7.0 Valued Components Effects Assessment

7.12 Human Health

Human health has been identified as a valued component to be assessed for the Cedar LNG Project (the Project) as specified in Section 5.0 of the AIR. This section describes and assesses the potential effects on human health from the Project. For this assessment, human health is defined as the state of physiological health from exposure to chemicals of potential concern (COPC) and other hazards (e.g., radiation, noise, electromagnetic fields) in the environment.

The human health valued component draws its primary conclusions from the human health risk assessment (HHRA) technical data report (TDR) (see Appendix 7.12A: Stantec 2021a), air quality TDR (see Appendix 7.2A: Stantec 2021b) and the acoustic TDR (see Appendix 7.3A: Stantec 2021c). Summary conclusions from these TDRs are presented here in this assessment.

This assessment is also linked to other valued components, either through integration (i.e., information from other valued components is incorporated into this assessment) or support (i.e., information from this assessment is incorporated into the assessment of other valued components).

Components of this assessment integrate information from the following valued components:

- Air Quality (Section 7.2)—Air quality modelling results are incorporated into the assessment to characterize the health risk from air contaminants.
- Acoustic (Section 7.3)—Acoustic modelling results are incorporated into the assessment to characterize the health effects to people from project-related noise.
- Wildlife (Section 7.5)—Species of wildlife in the region that are harvested as country foods by Indigenous Nations are described in the HHRA TDR (Appendix 7.12A: Stantec 2021a).
- Freshwater Fish (Section 7.6)—Species of freshwater fish in the region that are harvested as country foods by Indigenous Nations are described in the HHRA TDR (Appendix 7.12A: Stantec 2021a).
- Marine Resources (Section 7.7)—Species of marine animals and fish in the region that are harvested as country foods by Indigenous Nations are described in the HHRA TDR (Appendix 7.12A: Stantec 2021a).

7.12.1 Relevant Statutes, Policies and Frameworks

The management of human health is subject to several statutes, policies and frameworks. In British Columbia, public health is the responsibility of the Ministry of Health in accordance with the *Public Health Act.* The *Public Health Act* includes provisions to address environmental health hazards from pollutants. At the federal level, Health Canada's mandate includes the protection of human health from exposure to chemicals in the environment.

The scope of this assessment satisfies the requirements under the British Columbia *Environmental Assessment Act* and the Canadian *Impact Assessment Act,* which require the consideration of the potential project effects to human health. The conclusions described in this assessment are based on the HHRA TDR (Appendix 7.12A: Stantec 2021a), air quality TDR (Appendix 7.2A: Stantec 2021b) and acoustic TDR (Appendix 7.3A: Stantec 2021c). This human health assessment framework is consistent with how environmental assessments are conducted in British Columbia and Canada.

The HHRA applies Health Canada's risk assessment guidance framework, *Guidance for Evaluating Human Health Impacts in Environmental Assessments* (Health Canada 2019). Within the HHRA guidance, Health Canada also provides supplemental guidance that is applicable to specific types of exposure pathways. These are listed below and apply only if the exposure pathway is applicable to the Project.

- Guidance for Evaluating Human Health Impacts in Environmental Assessments: Country Foods (Health Canada 2018)
- Guidance for Evaluating Human Health Impacts in Environmental Assessment: Air Quality (Health Canada 2016a)
- Guidance for Evaluating Human Health Impacts in Environmental Assessment: Drinking and Recreational Water Quality (Health Canada 2016b)
- Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise (Health Canada 2016c)
- Guidance for Evaluating Human Health Impacts in Environmental Assessment: Radiological Impacts (Health Canada 2017a)
- Supplemental Guidance on Human Health Risk Assessment of Contaminated Sediments: Direct Contact Pathway (Health Canada 2017b)

Other provincial guidance for conducting HHRAs that are not specifically designed for environmental assessments may be considered as needed, and include:

- Guidance on Human Health Risk Assessment (Northern Health 2015)
- British Columbia Guidance for Prospective Human Health Risk Assessment – Version 1.0 (Ministry of Health 2021)

7.12.2 The Influence of Consultation and Engagement

This section describes information and concerns related to human health raised through consultation with Indigenous Nations, government agencies, stakeholders, and community members. Where made available by Indigenous Nations through consultation, and voluntary information sharing, information on Indigenous knowledge and traditional use has been included.

Table 7.12.1 provides a summary of the topics and key information and concerns that Cedar identified during its consultation and engagement efforts that relate to human health. It also summarizes the influence that the outcomes of this consultation and engagement had on the assessment.

TABLE 7.12.1 SUMMARY OF KEY INFORMATION AND CONCERNS FOR THE PROJECT RELATED TO HUMAN HEALTH

Topic	Key Information and Concerns	Influence on the Assessment
Scope of the Assessment	Northern Health and Ministry of Health requested that project effects to the quality of air, soil, sediment, water, and health-related topics (e.g., country foods) must be considered in the assessment of human health.	The assessment of human health includes the consideration of project effects to the quality of air, soil, sediment, water, and country foods. These effects are discussed in the HHRA TDR (Appendix 7.12A: Stantec 2021a). If the HHRA results indicate that there are negligible effects to the quality of air, soil, sediment, water, and/or country foods, no further assessment of that pathway is required in the HHRA TDR. If the HHRA results indicate that there is a potential effect to the quality of air, soil, sediment, water, and/or country foods, a detailed assessment is conducted and the results are summarized in the human health valued component.
Scope of the Assessment	Health Canada requested that the assessment of human health consider the effects from project noise and electric and magnetic fields from the transmission line.	The assessment of human health includes the consideration of project noise and electric and magnetic fields from the transmission line in the HHRA TDR (Appendix 7.12A: Stantec 2021a). If the HHRA results indicate that there are negligible effects to human health from project noise or electric and magnetic fields, no further assessment of that pathway is required in the HHRA TDR. If the HHRA results indicate that there is a potential effect to human health from project noise and electric and magnetic fields, a detailed assessment is conducted, and the results are summarized in the human health valued component.
Scope of the Assessment	The Gitxaała Nation requested that psychosocial and other non-physiological determinants of health and well-being be included in the human health valued component or advise where these other health indicators are assessed in the Application.	The human health valued component and HHRA TDR (Appendix 7.12A: Stantec 2021a) characterizes physiological aspects of health using the assessment methods prescribed by Health Canada. Psychosocial and other non-physiological aspects of health (e.g., economic health, psychological health, emotional health, cultural health) are described in the Human and Community Well-Being section of this Application (Section 22.0) or requires an assessment by a licensed medical professional if the effects are unique to an individual and their personal circumstances and conditions.
Chemicals of Potential Concern	Health Canada requested that diesel particulate matter, volatile organic compounds, polycyclic aromatic hydrocarbons, and ozone be considered as possible chemicals of potential concern in the assessment of human health.	The HHRA TDR (Appendix 7.12A: Stantec 2021a) considers diesel exhaust, volatile organic compounds, polycyclic aromatic hydrocarbons, ozone, and carbon monoxide as possible chemicals of potential concern. Chemicals that are classified as chemicals of potential concern are carried forward into the human health valued component for discussion. Chemicals that are not classified as chemicals of potential concern are not carried forward in the human health valued component for discussion, with the technical rationale described in the HHRA TDR.

TABLE 7.12.1 SUMMARY OF KEY INFORMATION AND CONCERNS FOR THE PROJECT RELATED TO HUMAN HEALTH

Topic	Key Information and Concerns	Influence on the Assessment
Traditional Food Harvest and Consumption Patterns	Cedar proposed to the Haisla Nation in 2019 to conduct Country Food Surveys to characterize the Haisla Nation's current traditional food harvesting and consumption practices.	Haisla Nation has not responded to Cedar's request to conduct a survey on traditional harvesting and consumption practices. The absence of this information has limited influence on the assessment of human health because the country food consumption exposure pathway was characterized as an inoperable pathway. Indigenous knowledge regarding the types of traditional foods consumed by Indigenous Nations is described in the human health risk assessment (Appendix 7.12A) from desktop studies.
Existing Human Health Studies	Ministry of Health requested that the report, "*Human Health Risk Assessment for Workers in the Workforce Accommodation Center (Cedar Valley Lodge): LNG Canada Export Terminal EAC E15-01 Condition 19*" (LNG Canada 2019) be considered in the assessment of human health for the Project.	The HHRA TDR (Appendix 7.12A: Stantec 2021a) includes a review of the cited LNG Canada report, and applies its findings as part of the rationale for selecting project-related chemicals of concern and operable exposure pathways.

7.12.3 Selection of Potential Effects and Indicators/Measurable Parameters

Potential effects of the Project on human health are identified in Table 7.12.2, as specified by the AIR. For each effect in Table 7.12.2, effect pathways, and indicators/measurable parameters have been identified to facilitate the quantitative or qualitative measurement of change in project-specific and cumulative effects potentially caused by the Project.

Where possible, the assessment of potential effects on human health uses quantifiable measurable parameters. The assessment may also include a qualitative assessment through use of scientific literature, input from Indigenous Nations, and professional judgment based on experience with similar projects.

TABLE 7.12.2 POTENTIAL EFFECTS, EFFECTS PATHWAYS AND INDICATORS/MEASURABLE PARAMETERS FOR HUMAN HEALTH

Potential Effect	Effect Pathway	Indicator and/or Measurable Parameter(s) and Units of Measurement
Change to human health	Project-related changes to the quality (i.e., chemical content) of air, soil, sediment, water, and biota can result in changes in human exposure to chemicals of potential concern. Project-related changes to levels of noise and electric and magnetic fields can result in changes in human exposure and subsequent health effects.	Hazard quotient (HQ)—the hazard quotient applies to non-carcinogenic effects, and it is the ratio between the dose (or exposure concentration) of a COPC to its toxicological reference value (i.e., the acceptable health-based dose or concentration) Incremental Lifetime Cancer Risk—the incremental lifetime cancer risk is a measurable parameter that applies to carcinogenic effects. It is the change in lifetime cancer risk associated with exposure to carcinogenic COPCs. Change in percent highly annoyed (%HA)—the change in the %HA people between existing noise levels to project-related noise levels. Sleep disturbance—an outdoor nighttime noise level of 60 dBA that should not be exceeded at any time, and an outdoor nighttime continuous average noise level of 45 dBA should not be exceeded. Change in electric and magnetic field exposure above background levels.

7.12.4 Boundaries

The spatial, temporal, administrative, and technical boundaries for the assessment of effects on human health are described below.

7.12.4.1 SPATIAL BOUNDARIES

The spatial boundaries for the human health valued component include the spatial boundaries of other valued components for which project-related changes in the exposure media are predicted or modelled. For example, if there is a predicted or modelled change in air quality for the Project, the spatial boundary for that effect is the modelling domain for which air quality is predicted. This is because project-related change to the exposure media is the underlying driver of health risk from exposure to chemicals or hazards. For this reason, the LAA and RAA are unique for each effect pathway. Figure 7.12.1 and Figure 7.12.2 illustrate the spatial boundary of the human health valued component for each effect pathway:

- **Air Quality**—A 40 km by 40 km square domain centered on the Project, which is used to predict project-related changes in air quality around the Project. A second domain that applies to the marine shipping route includes a 1.5 km zone on either side of the marine shipping route centreline from the Project to Triple Islands, and includes the Indigenous communities of Hartley Bay, Kitkatla, and Metlakatla Village, which are located outside of the 1.5 km zone. The spatial boundary for air quality effects on human health is based upon the spatial domain of the air quality dispersion model that was conducted as part of the air quality valued component. The LAA and RAA for air quality effects are the same.
- **Acoustic**—An area 3 km in all directions from the Project Area, transmission line corridor, and shipping route. The LAA/RAA extends 3 km from the Project Area to encompass the nearest community Kitamaat Village (Kitamaat 2). The spatial boundary for acoustic effects on human health is based upon the spatial domain of the acoustics model that was conducted as part of the acoustics valued component. The LAA/RAA for acoustic effects are the same.

7.12.4.2 TEMPORAL BOUNDARIES

The temporal boundaries for human health include all project phases, because each phase includes a different set of project activities responsible for the emission or discharge of COPCs.

