations were exposed to higher $NO_2$ levels.

- Lee, Chan & Chiu (1999) studied the indoor and outdoor air quality of 14 public places with mechanical ventilation systems in Hong Kong (October 1996 to March 1997) during peak traffic hours. The authors found overall, Indoor/Outdoor ratios for $SO_2$ and $NO_2$ were 0.92 and 0.75 respectively.

- Cyrys et al. (2000) assessed the contribution of the most important indoor sources (e.g. the presence of gas cooking ranges, smoking) and outdoor sources (traffic exhaust emissions) for indoor and outdoor concentrations of $NO_2$ in Erfurt and Hamburg (East and West Germany respectively). While not focusing on Indoor/Outdoor ratios they determined that the most important predictors of indoor $NO_2$ concentrations were gas in cooking followed by other characteristics, such as ventilation or outdoor $NO_2$ level.

- Chao and Law (2000) studied personal exposure to $NO_2$ in Hong Kong using passive samplers (*note there is uncertinaty associated with the use of passive monitors, 20 years ago)*. The participants were selected from the group of people who spent most of their time at home and in an air-conditioned office environment. The study indicated that cooking activities had a strong impact on the $NO_2$ level. When cooking existed, the average indoor $NO_2$ level was 59.7 $\mu g/m^3$ and when cooking did not exist, the $NO_2$ level was 41.8 $\mu g/m^3$. The average $NO_2$ Indoor/Outdoor ratios was 0.80. The study indicated that the home environment showed the highest impact to the total personal $NO_2$ exposure due to the relatively higher $NO_2$ level caused by combustion effect in the kitchen as well as the long time period spent every day in this micro-environment. (*Note, exposure to $NO_2$ from cooking is not an issue at the CVL dorms as they are isolated from the dining area*).

- Chao (2001) studied the relationships between indoor and outdoor levels of various air contaminants (NO, $NO_2$, $SO_2$ and $O_3$) in ten (10) non-smoking residential buildings in Hong Kong using passive samplers (*note there is uncertinaty associated with the use of passive monitors, 20 years ago)*. The average Indoor/Outdoor ratios for NO, $NO_2$, $SO_2$ and $O_3$ were 0:98 (S:D: = 0:19); 0:79 (S:D: = 0:30); 1:01 (S:D: = 0:78) and 0:40 (S:D: = 0:31), respectively. The results also indicated that on average the residential buildings in Hong Kong acted as sinks for these four air contaminants.
- Kindzierski and Sembaluk (2001) used passive monitoring techniques to measure 7-day average concentrations of $SO_2$ in indoor–outdoor air in two (2) Alberta communities, Boyle (population 860) and Sherwood Park (population 42,000). Sampling occurred during a 5-week period in late fall, a time of year when $SO_2$ is less reactive in the outdoor environment. The median Indoor/Outdoor $SO_2$ ratios for Boyle was 0.13 (range 0.05–0.52). For Sherwood Park the median Indoor/Outdoor $SO_2$ ratio was 0.13. (range 0.08–0.4). Kindzierski and Sembaluk (2001) note these results are quite reasonable in comparison to Indoor/Outdoor $SO_2$ ratios they found in the literature (e.g. Spengler et al. (1979) reported $SO_2$ Indoor/Outdoor ratios in six American cities ranging from 0.08 to 0.67. Stock et al. (1985) found an $SO_2$ Indoor/Outdoor ratios of 0.54 in Houston, Texas. Chan et al. (1994) found the $SO_2$ Indoor/Outdoor ratios during winter to be 0.23).

***The post-2001 studies***

Two of the most comprehensive and locally relevant post-2001 works are those of Alberta Health and Wellness (2003, 2007).

- Alberta Health and Wellness (2003) undertook a community exposure and health effects assessment in Fort Saskatchewan to assess the impact of airborne contaminants on the health of the population. This exposure assessment considered outdoor concentration, indoor concentrations (homes) and personal concentrations. For $SO_2$, median indoor and outdoor exposures were 0.34 vs 2.30 µg/m$^3$, respectively. For $NO_2$, median indoor and outdoor concentrations were 10.0 vs 10.4 µg/m$^3$, respectively. For $PM_{2.5}$ median indoor and outdoor concentrations were 6.56 vs 6.98 µg/m$^3$, respectively. This work suggests that the indoor concentrations is lower than or equivalent to outdoor concentrations for $SO_2$, $NO_2$, and $PM_{2.5}$. A companion study in the Wood Buffalo Region of northeast Aleberta (Alberta Health and Wellness, 2007) showed very similar results.
- Demirel et al. (2014) studied personal exposure of primary school children to benzene, toluene, ethylbenzene and xylene (known as BTEX), $NO_2$ and $O_3$ in Eskişehir, Turkey. These pollutants were measured using organic vapor monitors and passive samplers (24-hour samples). They concluded that while outdoor air is an important source of indoor $NO_2$, tobacco smoke, woodstoves and fireplaces, gas appliances, and kerosene heaters are the main indoor sources of $NO_2$. Their Indoor/Outdoor $NO_2$ ratio was 1.08, underscoring the importance of indoor sources in the homes studied. The “Personal/Outdoor” exposure ratio was 1.42.
- Ielpo et al., 2019 studied nine (9) sites in a highly industrialized Italian city. Their work demonstrated that $SO_2$ and $NO_2$ Indoor/Outdoor ratios are well below one (1.0) for homes and rooms not in proximity to indoor cooking appliances.

***Conclusion***

The more recent work is consistent with many studies of indoor air quality, both recent and dating back to those examined in the 1982 Critical Review by Yocom (1982). Studies consistently demonstrate that, in the absence of significant indoor sources of $PM_{2.5}$, $SO_2$ and $NO_2$, the indoor environment provides a quantifiable reduction of exposure.

Recently, Laumbach et al. (2015) examined what individuals can do to reduce personal health risks from air pollution. They concluded that “personal exposure to ambient air pollution can be reduced on high air pollution days by staying indoors, reducing outdoor air infiltration to indoors, cleaning indoor air with air filters, and limiting physical exertion, especially outdoors and near air pollution sources”. They also note that “health care providers and their patients should carefully consider individual circumstances related to outdoor and indoor air pollutant exposure levels and susceptibility to those air pollutants when deciding on a course of action to reduce personal exposure and health risks from ambient air pollutants. Careful consideration is especially warranted when interventions may have unintended negative consequences, such as when efforts to avoid exposure to air pollutants lead to reduced physical activity."

# 6. Avoidance, Management and Mitigation Measures

The HHRA concluded that generally the potential effects of $SO_2$ are the primary air quality health concern at CVL for residents. As nearly all the $SO_2$ originates at a neighboring industrial facility, mitigating measures related to construction have no effect on $SO_2$. As the Project is a receptor, rather than emitter, mitigation measures respecting $SO_2$ exposures are based on monitoring, informing, and reacting. Mitigations associated with the design of CVL will also be applicable for $PM_{2.5}$ and $NO_2$.

Possible avoidance, management, and mitigation measures are:

- Monitoring:
    - Develop and implement an air quality monitoring program, which includes installation of a local on-site ambient air quality monitoring station near CVL to allow for near real time monitoring while CVL is being occupied, plus validation of indoor air quality during when $SO_2$ concentrations are measured above 305 ppb (800 µg/m$^3$) (refer to Section 7.1).
    - On-site medical staff assess data to identify signs and symptoms of over exposure to reduced air quality, including surveillance for increased cases (reported) of respiratory issues and other health issues potentially associated with exposure to poor air quality (eg., cardiovascular effects, respiratory infections).
- Informing:
    - Develop a communication procedure to promptly inform CVL residents when they are recommended to change their behaviour while off-shift.
    - Include information on the air quality notification protocol in the site orientation; including what workers would “feel” if they were being effected by $SO_2$.
- Reacting:
    - Issued health notifications (based on the hourly air quality); that will inform CVL residents when they are recommended to change their behaviour while off-shift.
    - Include instructions of how to turn off the individual PTAC units in the dormatories and air intakes for the makeup unit in the hallways and laundry within the emergency response plans; including education / awareness to the CVL workforce.
    - Develop clear roles and responsibilites related to implementation.
- Design of CVL to withstand the effects of expected environmental conditions at site.
    - General:
        - Where HVAC equipment is exposed to harsh ambient environment, moist ambient or with highly corrosive contaminants, appropriate corrosion protection will be provided.
        - HVAC system to have the ability to limit the intake of outside air; and increase the recirculation of air inside.
    - Specific to mitigating $PM_{2.5}$ effects indoor:
        - Locate outside air intakes as far away as practical from all sources of air contaminants; avoid locating intakes at loading docks, fume hood exhausts, generator exhausts, process exhausts etc.
        - All air shall be filtered before entering the coils, equipment or occupied spaces. On re-circulating air systems, provisions should be made for having filters capable of an 80% average efficiency.