Based on the current project schedule, the temporal boundaries for the human health assessment are:

- **Construction:** up to approximately four years long, commencing following receipt of necessary regulatory approvals and a final investment decision by Cedar.
- **Operation:** pursuant to Licence GL-327 issued by the National Energy Board (now Canada Energy Regulator), the Project will operate for 25 years following completion of construction. Cedar may apply to extend GL-327 to a 40-year term. A 40-year lifespan will be used for the purposes of this Application.
- **Decommissioning:** approximately 12 months following the end of operation.

When an effect pathway is quantified for its effects to human health, only the worst-case project phase is considered. For example, the project phase with the greatest environmental effect on air quality or noise is used to represent the effect pathway. If there is no unacceptable health risk under the worst-case project phase, there would also be no unacceptable health risk from the other project phases.

7.12.4.3 ADMINISTRATIVE BOUNDARIES

There are no administrative boundaries imposed by political, economic, or social constraints related to human health.

7.12.4.4 TECHNICAL BOUNDARIES

There are no technical boundaries related to human health.

7.12.5 Existing Conditions

Human health is influenced by multiple environmental factors such as the quality of air that people breathe, the quality of water that people drink, and the quality of food that people eat. In the context of this assessment, the "quality" of air, soil, sediment, water, and country foods refers to the chemical content in the environmental media. This means that a change in water or soil quality refers specifically to the chemical or contaminant load in the water or soil. The existing condition for human health is the combined effect that these environmental factors may have on people.

When the Project influences one or more of these environmental factors, establishing the existing conditions for that effect pathway is necessary to identify the project-related change.

The potential health effect from exposure to chemicals in the environment is based upon scientific studies on how contaminants interact with the human body. Indigenous knowledge or personal perceptions do not influence how contaminants interact with the human body, and are therefore not applicable to the description of existing conditions for human health.

In the HHRA TDR (see Section 3.3, Appendix 7.12A: Stantec 2021a), 20 exposure pathways were considered for their potential effects on human health. These exposure pathways are discussed in detail in Section 7.12.6 (Project Interactions with Human Health). Among these exposure pathways, two were identified as "operable pathways", meaning that there is a complete pathway for people to be exposed to project-related contaminants or environmental effects that could affect human health. The two operable pathways include:

1. Inhalation of air COPCs during the operation phase
2. Exposure to project-related noise during the construction and operation phases

Therefore, the existing air quality and acoustic conditions are applicable to the human health valued component. Data on existing air quality and acoustic conditions come from their respective valued component chapters and supporting TDRs including:

- Air quality (Section 7.2); Air Quality TDR (Appendix 7.2A: Stantec 2021b)
- Acoustic (Section 7.3); Acoustic TDR (Appendix 7.3A: Stantec 2021c)

The existing air quality and acoustic conditions are presented in Section 7.12.7 (Assessment of Residual Effects on Human Health) along with the project-related conditions since the assessment is based upon the project-related change to human health.

7.12.6 Project Interactions with Human Health

Table 6.6.1, Section 6.6 (Project Interactions), identifies the potential interactions between the Project's components and physical activities with human health; these interactions are consistent with Table 6.4.1 of the AIR. Interactions that have been identified (ranked as 1 or 2) are carried forward and assessed within this section. Where a ranked interaction has been identified, Table 7.12.3 identifies the potential effects on human health. This is followed by a discussion of how project activities and physical works may result in changes to human health.

Potential exposure pathways are screened and characterized as either an operable pathway or an inoperable pathway. Operable pathways are assessed in greater detail in the assessment and HHRA TDR (Appendix 7.12A: Stantec 2021a). Inoperable pathways are not assessed further. A rationale is provided for characterizing an exposure pathway as operable or inoperable.

TABLE 7.12.3 POTENTIAL PROJECT INTERACTIONS AND EFFECTS ON HUMAN HEALTH

Project Activities and Physical Works	Potential Project Effects
	Change in Human Health
Construction	
Site preparation and clearing	1
Construction of land-based infrastructure	1
Construction of marine-based infrastructure	1
Marine transport of construction materials to the site	1
Vehicle traffic	1
Operation	
Pre-treatment, liquefaction, storage and offloading of natural gas at the FLNG facility	2
LNG carrier loading	1
Marine shipping and transportation	1
Facility and infrastructure maintenance	1
Vehicle traffic	1
Decommissioning	
Decommissioning of land-based infrastructure	1
Decommissioning of marine-based infrastructure	1
Marine transport of decommissioned infrastructure	1
Vehicle traffic	1

Key:

1 = Potential adverse effect requiring additional mitigation; warrants further consideration.

2 = Key interaction resulting in potential adverse effect of particular importance or concern; warrants further detailed consideration

+ = Potential positive effect that can be enhanced; warrants further consideration

NOTE:

Only activities with an interaction of 1, 2 or + for at least one effect are shown

7.12.6.1 EXPOSURE PATHWAYS FOR HUMAN HEALTH

The assessment of human health begins with the development of an overall understanding of how people may be exposed to chemicals and hazards from the project activities and physical works, so that potential health risks can be evaluated. The first step is to identify the three components of health risk:

1. **Chemicals of potential concern or hazard** – Identifying the project-related chemicals released to each type of environmental media (e.g., air, soil, sediment, water, biota) and/or other hazards (e.g., noise) that could adversely affect human health.
2. **Human receptors** – Identifying the types of people within the LAA or RAA that could be exposed to COPCs or hazards (e.g., residents, Indigenous groups, recreational users, children, adults).
3. **Exposure pathways** – Identifying the plausible pathways through which human receptors could be exposed to COPCs and hazards.

These three components of health risk are integrated to develop a conceptual site model. The conceptual site model lists the exposure pathways that are considered in the human health valued component and characterizes each as either an operable pathway (i.e., a plausible risk exists from exposure to chemicals of potential concern or hazards) or an inoperable pathway (i.e., a non-plausible risk from exposure to chemicals of potential concern or hazards).

An operable pathway triggers a more detailed investigation of the pathway for its potential effects on human health. If one or more component of risk is absent, the exposure pathway is characterized as an inoperable pathway. An inoperable pathway indicates that there may be no human receptors, no COPC, or no exposure route between the human receptor and the COPC/hazard. There would be no change in human health risk, and a more detailed assessment is not necessary.

Table 7.12.4 lists the exposure pathways that were considered in the HHRA TDR (Appendix 7.12A: Stantec 2021a). The table shows whether there were any project-related COPCs released to the environmental media (e.g., air, soil, sediment, water), whether there are any human receptors applicable to the exposure pathway, and the determination of whether the pathway is an operable or inoperable pathway.

The operable pathways include:

1. **Pathway 1** – Inhalation of air COPCs
2. **Pathway 19** – Exposure to project-related noise

Table 7.12.4 shows that for these two operable pathways, the operation phase of the Project represents the worst-case phase as it relates to emissions of COPCs in the air and noise levels based on the ranking of 2. However, as an outcome from consultation with the Haisla Nation regarding the potential construction noise effects to residents of Kitamaat Village, the construction phase is also considered.

TABLE 7.12.4 EXPOSURE PATHWAYS CONSIDERED IN THE HUMAN HEALTH VALUED COMPONENT

Environmental Media	Pathway	Description of Exposure Pathway	Project-related COPC	Presence of Human Receptors	Operable or Inoperable Pathway
Air	1	Inhalation of COPCs in the air	Yes	Yes	***Operable***
Soil	2	Incidental ingestion of soil containing COPCs	No	Yes	Inoperable
	3	Dermal absorption of COPCs from soil adhering to skin	No	Yes	Inoperable
	4	Inhalation of suspended soil particulates containing COPCs	No	Yes	Inoperable
	5	Inhalation of vapours migrating from soil to air	No	No	Inoperable
Sediment	6	Incidental ingestion of sediment containing COPCs	No	No	Inoperable
	7	Dermal absorption of COPCs from sediment adhering to skin	No	No	Inoperable
Surface Water	8	Incidental ingestion of surface water containing COPCs	No	Yes	Inoperable
	9	Ingestion of surface water containing COPCs from drinking/cooking	No	Yes	Inoperable
	10	Dermal contact with surface water containing COPCs	No	Yes	Inoperable
	11	Inhalation of COPC vapours from showering/cooking	No	Yes	Inoperable
Groundwater	12	Ingestion of groundwater containing COPCs from drinking/cooking	No	No	Inoperable
	13	Inhalation of COPC vapours from showering/cooking	No	No	Inoperable
	14	Inhalation of COPC vapours from contaminated groundwater to air	No	No	Inoperable
	15	Dermal contact with groundwater containing COPCs from bathing	No	No	Inoperable
Country Foods	16	Ingestion of vegetation grown on soils affected by project COPCs	No	Yes	Inoperable
	17	Ingestion of wild game harvested from areas affected by project COPCs	No	Yes	Inoperable
	18	Ingestion of seafood harvested from marine areas affected by project COPCs	No	Yes	Inoperable
Other	19	Noise: exposure to noise from project activities and physical works	Yes	Yes	***Operable***
	20	Electromagnetic fields: exposure to electromagnetic fields from the transmission line	No	Yes	Inoperable

7.12.6.2 RATIONALE FOR OPERABLE PATHWAYS

Pathway 1 (Air Pathway)

During all phases of the Project, vehicle and equipment exhaust is produced from fuel combustion and released into the air. The operation of the FLNG facility also produces COPC emissions into the air from flaring. These emissions disperse from their point of origin into the atmosphere. As a result, people in the air quality LAA/RAA may be exposed to these COPCs through inhalation.

The COPC screening process described in the HHRA TDR (see Section 3.2 of Appendix 7.12A: Stantec 2021a) identified the COPCs in the air to be sulphur dioxide, nitrogen dioxide and $PM_{2.5}$. Data from the air quality valued component and its TDR shows that the existing concentration of these COPCs in the air already exceed provincial and federal air quality objectives and standards in certain areas within the LAA/RAA. This qualifies these substances as COPCs. Substances that were not identified as COPCs include metals, coarse particulate matter, carbon monoxide, hydrogen sulfide, volatile organic compounds, polycyclic aromatic hydrocarbons, and diesel exhaust / diesel particulate matter.

The human receptors that are exposed to COPCs in the air though the inhalation exposure route includes all people in the LAA/RAA. The presence of COPCs, human receptors, and an exposure route for people to be exposed to COPCs, qualifies this as an operable pathway.

Pathway 19 (Noise Pathway)

During the construction and operation phases of the Project, project activities and physical works will produce noise. Noise from vehicles, equipment, LNG carriers, and project infrastructure has the potential to adversely affect the quality of life of nearby residents or land users. These noise levels dissipate with distance and with barriers between the noise source and the human receptor. Therefore, it is necessary to identify the human receptors and their orientation and proximity to the Project to characterize the effects from noise.

The human receptors that are exposed to project-related noise include all people within the noise LAA/RAA. This includes residents in Kitamaat Village, people living within 3 km of the shipping route, recreational or temporary land users (e.g., campers, hikers), and Indigenous land users engaging in traditional use practices (e.g., harvesting country foods).

The presence of a hazard, human receptors, and a reasonable expectation that people will be exposed to project-related noise qualifies this as an operable pathway.

7.12.6.3 RATIONALE FOR INOPERABLE PATHWAYS

Pathway 2 to 5 (Soil Pathways)

The identified exposure pathways related to soil are inoperable pathways.

During the process of selecting valued components, changes to soil quality were deemed not applicable to this Project. Soil was not selected as a valued component and a characterization of changes to soil quality is not within the scope of the project environmental assessment. Valued components were selected through a process led by the EAO with support from the working group, which includes the Impact Assessment Agency of Canada, Indigenous Nations, federal and provincial regulatory agencies, and local government.

A review of the project activities during construction, operation, and decommissioning (including a review of the types of emissions, discharges, and wastes) did not identify potential COPCs in soil.

During the construction phase of the Project, consideration was given on whether the construction of land-based facilities such as the transmission line, administrative buildings, warehouses, electrical substation and road upgrades could change the soil quality. No point-source contaminant emissions were identified with these construction activities.