- In the event of extended timeframes of poor air quality, ensure air filters can be changed more frequently, or filter medium changed as per the manufacturer specifications and depending on the circumstance which will limit the intake of particulate matter.
- All buildings shall be made weather proof to eliminate dust and water penetration by sealing all piping, cable and equipment penetrations using an approved silicone rubber caulking compound.

On-site health services will provide CVL residents with access to health services and medical emergency response. Further information on site health services are documented in the Health Services and Medical Emergency Response Strategy (developed in conformance with EAC Condition 15).

Mitigation measures to minimize emissions of particulate matter and other emissions (e.g. $NO_2$) from construction sources are documented in the Project Construction Environmental Management Plan, Project Air Quality Management Plan (Construction) (developed in conformance with EAC Condition 1), and Project Erosion and Sediment Control Plan. Mitigation measures include the following topics (but not limited to): dust suppression, speed restrictions, equipment/vehicle maintenance and material handling.

As stated in the Project Air Quality Management Plan (Construction): *Environmental topics, including air quality, will be discussed regularly via HSE meetings, tailgate meetings, kick-off meetings and work plan development. It is the responsibility of the on-site HSE or Environment Manager to provide this information for air quality matters.*

# 7. Monitoring, Reporting and Record Keeping

## 7.1. Ambient Air Quality Monitoring Station

In 2018, LNG Canada committed to installing an on-site ambient air monitoring station to monitor select criteria air contaminants (CAC) in a location representative of worker exposure at the CVL for the duration of the construction activities (Stantec, 2018). In consultation with BC ENV, the location for the on-site ambient air monitoring station was selected south of CVL, in an area that would be relatively undisturbed during CVL construction, and would be representative of near-worst case levels of $SO_2$ per the dispersion modelling (refer to Section 5.1 and Figure 3).

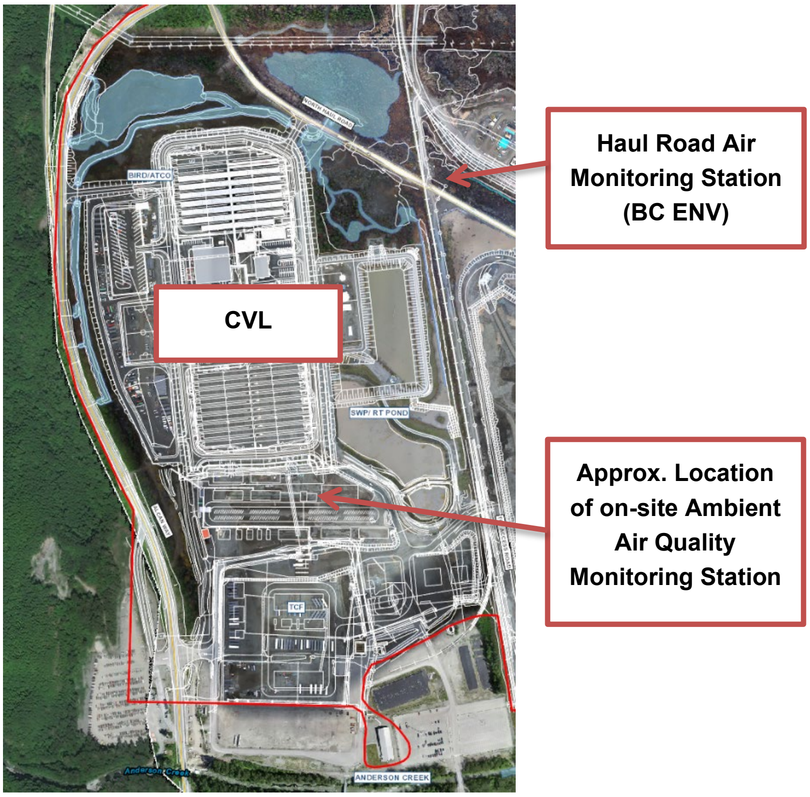


**Figure 3: Approximate location of the on-site Ambient Air Quality Monitoring Station**

The following parameters are being measured at the on-site ambient air quality monitoring station:

- Sulphur Dioxide ($SO_2$)
- Oxides of Nitrogen ($NO_X$): Nitric Oxide (NO) and Nitrogen Dioxide ($NO_2$)
- Ozone ($O_3$)
- Respirable Particulate Matter ($PM_{2.5}$)
- Inhalable Particulate Matter ($PM_{10}$)
- Wind Speed and Direction
- Ambient Temperature and Relative Humidity
- Barometric Pressure

A data monitoring program will be developed that will address data management (consistent with Stantec, 2018). It will include reviews by JFJV, AGAT Laboratories (the ambient air quality monitoring station provider), as well as a semi-annual audit by a qualified third party. The audit will involve challenging each analyzer at multiple points across its measurement range with appropriate transfer standards and instruments. The first audit is proposed at the time of CVL commencing operations and will repeat approximately every six months.

Information on indoor air quality verification for $SO_2$ is provided in Section 7.3.1.

## 7.2. Notification Levels / Index

### 7.2.1. COPC Trigger Action Response Plan (TARP)

The Project used the Trigger Action Response Plan (TARP) for the first several years of CVL operations, which was based on issuing notification alerts for three COPC ($SO_2$, $PM_{2.5}$, and $NO_2$) based on their individual concentrations measured. For further information on the TARP, refer to Revision 0 of this Plan.

After a year of CVL operations, the Project undertook a review the effectiveness of the TARP and the Kitimat $SO_2$ Alert Pilot Project; which resulted in EAO directing LNG Canada to update this Plan, replacing the TARP approach with the use of the AQHI+$SO_2$ (Air Quality Health Index + Sulphur Dioxide) program in consultation with technical advisors.

### 7.2.2. AQHI+$SO_2$ Program

The AQHI+$SO_2$ program is used by ENV to inform residents of Kitimat of the air quality in the region; publishing an index value on a scale of 1 to 10+ based on a series of equations using $NO_2$, $O_3$, $PM_{2.5}$ and $SO_2$ data from selected air quality monitoring stations in Kitimat:

- Low Health Risk – AQHI+$SO_2$ values from 1 to 3
- Moderate Health Risk – AQHI+$SO_2$ values from 4 to 6
- High Health Risk – AQHI+$SO_2$ values from 7 to 10
- Very High Health Risk – AQHI+$SO_2$ values above 10

AGAT coordinated with DR-DAS (who provides the software to support environmental data collection and reporting for air quality from CVL station), to develop the AQHI+$SO_2$ programming for CVL; and trials were undertaken between January and April 2023 to test the new system, with input from ENV. The learnings through the trial resulted in updates to the programming.

The three equations that inform the resulting AQHI+$SO_2$ Index value as follows, with the resulting AQHI+$SO_2$ Index value being the maximum value from these three equations, calculated every hour.

**Equation 1 – AQHI Classic**

$$AQHI_{(classic)} = 10/10.4*(100*(e^{(0.000871*NO2)}-1 + e^{(0.000537*O3)}-1 + e^{(0.000487*PM2.5)}-1))$$

Basis:

- Use the 3-hour rolling average pollutant concentration for $NO_2$, $O_3$ and $PM_{2.5}$
- Resulting Index value is rounded to the nearest integer using basic "grade 6" rounding principles (i.e., 3.49 rounds down to 3, 3.50 rounds up to 4).

**Equation 2 – AQHI Plus**

$$AQHI\ Plus = CEILING(PM_{2.5}/10)$$

Basis:

- Use the 1-hour concentration for $PM_{2.5}$
- The ceiling function will automatically round the resulting Index value up to the next interger (i.e., 3.1 rounds up to 4).

**Equation 3 – $SO_2$ Index**

If $SO_2$ concentration is greater than 185ppb, the resulting index value is 7, unless the $AQHI_{(classic)}$ or AQHI Plus is 8 or higher.

Basis:

- Use the 1-hour concentration for $SO_2$

The TARP approach will be transitioned to the AQHI+SO2 Index approach in July 2023. **7.3.**

## 7.3. Notification Approach

The on-site ambient air quality monitoring station will be programed to send an automated health message via email or text, based on the AQHI+$SO_2$ Index value (refer to Revision 0 of this Plan for the notifications sent under the TARP). JFJV will also use the Project emergency notification system for the High Health Risk Alert events.

The corresponding notifications are issued based on the index values, consistent with the ENV AQHI alert system (refer to Table 5).

**Table 5: AQHI Index – Notification Health Message**

| Index Value | Risk Category | Notification Health Message |
|---|---|---|
| 1 to 3 | Low | Enjoy your usual outdoor recreational activities when off-shift. A separate alert will be issued if the hourly $SO_2$ is recorded between 36 to 184 ppb. |
| 4 to 6 | Moderate | Persons with chronic respiratory issues should consider reducing or rescheduling strenuous recreational activities outdoors if experiencing symptoms when off - shift. No effects are expected for the general population. A separate alert will be issued if the hourly $SO_2$ is recorded between 36 to 184 ppb. |
| 7 – 10 | High | Persons with chronic respiratory conditions should consider reducing or rescheduling strenuous recreational activities outdoors when off-shift; others (esp. elderly), should also consider avoiding strenuous recreational activities outdoors when off-shift. |
| Above 10 | Very High | Persons with chronic respiratory conditions should reduce or reschedule strenuous recreational activities outdoors when off-shift; others (esp. elderly), should also consider avoiding strenuous recreational activities outdoors when off-shift. |

BC ENV also has a $SO_2$ Alert System in Kitimat, based on the 1-hour concentration of $SO_2$ (refer to Figure 4). When $SO_2$ is above 185ppm, an AQHI+$SO_2$ Index value of 7 is issued (per Equation 3 above). An $SO_2$ of 36 to 184 ppb is equivalent to a Level 2 and 3 alert issued under the TARP approach.

**Figure 4: ENV Kitimat $SO_2$ Alert Pilot Project – SO2 Alert System**[v]

| $SO_2$ Levels | $SO_2$ Alert Health Messages |
|---|---|
| **0-35 ppb** | None (no alert issued) |
| **36-184 ppb** | Persons with chronic respiratory conditions such as asthma should consider reducing or rescheduling strenuous outdoor activities if experiencing symptoms. No effects are expected for the general population. |
| **185+ ppb** | Persons with chronic respiratory conditions such as asthma should reduce or reschedule strenuous activities outdoors. Others, especially children and the elderly should also consider avoiding outdoor physical exertion. |

For Moderate Health Risk events, assigned personnel from LNG Canada and JFJV will be notified via the automated on-site ambient air quality monitoring station (which will include the JFJV Environment Manager, JFJV Site HSE Manager and their respective delegates when they are not on-site), as well as BC MOH and BC ENV if they have "opted-in". The assigned personnel from LNG Canada and JFJV will have undergone training to access and review the air quality data, and determine what additional mitigations need to be implemented on the Project site. The assigned personnel (or approved delegate) will monitor the online air quality data to assess if the air quality is escalating to a High Health Risk event or reducing to a Low Health Risk event.

In the event that the COPC concentration is trending to a High Health Risk event, the JFJV Environment Manager (or delegate) will communicate with the assigned personnel from the JFJV HSE and External Affairs teams, to prepare them to implement the non-automated High Health Risk notification requirements.

For High Health Risk events, the workforce will be issued the relevant health message via an automated notice through the Project emergency notification system. In addition, signage will be placed in visible locations around CVL; and a JFJV representative will raise awareness through CVL by speaking with residents. JFJV will cancel any scheduled strenuous outdoor exercise activities at CVL. In addition, when $SO_2$ is measured greater than 305 ppb (800 µg/m$^3$), JFJV will recommend that those sensitive to the effects of $SO_2$ (including persons with asthma) should limit indoor strenuous activities also. The notifications will include the anticipated duration of the event if known; and the information will be shared with Northern Health Authority and BC ENV (refer to Section 7.5.2).

Other general communication tools will include:

- Site Orientation: Include a slide on local air quality, notificaton protocol and what workers would "feel" if they were being effected by $SO_2$. The orientiation program already includes information on the Project health and medical services.
- Site Bulletin: A site bulletin will be issued to ensure all workers who have already undertaken orientation, will be provided with pertinent information.
- As noted in Section 6, environmental topics, including air quality, will be discussed regularly via HSE meetings, tailgate meetings, kick-off meetings and work plan development. It is the responsibility of the on-site JFJV HSE or Environment Manager to provide this information for air quality matters.