Further consideration was given on whether non-point sources of chemicals such as vehicle and equipment exhaust from fuel combustion could change soil quality to the degree that it could reasonably have an adverse effect on human health. This includes diesel exhaust, diesel particulate matter, polycyclic aromatic hydrocarbons, volatile organic compounds, and metals. Deposition of these substances from the air to the soil is a potential pathway to change soil quality.

As part of this investigation, studies from the nearby LNG Canada Export Terminal Project were considered. In 2019, LNG Canada conducted an HHRA to assess human health for its construction workers living at their workforce accommodation centre known as the Cedar Valley Lodge (LNG Canada 2019). This HHRA included the assessment of potential health effects to its workforce of up to 7,500 people during the construction phase because the Cedar Valley Lodge is located within 100 metres (m) of the LNG Canada Export Terminal Project's construction zone. Off-duty construction workers were assumed to have exposure characteristics comparable to permanent residents, and the proximity of the Cedar Valley Lodge to the construction zone suggested a heightened risk of exposure to construction-related chemical releases.

The LNG Canada HHRA included modelling of soil quality changes over the 8-year to 10-year construction period resulting from the deposition of substances in vehicle and equipment exhaust such as diesel particulate matter, polycyclic aromatic hydrocarbons, and metals. Fugitive dust from soil piles were also assumed to contribute metals to the surrounding soil. The soil quality modelling results indicated a negligible change in concentration of these substances over the 8-year to 10-year construction period, while volatile organic compounds that deposit to the soil were assumed to transition back into a gaseous state. This meant that construction of the LNG Canada Export Terminal Project did not contribute chemicals to the soil that qualified them as COPCs (LNG Canada 2019).

Based upon these conclusions, it is reasonable to expect that the Project would also have a negligible change in soil quality and that there would be no chemicals that qualify as a COPC.

The Project's land-based construction activities are substantially lesser in scope, scale, and duration compared to LNG Canada. The FLNG facility for the Project is a purpose-built facility constructed overseas and brought to the Project Area, compared to the land-based construction of the LNG processing facility for the LNG Canada Export Terminal Project. Land-based facilities for the Project include the transmission line, administrative buildings, warehouses, and an electrical substation. The nearest residence from the Project is approximately 3 km east, across Douglas Channel in Kitamaat Village, which is sufficient distance for vehicle and equipment exhaust to disperse in the air. While there may be recreational or temporary land users passing near the Project Area.

During the operation phase of the Project, land-based facilities such as the transmission line, administrative buildings, warehouses, and electrical substation do not discharge contaminants to the soil with the exception of releases associated with malfunctions and accidents.

Based on these findings, there are no COPCs applicable to soil, and the three conditions for an operable pathway are not met.

Pathway 6 to 7 (Sediment Pathways)

All exposure pathways related to sediment are inoperable pathways.

During the process of selecting valued components, changes to sediment quality were deemed not applicable to this Project. Sediment quality was not selected as a valued component and a characterization of changes to sediment quality is not within the scope of the Project's environmental assessment. Valued components were selected through a process led by the EAO with support from the working group, which includes the Impact Assessment Agency of Canada, Indigenous Nations, federal and provincial regulatory agencies, and local government.

The Project does not discharge chemicals or effluents into the marine environment that could affect sediment quality. The land-based infrastructure (i.e., administrative building, warehouse building, and electrical substation building) does not discharge chemicals to the marine environment that could affect sediment quality. The FLNG facility that is permanently moored at the marine terminal cools natural gas into a liquid. The extracted heat from the liquefaction process is dissipated by air coolers, meaning that water is not used for cooling. This design feature eliminates the release of heated water into the marine environment which could have higher than natural concentrations of salts and metals (due to water evaporation that concentrates solutes). This means that the Project is not expected to contribute COPCs to the marine sediment.

In addition, there is limited opportunity for human receptors exposure to marine sediment in the Project Area. The Project Area is located on private property, and the public will not be able to access the intertidal zone within the Project Area for recreational purposes during the operation phase, largely due to the risk to personal safety. This means that dermal contact with sediment or incidental ingestion of sediment while engaging in recreational activities is improbable. Based on this rationale, exposure pathways related to sediment are inoperable pathways because none of the three conditions for an operable pathway are met.

Pathway 8 to 11 (Surface Water Pathways)

The identified exposure pathways related to surface water are inoperable pathways.

The freshwater fish valued component (Section 7.6) describes the baseline surface water quality in nearby watercourses. This section also characterizes the Project's effect to surface waters from non-contaminants such as changes in erosion, suspended solids, and nutrient levels because these are important in the context of fish habitat and stream classification.

A review of the project components and project activities did not identify project-related contaminants to surface water, given that the Project is primarily based near the marine environment (with the exception of the transmission line).

The construction and operation of land-based infrastructure (e.g., road upgrades, administrative building, warehouse building, and electrical substation building) along the marine shoreline does not release chemical contaminants into the surface water. The Project also will not discharge or emit chemicals to nearby rivers, creeks or streams, meaning that there are no COPCs associated with the surface water exposure pathways.

Human receptors are likely to use nearby rivers, creeks, and streams for fishing or other recreational activities. Municipal water in Kitimat is drawn from the Kitimat River approximately 10 km northeast of the Project. Residents use this water for cooking, bathing and other domestic applications. However, there are no COPCs applicable to surface water, thus, in the absence of project-related COPC, surface water-related exposure pathways are considered inoperable for the purposes of this assessment.

Pathway 12 to 15 (Groundwater Pathways)

The identified exposure pathways related to groundwater are inoperable pathways.

During the process of selecting valued components, changes to groundwater quality were deemed not applicable to this Project. Groundwater quality was not selected as a valued component and a characterization of changes to groundwater quality is not within the scope of the Project's environmental assessment. Valued components were selected through a process led by the EAO with support from the working group, which includes the Impact Assessment Agency of Canada, Indigenous Nations, federal and provincial regulatory agencies, and local government.

The construction and operation of land-based infrastructure (e.g., road upgrades, administrative building, warehouse building, and electrical substation building) will not affect groundwater quality. During normal operation, the Project also will not discharge or emit chemicals that would affect groundwater quality, meaning that there are no COPCs associated with the groundwater exposure pathways. The Project is also located along the marine coastline, and saltwater intrusion would make the groundwater non-potable for drinking, cooking, and other domestic applications such as bathing. As a result, there are no human receptors applicable to the groundwater exposure pathways. Furthermore, the online British Columbia Water Resources Atlas does not show an aquifer or any water wells to be present in the vicinity of the Project.

Since there are no COPCs applicable to groundwater, no current human receptors that access groundwater, and no reasonable expectation that human receptors would access groundwater in the future (due to saltwater intrusion), none of the three conditions for an operable pathway are met.

Pathway 16 to 18 (Country Food Pathways)

All exposure pathways related to country foods are inoperable pathways.

The country food pathways are related to Indigenous people, hunters, trappers, and recreational users (fishers, campers, tourists) harvesting food from the land and water. While there are human receptors that engage in all of these activities, the change in human health from harvesting and consuming country foods is based upon changes in the food quality.

For example, Pathway 16 (ingestion of vegetation grown on soils affected by project COPCs) requires a change in soil quality for a COPC because plants absorb nutrients and minerals from the soil via their roots. Since there are no project-related COPCs in the soil, there are no project-related changes to the quality of vegetation that would be captured using predictive modelling techniques.

This also applies to Pathway 17 (ingestion of wild game harvested from areas affected by project COPCs). Wild game (e.g., deer, moose, rabbit) absorb nutrients and minerals from their environment. The quality of wild game meat depends on their diet (e.g., prey animals, vegetation), incidental ingestion of soil (i.e., consumption of soil attached to vegetation or soil adhered onto prey), and the quality of the surface water that is consumed. Since there are no project-related COPCs in the soil and surface water, there are no changes to the quality of wild game that would be captured using predictive modelling techniques.

For Pathway 18 (ingestion of seafood harvested from marine areas affected by project COPCs), the quality of seafood depends on marine water quality and sediment quality. Since there are no project-related COPCs in the marine environment, there are no changes to the quality of seafood that would be captured using predictive modelling techniques.

Another consideration for Pathway 18 is the possibility that the Project could cause existing contaminants in the sediment to recirculate into the marine environment and affect the quality of seafood. This was the premise for an investigation on seafood quality effects from the nearby LNG Canada Export Terminal Project, located in Kitimat Harbour (LNG Canada 2015). The marine sediment within Kitimat Harbour is confirmed to contain man-made contaminants from decades of industrial use. To accommodate LNG carriers mooring at the site, dredging of these contaminated sediments is required to deepen the harbour to at least 14 m below sea level. Concern was raised over the possibility that dredging of these contaminated sediments could create a sediment plume and bring sequestered contaminants in the sediment back into the marine environment and contaminate marine life and the seafood that local people harvest and consume.

This premise does not apply to the Project, since dredging is not required, and the Project Area has had no prior commercial or industrial activity except for past use as a log sort. Furthermore, dredging is not required for the Project. Bathymetry data shows that the location where the LNG carriers will moor alongside the FLNG facility has a water depth ranging from 70 to 100 m below sea level.

Based on this rationale, all exposure pathways related to country foods are inoperable pathways.

Pathway 20 (Electromagnetic Field Pathway)

An electromagnetic field is an electric and magnetic field produced by an electric charge and electrical current. Electromagnetic fields are produced by all electronic devices (television monitors, computers, cars, household appliances, cell phones, and lights). The consideration of this exposure pathway in regard to the electromagnetic field fields produced by the 287-kV transmission line was requested by Health Canada during the development of the AIR.

The potential health effects from exposure to the electromagnetic fields from the transmission line is an inoperable exposure pathway. The transmission line will run from the existing BC Hydro Minette Substation for approximately 8 km to the Project Area. While there may be human receptors that use the cleared right-of-way to access the land, the type of electromagnetic field that the transmission line produces is not hazardous to human health. The transmission line would produce an extremely low-frequency electromagnetic field of 60 hertz along the right-of-way. The International Commission on Non-Ionizing Radiation Protection states that current research has not shown a detrimental health effect from long-term low-frequency electromagnetic field exposure (ICNIRP n.d.).

Health Canada’s publications also state similar conclusions where (verbatim), “The potential health effects of extremely low frequency electromagnetic field has been studied extensively. While some people are concerned that long term exposure to extremely low frequency electromagnetic fields may cause cancer, the scientific evidence does not support such claims.” (Health Canada 2020).

The International Commission on Non-Ionizing Radiation Protection recognizes that the body of research supporting potential adverse health effects from electromagnetic fields is focused on high-frequency fields in the megahertz (i.e., 1 million hertz) or gigahertz (i.e., 1 billion hertz) frequency range, rather than extremely low-frequency electromagnetic fields associated with power transmission.

Although there may be human receptors along the transmission line right-of-way, the extremely low-frequency electromagnetic fields produced by the transmission line is not recognized as a hazard, and it is not recognized as having a detrimental health effect to people. The conditions for an operable pathway for electromagnetic fields are not met.

7.12.7 Assessment of Residual Effects on Human Health

The assessment of residual effects on human health is based upon the conclusions described in the HHRA TDR (Appendix 7.12A: Stantec 2021a) and the acoustic TDR (Appendix 7.3A: Stantec 2021c). The complete technical details regarding the assessment methods and data sources are discussed in these reports.

Also included is a description of the residual effects characterization in the context of the environmental assessment.

The residual effects on human health are based upon the comparison of air contaminant levels and noise levels to their respective health risk thresholds. These health risk thresholds are typically protective of health-sensitive people within a population. For example, health risk thresholds for air quality are protective of people with existing respiratory conditions such as asthma or chronic obstructive pulmonary disease. Health risk thresholds for noise are protective of people with lower noise tolerances such as people living in quiet rural areas.

Factors such as sex, age, gender identity, and ethnicity as defined under gender-based analysis plus (GBA+1) typically do not result in a different or disproportionate residual effect to human health. Specific to this assessment, exposure to air contaminants and noise do not result in different health outcomes based on a person's sex, age, gender identity, or ethnicity. There are also no health risk thresholds based on differences in sex, age, gender identity, and ethnicity. For this reason, GBA+1 analysis does not apply to the assessment of human health.

7.12.7.1 ASSESSMENT METHODS

This section provides a high-level summary of the assessment methods used to characterize the change in human health from the inhalation of air COPCs and noise-related annoyance rates and sleep disturbance. The assessment methods to characterize the residual effects to human health in the context of an environmental assessment are also provided.

Assessment Methods for Inhalation of COPCs in Air

Within the LAA/RAA around the Project Area, the change in human health from the inhalation of COPCs in the air is based upon the CALPUFF air dispersion modelling results presented in the air quality TDR (Appendix 7.2A: Stantec 2021b). The CALPUFF air dispersion model was designed to predict the concentration of COPCs in the air during the operation phase of the Project.

The CALPUFF air dispersion model predicted the air quality conditions under three scenarios:

- **Base case**—The base case represents the existing concentration of COPCs in the air within the LAA/RAA. The base case includes COPC concentrations in the air from natural background sources, existing commercial and industrial facilities (e.g., Rio Tinto Aluminum Smelter, LNG Canada Export Terminal Project), and non-point sources (e.g., emissions from the population centres of Kitimat, Kitamaat Village).

- **Project-alone case**—The project-alone case represents the dispersion of project-generated COPCs in the air within the LAA/RAA. The project-alone scenario excludes the emissions from natural background sources, existing commercial and industrial facilities, and existing non-point sources and therefore does not represent conditions that could exist. This modelling scenario is applied only to illustrate the spatial extent of project-generated COPC dispersion in the air.
- **Application case**—The application case represents the future concentration of air COPCs in the LAA/RAA during the operation phase of the Project. The application case combines the emissions from the base case and project-alone case.

The concentration of each air COPC is averaged over short-term durations (e.g., 1-hour, 24-hours) and long-term durations (e.g., annual average) to distinguish between short-term acute health effects, and long-term chronic health effects. The averaging period used for each air COPC includes:

- 1-hour sulphur dioxide
- 1-hour nitrogen dioxide
- Annual nitrogen dioxide
- 24-hour $PM_{2.5}$
- Annual $PM_{2.5}$

The long-term effects from sulphur dioxide inhalation are not assessed based upon Health Canada review of the existing scientific literature that concludes there is inadequate evidence to infer a causal relationship between long-term exposures to sulphur dioxide and health effects (Health Canada 2016d).

For each air quality modelling scenario, there is a location known as the Maximum Point of Impingement (MPOI). The MPOI is the location with the highest concentration of the COPC. For the base case and application case, the MPOI location will typically be located in the general vicinity or downwind of the largest emission source. For the project-alone case, the MPOI location will be in the immediate vicinity of the Project since it is the only source of the COPC. The MPOI location is important because it indicates the location with the highest potential health risk (assuming that there are people at the location). If the MPOI location changes between base case and application case, it means that the Project's contribution of COPCs in the air shifts the location with the highest potential risk. If the MPOI location does not change between base case and application case, it means that the Project's contribution of air COPCs has limited effect on the location with the highest potential risk.

The health risk associated with each COPC is defined by the Hazard Quotient (HQ). The HQ is the ratio between the COPC concentration and the toxicological reference value (TRV). The TRV is the exposure benchmark that indicates the potential for an adverse health risk. The HQ is calculated using the following formula:

$$\text{Hazard Quotient (HQ; unitless)} = \frac{COPC\ Concentration\ in\ the\ Air\ (\frac{\mu g}{m3})}{Toxicological\ Reference\ Value\ \ (\frac{\mu g}{m3})}$$

The HQ is calculated for the base case and application case scenarios to characterize the incremental change in health risk associated with the Project. The risk threshold is defined as a HQ 1.0, or in cases where the base case HQ is near or greater than 1.0, an increase of 0.2 or greater from the base case to the application case. Overall, an HQ greater than 1.0 may indicate an unacceptable health risk at a specific human receptor location. The purpose of this assessment is to identify the potential change in human health risk that may be attributed to the Project.

Since the COPC concentration in the air varies by location, the HQ also varies by location. Therefore, a set of human receptor locations have been identified to characterize the health risk at specific locations of interest within the LAA/RAA. Human receptor locations include places where health-sensitive people such as children, elderly or sick people may be located (e.g., daycares, schools, hospitals), residences within a population center (e.g., Kitimat, Kitamaat Village, Cedar Valley Lodge), or recreational sites (e.g., camping sites). The human receptor locations are shown in Table 7.12.5, and illustrated in Figure 7.12.3. The base case and application case HQs are calculated for each of the COPCs in the air for each human receptor location.

Within the LAA/RAA along the shipping route, a plume dispersion study was used to predict the change in air quality when an LNG carrier and escort tugs pass near the community of Harley Bay (Receptor 30) which is located 3 km away from the shipping route. The plume dispersion results for Hartley Bay are applied to infer the potential effects on more the more distant communities of Kitkatla (15 km away from the shipping route) and Metlakatla Village (30 km away from the shipping route).

TABLE 7.12.5 HUMAN RECEPTOR LOCATIONS FOR INHALATION OF COPCS IN AIR

Receptor #	UTM Zone 9		Description
	Easting	Northing	
1	524512	5990357	Mount Elizabeth Secondary High School
2	524114	5989809	Nechako Elementary School
3	522251	5989177	Kildala Elementary school
4	524975	5989606	St Anthony's Catholic Elementary School
5	523302	5989884	Kitimat City High School
6	523150	5980708	Haisla Community School
7	523016	5980749	C'Imo'Ca Child Care Centre
8	524529	5990549	Kitimat Child Development Centre
9	524198	5990214	Stepping Stones Preschool
10	523067	5989132	Kitimat General Hospital and Health Centre
11	522881	5980891	Kitamaat Village - Haisla Recovery Centre
12	523078	5981322	Kitamaat Village - Nearest Residence
13	522056	5988463	Kitimat - Nearest Residence 1
14	521314	5989938	Kitimat - Nearest Residence 2
15	523502	5986309	SE residence
16	522694	5991544	Kitimat Residence - North
17	524485	5993829	N Kitimat (SW)
18	524907	5994564	N Kitimat (NW)

TABLE 7.12.5 HUMAN RECEPTOR LOCATIONS FOR INHALATION OF COPCS IN AIR

Receptor #	UTM Zone 9		Description
	Easting	Northing	
19	525922	5994860	N Kitimat (NE)
20	526001	5993572	N Kitimat (SE)
21	522929	5989229	Kiwanis Senior Society
22	516535	5968079	Coste Island
23	519911	5982474	Southwest Dockyard
24	519840	5981852	Half Moon Bay
25	525621	5986610	Minette Bay
26	524665	5987418	Minette Bay Lodge
27	520279	5989605	Kitimat Service Area
28	533408	5965438	Kildala Beach
29	519080	5986420	Cedar Valley Lodge
30	483350	5919450	Hartley Bay (3 km from shipping route)
31	405700	6021960	Metlakatla Village (30 km from shipping route)
32	405760	5961600	Kitkatla (15 km from shipping route)

Assessment Methods for Exposure to Noise

The assessment of human health from exposure to noise is based upon the increase in annoyance rates and sleep disturbance. Annoyance generally applies to all times of the day, while sleep disturbance applies to nighttime hours.

Annoyance Rates

The effect of noise on human health varies by individual and their environmental setting. For example, people living in rural areas could be considered to have a greater expectation of “peace and quiet” relative to people living in densely populated urban cities. Health Canada considers a “quiet rural area” to be an area with a *day-night equivalent sound level* (L_{dn}) of 45 dBA or less due to human-made sounds. People living in urban areas may be acclimated to the higher levels of noise throughout the day and are therefore less susceptible to being annoyed by noises that would affect a person from a rural setting. Due to this variable, the assessment of human health from noise effects is based on the incremental increase of the population’s annoyance rates from the existing scenario to the project scenario.

The Health Canada noise guidance uses the percent highly annoyed (%HA) metric to quantify annoyance due to noise effects for activities with a duration of more than 12 months. The %HA was used to quantify the construction and operation noise effect based on the following formula:

$$\%HA = \frac{100}{1+e^{[10.4-0.132*Ldn]}}$$

The %HA is calculated for the base case (i.e., existing noise conditions), construction case and operation case. The difference in %HA between the construction/operation case and the base case is the change in %HA.

Health Canada's noise guidance recommends the highest increase for change in %HA is 6.5% at a human receptor location with an exposure duration of more than one year. This means that the %HA metric does not apply to recreational land users (e.g., campers, hikers, hunters and other temporary land users). If the change in %HA exceeds 6.5%, effects are of concern and may require mitigation. Health Canada also recommends mitigation of project noise if it exceeds L_{dn} of 75 dBA at a receptor, even if the change in %HA does not exceed 6.5%. Impulsive and tonal characteristics of source noise are accounted for in the %HA calculations because their presence can increase annoyance.

Noise levels vary in proximity to the source of the noise, so human receptor locations have been identified throughout the acoustic LAA/RAA in Table 7.12.6, and illustrated in Figure 7.12.4. To be conservative and because human receptor locations along the shipping route are few in numbers, some human receptor locations are slightly outside of the LAA/RAA.

Sleep Disturbance

To assess sleep disturbance, Health Canada recommends the use of noise guidelines prescribed by the World Health Organization for community noise (WHO 1999). The World Health Organization guideline recommends a target for sleep disturbance as being an indoor sound level of no more than 30 dBA based on the energy equivalent sound level (L_{eq}) for continuous noise during the sleep period (WHO 1999). Health Canada also recommends that indoor sound levels not exceed 45 dBA more than 10 to 15 times per night to provide for a good sleep environment. As per Health Canada noise guidance, the recommended outdoor-to-indoor transmission loss with windows at least partially open is 15 dBA and fully closed windows are assumed to reduce outdoor sound levels by approximately 27 dBA. Therefore, the equivalent outdoor levels should not be more than 60 dBA. The outdoor noise level of 45 dBA L_{eq} was also used as the threshold for continuous noise (Health Canada 2016c).

TABLE 7.12.6 HUMAN RECEPTOR LOCATIONS FOR NOISE EFFECTS

Receptor #	UTM Zone 9		Description
	Easting	Northing	
1	523066	5980755	Kitamaat Village Childcare Centre
2	523151	5980707	Kitamaat Village School
3	522957	5980687	Kitamaat Village Church
4	523179	5980675	Kitamaat Village Health Centre
5	483667	5919585	Hartley Bay Residence
6	481423	5908389	Gil Island Traditional Use Area
7	478990	5902839	Fin Island Traditional Use Area
8	460900	5896173	Otter Channel Traditional Use Area
9	432995	5928312	Anger Island Traditional Use Area
10	404163	5943106	Banks Island North Traditional Use Area
11	408572	5946470	McCauley Island Traditional Use Area
12	440131	5914969	Banks Island South Traditional Use Area
13	522774	5979712	Kitimaat Village Residence 1
14	522934	5980462	Kitimaat Village Residence 2
15	522869	5981030	Kitimaat Village Residence 3
16	523078	5981322	Kitimaat Village Residence 4
17	509425	5967551	Jesse Lake
18	516262	5986538	Anderson Creek 1 Traditional Use Area
19	518978	5985696	Anderson Creek 2 Traditional Use Area
20	519186	5984492	Moore Creek 1 Traditional Use Area
21	519220	5984496	Moore Creek 2 Traditional Use Area
22	509376	5967643	West Lake Traditional Use Area
23	523016	5980749	C'Imo'Ca Child Care Centre
24	522881	5980891	Haisla Recovery Centre
25	516535	5968079	Coste Island Traditional Use Area
26	519911	5982474	SW dockyard
27	519840	5981852	Half Moon Bay Traditional Use Area
28	520279	5989605	Kitimat Service Area

Residual Effects Characterization

Table 7.12.7 presents definitions and criteria that are used to characterize the residual effects on human health.