### 7.3.1. $SO_2$ Indoor Notifications and Validation

In the event of a 1-hour concentration of $SO_2$ greater than 185 ppb, CVL residents will be advised to keep windows and doors closed.

BC ENV and BC MOH do not issue alerts specific to modifying indoor activities in the event of elevated $SO_2$. The literature review outlined in Section 5.3, presented various literature sources that assessed indoor to outdoor ratio

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[v] Source: Kitimat SO2 Alert Pilot Project - Province of British Columbia (gov.bc.ca)

exposures. In the two Alberta studies, the indoor to outdoor ratio ranged from 0.05 to 0.52; in the American cities, the ratio ranged from 0.08 to 0.67. Higher values were recorded in other areas of the world (Hong Kong, Korea); the ratios reported in the pre-1990's studies ranged from 0.2 to 0.7.

For the purposes of this Project, a ratio of 0.5 is being adopted to guide the notification related to indoor behaviors; when $SO_2$ is measured at greater than 305 ppb (>800 µg/m$^3$) (the former TARP "Level 5"), the inside air quality could be in the order of 400 µg/m$^3$ (152 ppb), which is in the range of the former TARP "Level 4" alert (persons with asthma should avoid strenuous activities outdoors). Therefore the further notifications will be issued when $SO_2$ is measured at greater than 305 ppb (>800 µg/m$^3$) to include this recommendation applied to indoors also (i.e., persons with asthma should avoid strenuous activities indoors).

In the event that $SO_2$ is measured at greater than 305 ppb (>800 µg/m$^3$), trained JFJV Environment or HSE personnel will use a $SO_2$ dosimeter tube for verification of indoor air quality purposes only. Dosimeter tubes are passive (exposure type) monitors that use time-weighted average gas concentrations. These tests are not accurate at low values, but will be suitable for verification testing during this elevated $SO_2$ event.

**7.4.**

## 7.4. Feedback and Grievance Procedure

The Community Feedback process is documented in the JFJV Community Impact Management Plan, which was developed to implement the LNG Canada Community-Level Infrastructure and Services Management Plan under EAC Condition 14.

JFJV is committed to providing an open and transparent means for the Project workforce, local community and general public to seek information and raise concerns and complaints, and to have them looked into in a timely manner during construction.

Inquiries from members of the public, including community residents, stakeholders and First Nations, and the workforce residing in CVL can be received through the following:

- Telephone – 1-250-632-5358 (JFJV)
- Toll-free – 1-888-499-5358 (JFJV)
- Email address – info@jfjvkitimat.com
- Project Resource Centre located at 234 City Centre Mall, Kitimat, BC
- Social Media: Facebook.com/jfjvkitimat

Once a message is received, the goal is to acknowledge receipt within 48 to 72 hours, then respond and close out the request within 10 days.

## 7.5. Reporting

There are two aspects for the Project reporting:

- Semi annual reporting
- Information sharing

### 7.5.1. Semi Annual Reporting

On a semi-annual basis, a memorandum will be prepared that provides a summary of the alerts undertaken during the period and the effectiveness of the mitigation measures. The memorandum will be accompanied by a flat-file containing quality assured minute and hourly data from the on-site ambient air quality monitoring station, and provided to Northern Health Authority and BC ENV, with EAO copied. The reporting periods are outlined in Table 6. The reporting period is scheduled to start April 1 to align with the commencement of CVL operations (noting the first report will be based on the actual occupancy of first beds CVL operations through September 30 2020).

**Table 6: Semi Annual Reporting**

| Reporting Period | Report Due Date |
|---|---|
| April 1 – September 30 | December 30 |
| October 1 – March 31 | June 30 |

### 7.5.2. Information Sharing

LNG Canada and JFJV have an agreement with an industrial neighbour, who will advise when there are planned changes in operations that may have an impact on the Project (including local air quality).

There is also a Project agreement with Northern Health Authority to share information; for all non-emergency notifications that can impact public health. JFJV assigned (or delegated) personnel will send notifications by email to “resource.development@northernhealth.ca”. Specific to this Plan, when there has been a High Health Risk event, a notification will be sent to Northern Health Authority and BC ENV. The notification will be copied to EAO. Northern Health Authority and BC ENV can “opt-in” at Moderate Health Risk event notifications.