TABLE 7.12.7 CHARACTERIZATION OF RESIDUAL EFFECTS

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Direction	The long-term trend of the residual effect	**Positive—**a residual effect that moves the measurable parameters related to the effect in a beneficial direction relative to baseline. **Adverse—**a residual effect that moves the measurable parameters related to the effect in a detrimental direction relative to baseline. **Neutral—**no net change in measurable parameters relative to baseline.
Magnitude	The amount of change in measurable parameters or the valued component relative to existing conditions	**No Measurable Change—**no measurable change in human health from existing conditions. **Low—**Low change in human health from existing conditions where the noise effect is below the %HA and sleep disturbance threshold; the air quality effect shows an application case HQ less than 1.0 or, where base case HQ is near or greater than 1.0 a, project increase in the HQ of 0.2 or less. **High—**High change in human health from existing conditions where the noise effect is above the %HA or sleep disturbance threshold; the air quality effect shows an application case HQ greater than 1.0, or where the base case HQ is near or greater than 1.0 a project increase in the HQ of 0.2 or more.
Extent[1]	The geographic area in which a residual effect occurs	**LAA**—residual effects extend into the LAA **RAA**—residual effects extend into the RAA
Duration	The time required until the measurable parameter or the valued component returns to its existing condition, or the residual effect can no longer be measured or otherwise perceived	**Short-term—**the residual effect is restricted to one year or less **Long-term—**the residual effect extends more than one year
Reversibility	Pertains to whether a measurable parameter or the valued component can return to its existing condition after the project activity ceases	**Reversible—**the residual effect is likely to be reversed after activity completion and reclamation **Irreversible—**the residual effect is unlikely to be reversed after activity completion and reclamation
Frequency	How often the residual effect occurs and how often during the Project or in a specific phase	**Single event—**effect occurs once **Multiple irregular event—**occurs at no set schedule **Multiple regular event—**occurs at regular intervals **Continuous—**occurs continuously

TABLE 7.12.7 CHARACTERIZATION OF RESIDUAL EFFECTS

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Affected Populations	The distribution of the effect amongst the population of affected people	**Evenly distributed—**the effect will be experienced by any or all subpopulations **Disproportionally distributed—**the effect will be experienced only by certain subpopulations or experienced more by certain subpopulations based on their proximity to the Project
Risk and Uncertainty	The level of uncertainty of the residual effect	**Underestimated**—the effects assessed are predicted to be an underestimate quantitively or qualitatively. **Overestimated**—the effects assessed are predicted to be an overestimate quantitively or qualitatively
NOTE: [1] LAA/RAAs are different for the air quality valued component and the acoustic valued component (see Section 7.12.4.1)		

Likelihood and Context of Residual Effects

The likelihood and context of a residual effect occurring was also assessed. In the context of human health, the residual effect is based upon project-related increases in COPC exposure. This means that when considering a COPC, the project-related effect to human health is typically an adverse effect. The likelihood is the probability of an adverse residual effects occurring to human health. Likelihood is determined by the degree or magnitude of the increased COPC exposure. Likelihood is determined based on an understanding of the potential effect and the likely effectiveness of available mitigation measures to reduce or avoid the residual effect. The categories and definitions for the likelihood of a residual effect on human health occurring are:

- **Low**—adverse interactions between the Project and human health can largely be avoided or mitigated and adverse residual effects are unlikely to occur
- **Medium**—adverse interactions between the Project and human health may be difficult to avoid or mitigate and adverse residual effects are likely to occur
- **High**—adverse interactions between the Project and human health cannot be practically avoided or mitigated and adverse residual effects are highly likely to occur

Key Residual Effects Threshold

A substantive adverse residual effect for human health is one that exposure that exceeds objectives established by relevant regulatory organization(s) and is likely to result in a long-term change in the health of an identified receptor(s).

7.12.7.2 ASSESSMENT OF CHANGE TO HUMAN HEALTH

This section describes the pathways, mitigation measures, predicted residual effects, and likelihood of predicted residual effects as they pertain to change in human health.

Project Pathways

Inhalation exposures to COPC in ambient air and exposure to noise during the construction, operation and reclamation phases of the Project could contribute to potential changes in human health risk. The change to human health from these pathways is generally a function of the person's proximity to the Project (due to dispersion of air emissions and dissipation of noise with distance from the source) and the duration of the exposure.

Therefore, the change to human health from noise and COPCs in the air included consideration of the location of the human receptor and the assumed exposure duration. Human receptors located in residential areas or confirmed structures that could be living facilities (e.g., cabins, hospitals) are assumed to be exposed 24 hours per day, 365 days per year. Human receptor locations associated with recreational or other types of land uses (e.g., schools, daycares) are assumed to be associated with short-term exposure durations (e.g., 1-hour to 24-hour exposure durations).

Mitigation and Enhancement Measures

Mitigation measures are actions taken to directly reduce the potential environmental effect on human health. Based on this definition, there are no recommended mitigation measures specific to human health to address health concerns related to air quality and noise.

The assessment of human health is an iterative process. If earlier iterations of the project design result in predictions of an unacceptable effect to human health, the project design is refined, and the human health assessment repeated until the final project design results in a prediction of no unacceptable effect to human health.

Since the environmental assessment only considers the final project design, previous iterations of the project design are not captured here. For example, the original project design included the option to power the LNG processing unit with gas-fired turbines, which would substantially increase COPC emissions to the atmosphere. The final project design uses electric power from the BC Hydro grid, and thus eliminates the need to produce power onsite thereby eliminating COPC emissions to the atmosphere associated with combustion.

For the acoustic valued component, an example of a mitigation measure is conducting noisy fabrication work at another site and transporting the finished product to the Project Area for installation or limiting construction activities to 0700 to 2200 every day (with the exception of special situations that require nighttime work such as emergencies or unplanned events), to meet the OGC's noise control guidelines at nighttime.

These mitigation measures for the air quality and acoustic valued components directly reduce COPC emissions in the air and noise levels, and they have an indirect effect of reducing the Project's predicted effects on human health. However, powering the FLNG facility through the power grid and conducting noisy fabrication work at another site are not mitigation measures specific to human health. After the mitigation measures air quality and acoustic were incorporated in the modelling of future project conditions, no further mitigation measures are required that are specific to human health.

Project Residual Effect

Inhalation of COPCs in the Air

To illustrate the project effects to air quality during the operation phase, the CALPUFF air dispersion modelling results are converted into isopleth maps which show concentration contours over space with the applicable averaging period (e.g., 1-hour, 24-hour, annual) and statistical metric. Concentrations of one-hour sulphur dioxide, one-hour nitrogen dioxide, annual nitrogen dioxide, 24-hour $PM_{2.5}$, and annual $PM_{2.5}$ are illustrated in isopleth maps for the base case, application case, and project-alone case. These isopleth maps include:

- Figure 7.12.5: 1-hour sulphur dioxide concentrations (base case)
- Figure 7.12.6: 1-hour sulphur dioxide concentrations (application case)
- Figure 7.12.7: 1-hour sulphur dioxide concentrations (project-alone case)
- Figure 7.12.8: 1-hour nitrogen dioxide concentrations (base case)
- Figure 7.12.9: 1-hour nitrogen dioxide concentrations (application case)
- Figure 7.12.10: 1-hour nitrogen dioxide concentrations (project-alone case)
- Figure 7.12.11: Annual average nitrogen dioxide concentrations (base case)
- Figure 7.12.12: Annual average nitrogen dioxide concentrations (application case)
- Figure 7.12.13: Annual average nitrogen dioxide concentrations (project-alone case)
- Figure 7.12.14: 24-hour $PM_{2.5}$ concentrations (base case)
- Figure 7.12.15: 24-hour $PM_{2.5}$ concentrations (application case)
- Figure 7.12.16: 24-hour $PM_{2.5}$ concentrations (project-alone case)
- Figure 7.12.17: Annual average $PM_{2.5}$ concentrations (base case)
- Figure 7.12.18: Annual average $PM_{2.5}$ concentrations (application case)
- Figure 7.12.19: Annual average $PM_{2.5}$ concentrations (project-alone case)

Project Residual Effects to Human Health from Sulphur Dioxide

Overall, the change in human health risk from short-term (one-hour) inhalation exposure to sulphur dioxide is negligible. Table 7.12.8 shows that the change in HQ from base case to application case is negligible for most human receptor locations including the two locations nearest to the Project (Receptor 23 and 24 – Southwest Dockyard and Half Moon Bay).

This is further supported by the project-alone case isopleth map Figure 7.12.7, which show that sulphur dioxide dispersion from the Project is limited to an approximate radius of 500 m and encompasses the two nearest human receptor locations. In addition, a comparison between the base case (Figure 7.12.5) and application case (Figure 7.12.6) one-hour sulphur dioxide isopleth maps show no meaningful change in the contour lines.

For health risks from sulphur dioxide along the marine shipping route, the plume dispersion study predicted that the one-hour sulphur dioxide concentration in Hartley Bay reaches a maximum of 4 $\mu g/m^3$. The maximum one-hour sulphur dioxide concentration of 4 $\mu g/m^3$ results in a conservative HQ estimate of 0.02. This value is conservative because the maximum (i.e., 100th percentile) concentration is used in the

HQ calculation rather than the 99th percentile of the one-hour daily maximum. It is also conservative because this maximum concentration takes place for only one hour every 7 to 10 days, shortly after an LNG carrier passes near Hartley Bay. If wind and climate conditions do not move the plume directly towards Hartley Bay, the one-hour sulphur dioxide concentration would be lower than 4 µg/m^3. Based on these results, the inhalation risk to Hartley Bay residents and people living along the marine shipping route from exposure to sulphur dioxide is negligible. For residents of Kitkatla and Metlakatla Village, which are even further from the marine shipping route, the risk from exposure to sulphur dioxide is also negligible.

TABLE 7.12.8 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR ONE-HOUR SULPHUR DIOXIDE

Receptor #	TRV[1] (µg/m^3)	1-hour SO_2 (µg/m^3)[1]		Hazard Quotient (unitless)		Change in HQ[2]
		Base	Application	Base	Application	
1	170	214.2	214.6	**1.26**	**1.26**	<0.01
2		215.5	216.1	**1.27**	**1.27**	<0.01
3		813.5	814.2	**4.79**	**4.79**	<0.01
4		196.3	196.7	**1.15**	**1.16**	0.01
5		542.6	543.0	**3.19**	**3.19**	<0.01
6		164.7	164.9	0.97	0.97	<0.01
7		168.1	168.2	0.99	0.99	<0.01
8		217.1	217.4	**1.28**	**1.28**	<0.01
9		250.8	251.3	**1.48**	**1.48**	<0.01
10		557.5	557.5	**3.28**	**3.28**	<0.01
11		167.6	167.7	0.99	0.99	<0.01
12		174.6	175.8	**1.03**	**1.03**	<0.01
13		363.9	365.2	**2.14**	**2.15**	0.01
14		421.5	422.1	**2.48**	**2.48**	<0.01
15		168.8	169.3	0.99	**1.00**	0.01
16		194.9	196.0	**1.15**	**1.15**	<0.01
17		276.5	276.7	**1.63**	**1.63**	<0.01
18		233.6	233.9	**1.37**	**1.38**	0.01
19		155.7	156.0	0.92	0.92	<0.01
20		119.9	120.4	0.71	0.71	<0.01
21		847.8	848.0	**4.99**	**4.99**	<0.01
22		141.1	142.7	0.83	0.84	0.01

TABLE 7.12.8 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR ONE-HOUR SULPHUR DIOXIDE

Receptor #	TRV[1] (µg/m^3)	1-hour SO_2 (µg/m^3)[1]		Hazard Quotient (unitless)		Change in HQ[2]
		Base	Application	Base	Application	
23	170	521.8	521.9	**3.07**	**3.07**	<0.01
24		434.3	434.6	**2.55**	**2.56**	0.01
25		244.3	244.7	**1.44**	**1.44**	<0.01
26		246.1	247.9	**1.45**	**1.46**	0.01
27		361.7	363.6	**2.13**	**2.14**	0.01
28		9.3	9.3	0.05	0.05	<0.01
29		439.4	440.0	**2.58**	**2.59**	0.01

NOTES:

[1] Based upon the 99th percentile of the 1-hour daily maximum sulphur dioxide (SO_2) concentration

[2] Effect threshold for change in HQ is 0.2.