It is our expectation that a very limited, if any, CVL workforce would contact Northern Health Authority for a Low Risk Health events, rather they would discuss potential symptoms with the on-site medical services team.

The expectations that will be included in the Protocol (to be drafted) would include that Northern Health Authority acknowledge that:

- The notification is based on real-time data, which will not have been quality assured.
- The notification is provided for awareness only, so they have the “same knowledge” as a CVL resident, if they are contacted.
- Northern Health Authority will advise JFJV if any CVL workforce contact them related to “air quality” health related information.

JFJV will not be contacting Northern Health Authority directly for every Moderate Health Risk event notification. Information related to sources that “triggered” the automatic notification and feedback from the medical staff related to cases (reported) of respiratory issues and other health issues potentially associated with exposure to poor air quality, will be discussed between LNG Canada, JFJV and Northern Health Authority at mutually agreed to times (i.e. “Information Sharing”); and documented in the semi-annual reports (noting that there will be direct lines of contact for with Northern Health Authority for Very High Health Risk events).

A meeting will be scheduled between LNG Canada, JFJV and Northern Health Authority, prior to April 1 2020, to discuss this protocol and the implementation of this Plan. The meeting should be attended by the personnel who will be responsible for implementing the Plan at CVL.

## 7.6. Record Keeping

All records, checklists, inspection reports, including any non-compliances or non-conformances and corrective action plans are to be maintained. Records shall be and remain legible, identifiable, and traceable. Records may be kept in hard copy as long as an electronic copy is also kept.

# 8. Adaptive Management Plan

Applying adaptive management in the context of this Plan involves a review of the effectiveness of the program to protect off-duty workers and those working at CVL from the potentially deleterious effects of air pollutants at CVL. Adaptation involves changing assumptions, plus management and mitigations in response to new or different information obtained through monitoring.

The health messaging are currently derived based on adaptation of the provincial and federal notification systems; the messaging will be generally reviewed every year to ensure it is still appropriate for this Project. Assumptions about the effects of various construction and other activities on air quality will be tested, and monitoring data will be reviewed to determine if management actions and mitigations are appropriate.

JFJV shall update this Plan as the Project progresses to ensure that it remains current with legislation and reflects environmental and human health outcomes. Keeping the Plan up to date shall be the responsibility of the JFJV Environment Manager in coordination with the HSE team; a scheduled review shall be undertaken at least annually. As noted above, during the annual review, the health messaging will be assessed for appropriateness and effectiveness with updates carried out if required. The ambient monitoring and visual inspection programs will also be reviewed if it is determined the current methods are not effective in indicating or predicting the occurrences of air quality events. This Plan will be updated to reflect any improvements that are identified.

Should any deficiencies be found during the scheduled reviews, an updated Plan shall be issued as required and outdated copies of the Plans shall be collected for archive.

Revision 0 of this Plan contained further information on the Annual Review to be undertaken after the first year of CVL operations using the TARP approach. As this review was undertaken and shared with EAO, it has been removed from this updated plan.

# 9. References

The supporting documentation referenced within this document is the following:


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# Appendix A Acronyms, Abbreviations

| | |
|---|---|
| AQHI | Air Quality Health Index |
| AQO | Air Quality Objective |
| BC | British Columbia |
| CAAQS | Canadian Ambient Air Quality Standards |
| CAC | Criteria Air Contaminants |
| CCME | Canadian Council of Ministers of the Environment |
| CR | Concentration Ratio |
| CO | Carbon Monoxide |
| COPC | Contaminants of Potential Concern |
| COPD | Chronic Obstructive Pulmonary Disease |
| CSM | Conceptual Site Model |
| CVL | Cedar Valley Lodge |
| DPM | Diesel Particulate Matter |
| EA | Environmental Assessment |
| EAC | Environmental Assessment Certificate (E15-01) |
| EAO | Environmental Assessment Office |
| ENV | Ministry of Environment and Climate Change Strategy (previously MOE) |
| EPC | Engineering, Procurement and Construction |
| H | hour |
| ha | hectares |
| HEPA | High Efficiency Particulate Arrestance |
| HF | Hydrogen fluoride |
| HHRA | Human Health Risk Assessment |
| HSE | Health, Safety and Environment |
| HVAC | Heating, Ventilation and Air Conditioning |
| JFJV | JGC Fluor BC LNG Joint Venture |
| LNG | Liquefied Natural Gas |
| LNG Canada | LNG Canada Development Inc. |
| LOAEC | Lowest Observable Adverse Effect Concentration |
| $\mu g/m^3$ | micrograms per cubic metre |
| MOH | Ministry of Health |
| NO | Nitric Oxide |
| $NO_X$ | Nitrogen Oxides |
| $NO_2$ | Nitrogen Dioxide |
| $O_3$ | Ozone |