Bold underline indicates the hazard quotient is greater than 1.0 or the change in HQ is greater than 0.2. Both conditions are required to meet the key residual effects threshold.

Project Residual Effects to Human Health from Nitrogen Dioxide

Overall, the change in human health from short-term (one-hour) inhalation exposure to nitrogen dioxide is negligible. Table 7.12.9 shows the base case HQ at all human receptor locations. The Project's contribution to the HQ at all locations is less than the HQ threshold of 0.2 indicating that the Project is predicted to have a negligible contribution to human health from short-term inhalation exposures to nitrogen dioxide.

The project-alone isopleth map, Figure 7.12.10, shows the spatial extent of nitrogen dioxide dispersion from project emissions up to 10 km away. However, the overall concentration of nitrogen dioxide is low. A comparison of the base case (Figure 7.12.8) and application case (Figure 7.12.9) isopleth maps show a small change in the contour lines, where a larger area is affected with one-hour nitrogen dioxide concentrations greater than the applicable TRV (indicated by the red contour line).

For health risks from nitrogen dioxide along the marine shipping route, the plume dispersion study predicted that the one-hour nitrogen dioxide concentration in Hartley Bay reaches a maximum of 31 µg/m^3. The maximum one-hour nitrogen dioxide concentration of 31 µg/m^3 results in a conservative HQ estimate of 0.39. This value is conservative because the maximum (i.e., 100th percentile) concentration is used in the HQ calculation rather than the 98th percentile of the one-hour daily maximum. It is also conservative because this maximum concentration takes place for only one hour every 7 to 10 days, shortly after an LNG carrier passes near Hartley Bay. If wind and climate conditions do not move the plume directly towards Hartley Bay, the one-hour nitrogen dioxide concentration would be lower than 31 µg/m^3. Based on these results, the inhalation risk to Hartley Bay residents and people living along the marine shipping route from exposure to nitrogen dioxide is negligible. For residents of Kitkatla and Metlakatla Village, which are even further from the marine shipping route, the risk from exposure to nitrogen dioxide is also negligible. Since the change in nitrogen dioxide concentration from a passing LNG carrier lasts for approximately one hour, long-term risk is not evaluated.

TABLE 7.12.9 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR ONE-HOUR NITROGEN DIOXIDE

Receptor #	TRV[1] ($\mu g/m^3$)	1-hour NO_2 ($\mu g/m^3$)[1]		Hazard Quotient (unitless)		Change in HQ[2]
		Base	Application	Base	Application	
1	79	34.2	37.3	0.43	0.47	0.04
2		41.2	43.6	0.52	0.55	0.03
3		91.6	91.9	1.16	1.16	<0.01
4		44.0	50.9	0.56	0.64	0.09
5		76.0	77.7	0.96	0.98	0.02
6		46.9	51.3	0.59	0.65	0.06
7		56.6	61.3	0.72	0.78	0.06
8		35.2	37.5	0.45	0.47	0.03
9		40.6	41.6	0.51	0.53	0.01
10		83.8	84.2	1.06	1.07	0.01
11		59.5	65.9	0.75	0.83	0.08
12		51.1	53.9	0.65	0.68	0.04
13		60.8	64.8	0.77	0.82	0.05
14		71.9	72.9	0.91	0.92	0.01
15		43.9	47.5	0.56	0.60	0.05
16		41.1	44.4	0.52	0.56	0.04
17		50.8	52.1	0.64	0.66	0.02
18		40.4	41.3	0.51	0.52	0.01
19		29.2	30.6	0.37	0.39	0.02
20		24.6	25.6	0.31	0.32	0.01
21		94.3	94.3	1.19	1.19	<0.01
22		28.6	32.7	0.36	0.41	0.05
23		75.6	76.9	0.96	0.97	0.02
24		75.0	76.7	0.95	0.97	0.02
25		51.1	56.7	0.65	0.72	0.07

TABLE 7.12.9 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR ONE-HOUR NITROGEN DIOXIDE

Receptor #	TRV[1] ($\mu g/m^3$)	1-hour NO_2 ($\mu g/m^3$)[1]		Hazard Quotient (unitless)		Change in HQ[2]
		Base	Application	Base	Application	
26	79	58.6	66.8	0.74	0.85	0.10
27		57.6	60.2	0.73	0.76	0.03
28		2.2	2.3	0.03	0.03	<0.01
29		62.8	65.7	0.79	0.83	0.04

NOTES:

[1] Based upon the 98th percentile of the 1-hour daily maximum nitrogen dioxide (NO_2) concentration

[2] Effect threshold for Change in HQ is 0.2

For long-term exposure to nitrogen dioxide, the change in human health is also negligible.

The project-alone isopleth map, Figure 7.12.13, shows the spatial extent of annual nitrogen dioxide dispersion from project emissions to be in the immediate vicinity of the project footprint. Table 7.12.10 shows the base case and application case HQ at all human receptor locations. The Project's contribution to the HQ is less than the HQ threshold of 0.2 indicating that the Project is predicted to have a negligible contribution to human health from long-term inhalation exposures to nitrogen dioxide.

TABLE 7.12.10 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR ANNUAL NITROGEN DIOXIDE

Receptor #	TRV ($\mu g/m^3$)	Annual Average NO_2 ($\mu g/m^3$)		Hazard Quotient (unitless)		Change in HQ[1]
		Base	Application	Base	Application	
1	23	1.6	2.0	0.07	0.09	0.02
2		1.8	2.1	0.08	0.09	0.01
3		6.0	6.7	0.26	0.29	0.03
4		2.1	2.6	0.09	0.11	0.02
5		3.5	3.9	0.15	0.17	0.02
6		0.7	0.8	0.03	0.03	<0.01
7		0.8	0.9	0.03	0.04	0.01
8		1.6	2.0	0.07	0.09	0.02
9		1.7	2.1	0.07	0.09	0.02
10		2.9	3.4	0.13	0.15	0.02
11		0.9	1.0	0.04	0.04	<0.01

TABLE 7.12.10 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR ANNUAL NITROGEN DIOXIDE

Receptor #	TRV ($\mu g/m^3$)	Annual Average NO_2 ($\mu g/m^3$)		Hazard Quotient (unitless)		Change in HQ[1]
		Base	Application	Base	Application	
12	23	0.8	0.9	0.03	0.04	0.01
13		2.8	3.3	0.12	0.14	0.02
14		4.0	4.6	0.17	0.20	0.03
15		1.4	1.8	0.06	0.08	0.02
16		2.7	3.0	0.12	0.13	0.01
17		3.4	3.7	0.15	0.16	0.01
18		2.9	3.2	0.13	0.14	0.01
19		1.7	1.9	0.07	0.08	0.01
20		1.3	1.6	0.06	0.07	0.01
21		4.5	5.0	0.20	0.22	0.02
22		1.0	1.2	0.04	0.05	0.01
23		3.3	5.5	0.14	0.24	0.10
24		3.2	5.4	0.14	0.23	0.09
25		0.9	1.0	0.04	0.04	<0.01
26		2.3	3.0	0.10	0.13	0.03
27		3.9	4.4	0.17	0.19	0.02
28		0.0	0.0	0.00	0.00	<0.01
29		2.5	3.0	0.11	0.13	0.02

NOTE:

[1] Effect threshold for change in HQ is 0.2

Project Residual Effects to Human Health from $PM_{2.5}$

Overall, the change in human health from short-term (24-hour) and long-term (annual) inhalation exposure to $PM_{2.5}$ is negligible. This is shown by the change in HQ for 24-hour and annual $PM_{2.5}$ in Table 7.12.11 and Table 7.12.12, where the change in HQ is less than the threshold of 0.2.

The limited spatial dispersion is clearly illustrated in the project-alone isopleth maps, Figure 7.12.16 and Figure 7.12.19, which show almost no isopleth contours from $PM_{2.5}$ emissions.

Based upon this information, the health risk associated with exposure to $PM_{2.5}$ along the marine shipping route from a passing LNG carrier was conducted. The dispersion model for the FLNG facility already includes $PM_{2.5}$ emissions from an LNG carrier moored at the Cedar site for several hours. If these emissions show a negligible change in $PM_{2.5}$ concentrations, an LNG carrier passing Hartley Bay would have a lesser effect. The potential risk to people in Kitkatla and Metlakatla Village would also be negligible.

TABLE 7.12.11 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR 24-HOUR $PM_{2.5}$

Receptor #	TRV[1] ($\mu g/m^3$)	24-hour $PM_{2.5}$ ($\mu g/m^3$)[1]		Hazard Quotient (unitless)		Change in HQ[2]
		Base	Application	Base	Application	
1	25	3.2	3.3	0.13	0.13	<0.01
2		3.5	3.6	0.14	0.14	<0.01
3		7.7	9.0	0.31	0.36	0.05
4		4.0	4.2	0.16	0.17	0.01
5		4.9	5.0	0.20	0.20	<0.01
6		3.2	3.2	0.13	0.13	<0.01
7		3.2	3.2	0.13	0.13	<0.01
8		3.3	3.4	0.13	0.14	0.01
9		3.4	3.5	0.14	0.14	<0.01
10		5.5	5.6	0.22	0.22	<0.01
11		3.6	3.7	0.14	0.15	0.01
12		3.3	3.3	0.13	0.13	<0.01
13		4.9	5.0	0.20	0.20	<0.01
14		7.1	7.4	0.28	0.3	0.02
15		3.6	3.9	0.14	0.16	0.02
16		5.0	5.1	0.20	0.20	<0.01
17		6.1	6.4	0.24	0.26	0.02
18		5.4	5.6	0.22	0.22	<0.01
19		3.8	4.3	0.15	0.17	0.02
20		3.8	3.9	0.15	0.16	0.01
21		7.7	7.8	0.31	0.31	<0.01
22		3.7	3.8	0.15	0.15	<0.01
23		13.9	13.9	0.56	0.56	<0.01
24		11.6	11.6	0.46	0.46	<0.01

TABLE 7.12.11 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR 24-HOUR $PM_{2.5}$

Receptor #	TRV[1] (µg/m³)	24-hour $PM_{2.5}$ (µg/m³)[1]		Hazard Quotient (unitless)		Change in HQ[2]
		Base	Application	Base	Application	
25	25	3.3	3.3	0.13	0.13	<0.01
26		3.6	4.4	0.14	0.18	0.04
27		6.4	7.3	0.26	0.29	0.03
28		0.5	0.5	0.02	0.02	<0.01
29		7.9	8.5	0.32	0.34	0.02

NOTES:

[1] Based upon the 98th percentile of the 24-hour daily average

[2] Effect threshold for change in HQ is 0.2

TABLE 7.12.12 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR ANNUAL $PM_{2.5}$

Receptor #	TRV (µg/m³)	Annual Average $PM_{2.5}$ (µg/m³)		Hazard Quotient (unitless)		Change in HQ[1]
		Base	Application	Base	Application	
1	8	1.2	1.3	0.15	0.16	0.01
2		1.3	1.4	0.16	0.17	0.01
3		3.0	3.2	0.38	0.40	0.02
4		1.2	1.4	0.15	0.17	0.01
5		1.8	2.0	0.23	0.24	0.01
6		1.1	1.1	0.14	0.14	<0.01
7		1.1	1.2	0.14	0.14	<0.01
8		1.2	1.3	0.15	0.16	0.01
9		1.3	1.4	0.16	0.17	0.01
10		1.9	2.0	0.23	0.25	0.01
11		1.2	1.2	0.15	0.15	<0.01
12		1.1	1.2	0.14	0.14	<0.01
13		1.7	1.8	0.21	0.23	0.01
14		2.4	2.5	0.30	0.31	0.02
15		1.2	1.4	0.16	0.17	0.01
16		1.7	1.8	0.22	0.23	0.01
17		2.0	2.1	0.25	0.26	0.01

TABLE 7.12.12 EXPOSURE CONCENTRATION AND HAZARD QUOTIENT FOR ANNUAL $PM_{2.5}$

Receptor #	TRV ($\mu g/m^3$)	Annual Average $PM_{2.5}$ ($\mu g/m^3$)		Hazard Quotient (unitless)		Change in HQ[1]
		Base	Application	Base	Application	
18	8	1.9	1.9	0.23	0.24	0.01
19		1.4	1.4	0.17	0.18	0.01
20		1.2	1.3	0.15	0.16	0.01
21		2.4	2.5	0.30	0.32	0.02
22		1.2	1.3	0.15	0.16	0.01
23		4.4	4.9	0.55	0.61	0.05
24		3.7	4.0	0.47	0.51	0.04
25		1.1	1.2	0.14	0.15	<0.01
26		1.4	1.5	0.17	0.19	0.02
27		2.2	2.3	0.28	0.29	0.01
28		0.7	3.2	0.09	0.40	0.31

NOTE:
[1] Effect threshold for change in HQ is 0.2

Noise Effects—Percent Highly Annoyed

To determine the incremental increase in %HA from the Project, noise levels were modelled for the baseline (i.e., existing conditions), construction, and operation scenarios. The modelled noise levels were used to calculate the associated %HA for each case, and the change in %HA was compared to the Health Canada %HA threshold of 6.5%. The construction phase daytime noise contours are illustrated in Figure 7.12.20. The results for the construction and operation phases are shown in Table 7.12.13 and Table 7.12.14, respectively. Receptor locations along the shipping route (Receptors 5 to 12, 17, 22, and 25) have been removed from Table 7.12.13 because they are not applicable during the construction phase.

The results in Table 7.12.13 indicate that the change in %HA during the construction phase is within the Health Canada noise threshold. The location with the greatest change in %HA is receptor 27, which corresponds to the Half Moon Bay traditional use area located 0.8 km away from the transmission line and 1 km north of the Project. The remaining receptor locations show a change in %HA of 1.1% or less. People in Kitamaat Village (Receptors 1 to 4 and 13 to 16) are predicted to experience an increase in noise levels with an increase in %HA of 0.8% or less. Receptors along the marine shipping route do not apply to the construction and have been removed from Table 7.12.13 (Receptor 5-12, 17, 22, and 25).

TABLE 7.12.13 PERCENT HIGHLY ANNOYED – CONSTRUCTION PHASE

Receptor #	Baseline Noise		Construction Noise	Total Noise Baseline + Construction		Change in %HA
	$L_{dn,\ adjusted}$ (dBA)	$\%HA_{Base}$	L_{dn} (dBA)	$L_{dn,\ adjusted}$ (dBA)	$\%HA_{Const}$	
1	46.9	1.5	46.9	49.9	2.2	0.7
2	46.9	1.5	46.6	49.7	2.1	0.7
3	46.9	1.5	47.5	50.2	2.2	0.8
4	46.9	1.5	46.5	49.7	2.1	0.6
13	55.3	4.3	44.6	55.7	4.5	0.2
14	46.9	1.5	47.5	50.2	2.2	0.8
15	47.2	1.5	47.9	50.5	2.3	0.8
16	47.0	1.5	43.8	48.7	1.8	0.4
18	55.3	4.3	15.5	55.3	4.3	0
19	48.7	1.9	33.9	48.9	1.9	0
20	47.4	1.6	27.6	47.5	1.6	0
21	47.5	1.6	28.1	47.6	1.6	0
23	46.9	1.5	47.2	50.0	2.2	0.7
24	45.8	1.3	47.9	49.9	2.2	0.9
26	48.8	1.9	50.1	52.5	3.0	1.1
27	47.1	1.5	59.0	59.2	7.0	5.5
28	45.5	1.2	24.5	45.6	1.2	0

For the operation phase, the daytime and nighttime noise contours are illustrated in Figure 7.12.21 and Figure 7.12.22. The results in Table 7.12.14 indicate that the change in %HA is also within the Health Canada noise threshold. The location with the greatest change in %HA is receptor 27, which corresponds to the Half Moon Bay traditional use area located 0.8 km away from the transmission line and 1 km north of the Project. The remaining receptor locations show a change in %HA of 0.6% or less. People in Kitamaat Village (Receptors 1 to 4 and 13 to 16) are predicted to experience an increase in noise levels with an increase in %HA of 0.2% or less.

TABLE 7.12.14 PERCENT HIGHLY ANNOYED – OPERATION PHASE

Receptor #	Baseline Noise		Operation Noise	Total Noise Baseline + Operation		Change in %HA
	$L_{dn, adjusted}$ (dBA)	$\%HA_{Base}$	L_{dn} (dBA)	$L_{dn, adjusted}$ (dBA)	$\%HA_{Ops}$	
1	46.9	1.5	40.2	47.7	1.6	0.2
2	46.9	1.5	39.8	47.7	1.6	0.2
3	46.9	1.5	40.6	47.8	1.7	0.2
4	46.9	1.5	39.7	47.6	1.6	0.2
5	48.0	1.7	11.2	48.0	1.7	0
6	55.1	4.2	17.1	55.1	4.2	0
7	55.1	4.2	20.9	55.1	4.2	0
8	55.0	4.2	15.6	55.0	4.2	0
9	55.0	4.2	15.3	55.0	4.2	0
10	55.0	4.2	13.7	55.0	4.2	0
11	50.5	2.3	12.6	50.5	2.3	0
12	55.0	4.2	14.4	55.0	4.2	0
13	55.3	4.3	40.5	55.5	4.4	0.1
14	46.9	1.5	40.6	47.8	1.6	0.2
15	47.2	1.5	41.0	48.1	1.7	0.2
16	47.0	1.5	40.0	47.8	1.6	0.2
17	55.0	4.2	13.4	55.0	4.2	0
18	55.3	4.3	8.8	55.3	4.3	0
19	48.7	1.9	33.1	48.8	1.9	0
20	47.4	1.6	31.8	47.5	1.6	0
21	47.5	1.6	36.9	47.9	1.7	0.1
22	46.6	1.4	12.6	46.6	1.4	0
23	46.9	1.5	40.4	47.8	1.6	0.2
24	45.8	1.3	40.9	47.0	1.5	0.2
25	55.1	4.2	13.7	55.1	4.2	0
26	48.8	1.9	46.8	50.9	2.5	0.6
27	47.1	1.5	54.1	54.9	4.1	2.6
28	45.5	1.2	26.5	45.6	1.2	0

Noise Effects—Sleep Disturbance

Sleep disturbance effects do not apply for the construction phase. Construction activities are primarily planned to occur during the hours of 0700 to 2200. When work at night is required (2200 to 0700), these activities are expected to be short-term and non-continuous to address specific situations (e.g., emergencies, unplanned events). Cedar will work with the OGC and the District of Kitimat to acquire the necessary permits and approvals for nighttime work.

For potential sleep disturbance effects during the operation phase, nighttime noise equivalent levels (L_n) and maximum sound levels (L_{max}) at night were modelled and compared to the sleep disturbance thresholds. Figure 7.12.23 shows the daytime noise contours along the shipping route.

Table 7.12.15 shows the L_{max} from LNG carrier marine horns at the sensitive residential receptors in Kitamaat Village (Receptors 13 to 16) and Hartley Bay (Receptor 5). The L_{max} at the five sensitive residential receptors is below the sleep disturbance threshold of 60 dBA. The L_n from facility operation is also below the sleep disturbance threshold of 45 dBA at Kitamaat Village.

TABLE 7.12.15 NIGHTTIME NOISE LEVEL DURING OPERATION

Receptor #	Marine Horn - Sleep Disturbance		Facility Operation - Sleep Disturbance	
	L_{max} (dBA)	L_{max} Exceeds 60 dBA	Nighttime L_n Outdoor (dBA)	L_n Exceeds 45 dBA
5	51.3	No	Negligible	No
13	56.6	No	34.1	No
14	59.1	No	34.2	No
15	58.7	No	34.6	No
16	54.3	No	33.6	No

Likelihood and Context of Residual Effect

The likelihood of residual effects to human health is low. Although there is a quantifiable increase in the measurable parameters for changes to human health, the increase is below the risk threshold that is applicable to the effects for air quality and noise. In the context of human health, this means that there are project-related increases in air emissions and noise, but these increases are below the health risk thresholds or health benchmarks.

Furthermore, the CALPUFF air dispersion model and noise model apply several levels of conservatism when predicting future environmental scenarios associated with the Project. There are also conservative assumptions applied in the HHRA process. As a result, the predicted changes in human health associated with the Project are likely to be lower than those quantified in this assessment. Based on these factors, the likelihood of residual effects to human health is low.

7.12.7.3 SUMMARY OF MITIGATION AND ENHANCEMENT MEASURES

There are no mitigation measures specific to human health. Project mitigation and enhancement measures have already been applied to the Project in upstream modelling to reduce the potential effects on human health to the degree that there are no unacceptable effects to human health. No further mitigation measures or enhancement measures are required.

7.12.7.4 SUMMARY OF PROJECT RESIDUAL EFFECTS

Table 7.12.16 summarizes project residual effects on human health. Overall, the direction of change to human health is adverse for all phases of the Project. The magnitude of effect is low for all phases of the Project. The spatial extent of the residual effects is within the LAA/RAA for their respective types of effects (air quality or noise effects). The duration of effect is long-term because all phases of the Project last more than one year. The effects are reversible for all phases of the Project because COPC emissions to the air and noise emissions stop after the Project is completed. The frequency of the effect is continuous over the life of the Project. There is a disproportionate distribution of effects to the subpopulation of residents living closest to the Project Area because the effects are typically associated with proximity to the Project's source of air emissions or noise. Overall, the human health risks have been overestimated because the predictive modelling techniques used in the CALPUFF air dispersion model and acoustic model are conservative (e.g., applying worst case scenarios), in addition, the methods used in the HHRA are also inherently conservative (e.g., applying TRVs that are protective of sensitive people). Given these characterizations, and the overestimation of risk associated with human health, the likelihood of residual effects on human health is low. No substantial adverse residual effect for human health is predicted because the predicted change to human health is less than the key residual effects threshold described in Section 7.12.7.1.

TABLE 7.12.16 PROJECT RESIDUAL EFFECTS ON HUMAN HEALTH

Project Phase	Direction	Residual Effects Characterization Criteria							Likelihood and Context of Residual Effects
		Magnitude	Extent	Duration	Reversibility	Frequency	Affected Populations	Risk and Uncertainty	
Change to Human Health									
Construction	A	L	LAA/RAA	LT	R	C	D	O	L
Operation	A	L	LAA/RAA	LT	R	C	D	O	L
Decommissioning	A	L	LAA/RAA	LT	R	C	D	O	L
Residual project effect for all phases	A	L	LAA/RAA	LT	R	C	D	O	L

KEY

See Table 7.12.7 for detailed definitions

Direction:
P: Positive
A: Adverse
N: Neutral

Magnitude:
NMC: No measurable change
L: Low
H: High

Geographic Extent:
LAA: Local assessment area
RAA: Regional assessment area

Duration:
ST: Short-term (<1 year)
LT: Long-term (1+ years)

Reversibility:
R: Reversible
I: Irreversible

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Affected Populations:
E: Evenly distributed effects to all subpopulations
D: Disproportionally distributed effects to subpopulations

Risk and Uncertainty:
O: Over-estimated
U: Under-estimated

Likelihood and Context of Residual Effects:
L: Low
M: Medium
H: High

7.12.8 Assessment of Cumulative Effects on Human Health

In accordance with the AIR, the assessment of cumulative effects on human health was undertaken because the following two conditions are met:

- Project is assessed as having residual effects on human health
- Residual effects could act cumulatively with residual effects of other past, present, or reasonably foreseeable future physical activities

Project residual effects to human health described in Section 7.12.7.4 that are likely to interact cumulatively with residual effects from past, present, or reasonably foreseeable projects are identified in this section and the resulting cumulative effects are assessed. This is followed by an analysis of the project contribution to residual cumulative effects. The spatial boundaries for cumulative effects to human health are the LAA/RAAs for air quality and acoustic related health effects. If other past, present, or reasonably foreseeable future physical activities affect have overlapping air quality or acoustic effects, there may be a cumulative effect to human health. There is no specific temporal boundary that applies to the cumulative effects assessment. The identified projects to be considered for the cumulative effects assessment are assumed to overlap temporally with the Project.