| | |
|---|---|
| OGC | Oil and Gas Commission (now known as the BC Energy Regulator) |
| PAH | polycyclic aromatic hydrocarbons |
| Plan | Workforce Air Quality Health Plan |
| $PM_{10}$ | Particulate Matter with an aerodynamic diameter of 10 micrometers or less |
| $PM_{2.5}$ | Particulate Matter with an aerodynamic diameter of 2.5 micrometers or less |
| ppb | Parts Per Billion |
| Project | LNG Canada Export Terminal |
| SMR | Social Management Roundtable |
| $SO_2$ | Sulphur Dioxide |
| ST | Shatin |
| Stantec | Stantec Consulting Ltd. |
| TARP | Trigger Action Response Plan |
| TRV | Toxicity Reference Value |
| TSTE | Tsim Sha Tsui East |
| UCLM | Upper Confidence Limit of the Mean |
| US EPA | United States Environmental Protection Agency |
| VOC | Volatile Organic Compounds |
| WAC | Workforce Accommodation Centre |

# Appendix B Stakeholder Commitments

The following mitigation measures are committed in the EA Application and apply to this Plan.

| Statement | Source | Section Number |
|---|---|---|
| Construct and operate workforce accommodation centre(s) for non-resident workforce during the pre-construction and construction phase to manage effects of temporary workforce on communities (Mitigation 6.2-5). | Environmental Assessment Certificate Application, September 2014 | 7.5.11 |
| Implement worker wellbeing and accommodation program to promote holistic worker health from a physical, mental, cultural and social perspective (Mitigation 7.5-2). | Environmental Assessment Certificate Application, September 2014 | 7.5.11 |
| Provide on-site health services and medical emergency response for primary care including health promotion, injury/illness prevention, and injury/illness management, in order to manage impact on the local public health care system. (Mitigation 7.5-3) | Environmental Assessment Certificate Application, September 2014 | 7.5.11 |
| Require contractors and subcontractors to adhere to health and safety programs that emphasize workplace health and welfare and adhere to traffic management policies. (Mitigation 7.5-7) | Environmental Assessment Certificate Application, September 2014 | 7.5.11 |
| Implement industry best practice for mobile construction equipment (i.e. regular maintenance, speed restrictions, correct sizing of equipment, modernizing of fleet, reduce idling, driver behavior, etc.) (Mitigation 5.3-1) | Environmental Assessment Certificate Application, September 2014 | 5.2.11 & 5.3.10 |
| Manage vehicle and equipment emissions by conducting regular maintenance on all machinery and equipment (Mitigation 5.2-1) | Environmental Assessment Certificate Application, September 2014 | 5.2.11 |
| Control construction-related fugitive road dust, through measures such as speed limits on private gravel roads and road watering on an as-needed basis (Mitigation 5.2-2) | Environmental Assessment Certificate Application, September 2014 | 5.2.11 |
| Prohibit the open burning (or incineration) of accumulated waste materials from the workforce accommodation centre(s) (Mitigation 5.2-4) | Environmental Assessment Certificate Application, September 2014 | 5.2.11 |

| Statement | Source | Section Number |
|---|---|---|
| Use buses, where feasible, instead of personnel transportation at the facility and workforce accommodation centre(s) to reduce traffic emissions (Mitigation 5.3-3) | Environmental Assessment Certificate Application, September 2014 | 5.3.10 |
| During construction, operation, and decommissioning, drivers will maintain slow (specified) speeds on all access roads in the Project footprint and be extra diligent during amphibian migration periods, especially when adjacent to wetlands, in order to reduce the potential for collisions with wildlife. (Mitigation 5.6-13) | Environmental Assessment Certificate Application, September 2014 | 5.6.11.1 |