7.12.8.1 ASSESSMENT METHODS

The assessment of cumulative effects on human health begins with identifying project-related health effects (i.e., air quality and noise effects). In order for there to be cumulative effects, other past, present, or reasonably foreseeable future projects must also have air quality and noise effects that overlap spatially and temporally with the Project. If this condition is met, the assessment of cumulative effects on human health is based upon the predicted cumulative change in air quality or cumulative noise effects from past, present, and reasonably foreseeable future projects. If this condition is not met, then there is no cumulative effect to human health (i.e., there are no past, present, and reasonably foreseeable future projects with air quality or noise effects that overlap temporally and spatially with the project effects).

7.12.8.2 PROJECT RESIDUAL EFFECTS LIKELY TO INTERACT CUMULATIVELY

Project residual effects likely to interact cumulatively are those related to air quality and noise.

Presently operating projects have the potential to interact cumulatively with the Project's residual effects to human health. However, these effects have already been integrated into the assessment. For example, the assessment of human health from the inhalation of COPCs in the air has already included presently operating projects in the CALPUFF air dispersion model's base case scenario. Emissions of COPCs in the air from the LNG Canada Export Terminal Project (under construction), Rio Tinto Aluminum Smelter (in operation), and Rio Tinto Terminal A Extension Project (under construction) are part of the base case scenario under the modelled assumption that all three projects are operating at full capacity. Also included in the base case scenario at the request of provincial regulators is the reasonably foreseeable future Kitimat LNG Project, located approximately 7 km southwest of the Project, which was modelled under the assumption that it is currently operating at full capacity. The Kitimat LNG Project is currently not under construction as a final investment decision has not been made for this Project. For these reasons, potential cumulative effects only apply to reasonably foreseeable future projects.

A review of the reasonably foreseeable future projects (excluding the Kitimat LNG Project) within the air quality LAA/RAAs did not identify any projects that could have overlapping residual effects with human health. Specifically, there are no human receptor locations with an unacceptable change in inhalation health risk that would overlap with other projects.

For cumulative effects related to noise, several reasonably foreseeable future projects have infrastructure within the acoustic LAA/RAA as listed in Table 7.12.17. However, no noise is produced by these pipeline projects during the operation of these projects. Compressor stations associated with these projects produce noise, but they are located outside the noise LAA/RAA and have no potential to overlap with project-related noise.

TABLE 7.12.17 PROJECT INCLUSION LIST FOR CUMULATIVE EFFECTS ON HUMAN HEALTH FROM NOISE

Other Projects and Physical Activities with Potential for Cumulative Effects	Description
Reasonably Foreseeable Physical Activities	
Cedar Feed Gas Connector Pipeline	An approximately 8 km long natural gas pipeline to deliver feed gas from a metering station near Kitimat to the Project. The pipeline will follow a shared multi-use utilities corridor identified by MOTI.
Kitimat LNG Project (Chevron Canada Limited/Woodside Energy Ltd.)	The project includes an LNG plant, marine terminal, powerline, connecting natural gas pipeline, condensate return pipeline, access road, and use of existing shipping routes in British Columbia coastal waters. The project received an EAC in 2006 and is currently approved for a 10 MTPA production capacity. An amendment process to increase the facility's capacity to 18 MPTA was initiated in July 2019 but this was withdrawn in July 2021.
Kitimat LPG Export Project (Pacific Traverse Energy)	A proposed 1.25 million tonne per year LPG export project to be located in Kitimat. The project is to include a new marine terminal with a floating storage vessel and supporting equipment, a new railyard, a new 15 km LPG pipeline from the railyard to the marine terminal. This project is currently in the pre-final investment decision phase.
Pacific Northern Gas Pipeline Looping Project (Pacific Northern Gas Ltd.)	Proposed upgrade to an existing natural gas pipeline between Summit Lake and Kitimat. The proposed project involves construction of a new 524 km long pipeline parallel to the existing pipeline. The project started the environmental assessment process in 2013 but has been on hold until recently due to lack of demand. Pacific Northern Gas may revive the project as new industrial projects (such as small-scale LNG projects) are proposed in the Terrace and Kitimat region.
Pacific Trail Pipelines (Chevron Canada Limited/Woodside Energy Ltd.)	A proposed 471 km natural gas pipeline from northeastern British Columbia via Summit Lake to the Kitimat LNG Terminal that will be located at Bish Cove in Kitimat. The final investment decision is expected along with the Kitimat LNG Project.
Westcoast Connector Gas Transmission Project* (Enbridge Inc.)	Proposed 850 km natural gas pipeline system consisting of two adjacent pipelines from northeastern British Columbia to Prince Rupert. The project was granted an environmental assessment certificate in 2014 but has yet to proceed. In 2019, the EAO granted an extension to the deadline in the environmental assessment certificate to substantially start the project.

7.12.8.3 SUMMARY OF CUMULATIVE EFFECTS

There are no cumulative effects from past and present projects. Past projects have no lasting effect on noise levels or COPC concentrations in the air after the Project is completed. Present projects have already been integrated into the assessment under the Project's base case scenarios (i.e., existing conditions). While there are reasonably foreseeable future projects located within the air quality and acoustic LAA/RAAs used for the human health assessment, these projects are not located within the spatial area for which the Project influences air quality and noise. Therefore, there are no cumulative effects to human health from reasonably foreseeable future projects.

7.12.9 Prediction Confidence

The prediction confidence for human health is high. This is based upon the multiple layers of conservatism applied in the human health risk assessment (Appendix 7.12A: Stantec 2021a), and the conservative assumptions applied in the air dispersion and acoustic modelling.

An example of conservatism in the human health risk assessment is the assumption that people are exposed to outdoor air at all of the human receptor locations for 24 hours a day, 365 days of the year (i.e., long term inhalation exposure). This overestimates the actual duration of inhalation exposure because people will spend a portion of the day indoors at residential locations, or for short periods of time (e.g., hours or days) recreational sites or traditional harvesting locations.

The air dispersion model also applies multiple conservative assumptions that over-estimates the COPC concentrations in the air. For example, the air dispersion model assumes that the adjacent LNG Canada Export Terminal Project and the Rio Tinto Aluminum Smelter Project are operating at full capacity. The model also assumed that the Kitimat LNG Project is operating at full capacity, even though the project proponent has not confirmed an investment decision to construct this project. The conversion rate between nitrogen oxides and ozone to form nitrogen dioxide and the formation of sulphur dioxide from sulfur-based impurities (i.e., hydrogen sulfide) in natural gas was also assumed to be 100%.

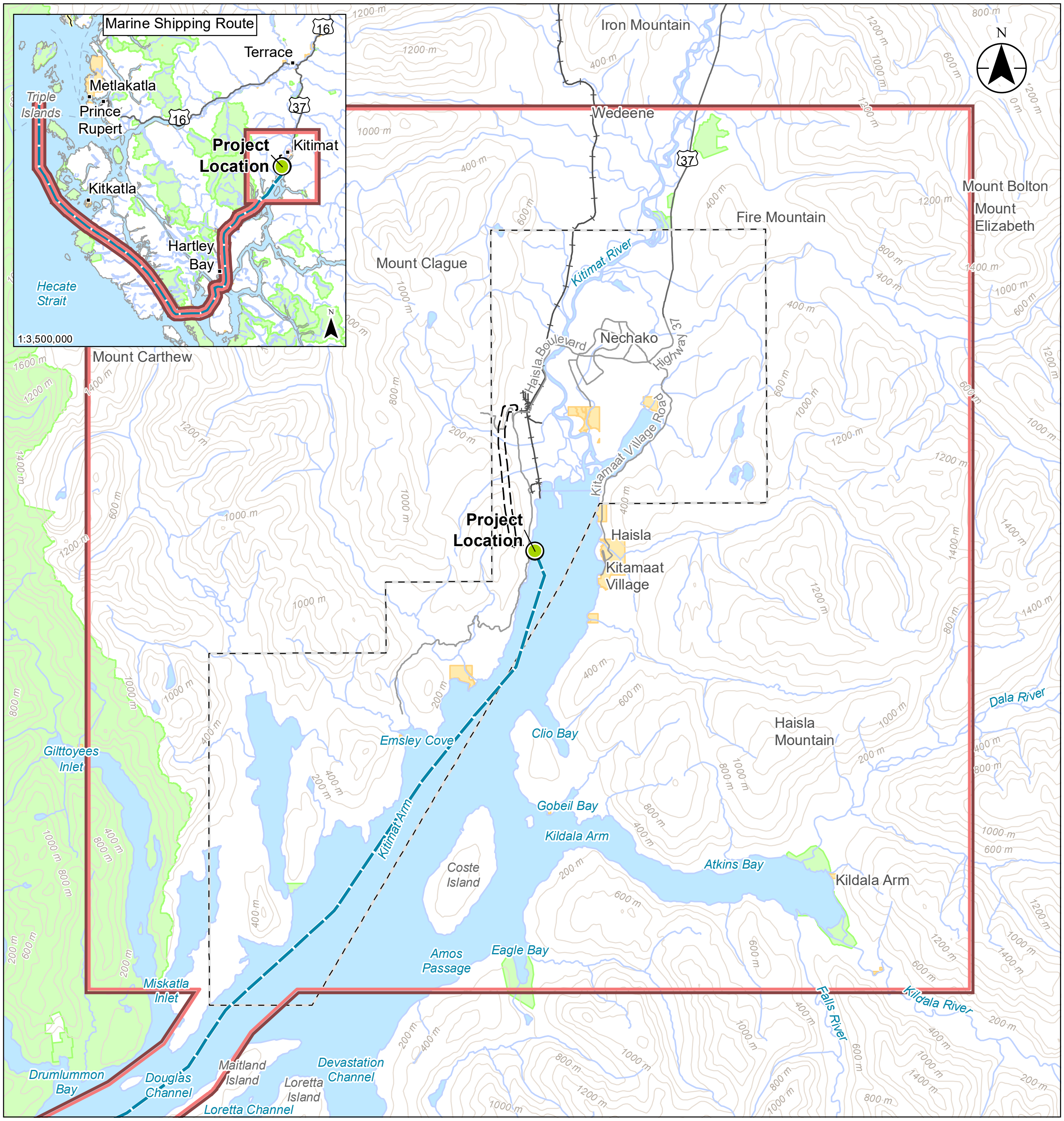
If the residual effects to human health are already low based upon these over-estimated exposures, there is a high degree of prediction confidence because refining the estimates to be more realistic would further reduce the residual effects to human health.

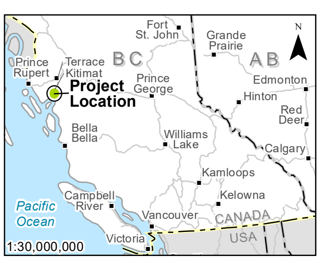
7.12.10 Follow-up Strategy

The predicted project-related health risk from the inhalation of COPCs is not expected to exceed the HQ threshold applicable to human health. Therefore, no follow-up strategy is proposed for human health to address air quality risks. However, as part of the follow-up strategy for the air quality valued component, Cedar expects to participate in the existing regime of continuous ambient air quality monitoring in the air quality LAA/RAA. The data from this monitoring program can be applied to re-evaluate the potential health risks if needed (e.g., if the monitored air quality data exceeds the concentrations predicted in the air dispersion modelling).

The predicted noise levels for the construction and operation phases of the Project are not expected to exceed the %HA and sleep disturbance thresholds applicable to human health. Therefore, no follow-up strategy is proposed for human health to address noise. However, noise levels will be considered throughout the permitting process with the Oil and Gas Commission.

7.12.11 Figures





Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Highway
Road
Railway
Topographic Contour
Watercourse
Waterbody
Reserve Land
Park or Protected Area
District of Kitimat Municipal Boundary

Project Location
Transmission Line Permitting Corridor
Marine Shipping Route (Approximate Location)

Air Quality (Marine Terminal)
Local Assessment Area
Regional Assessment Area

0 2 4 6 8 10 km
1:270,000 (at original document size of 8.5x11)

Stantec
CEDAR LNG

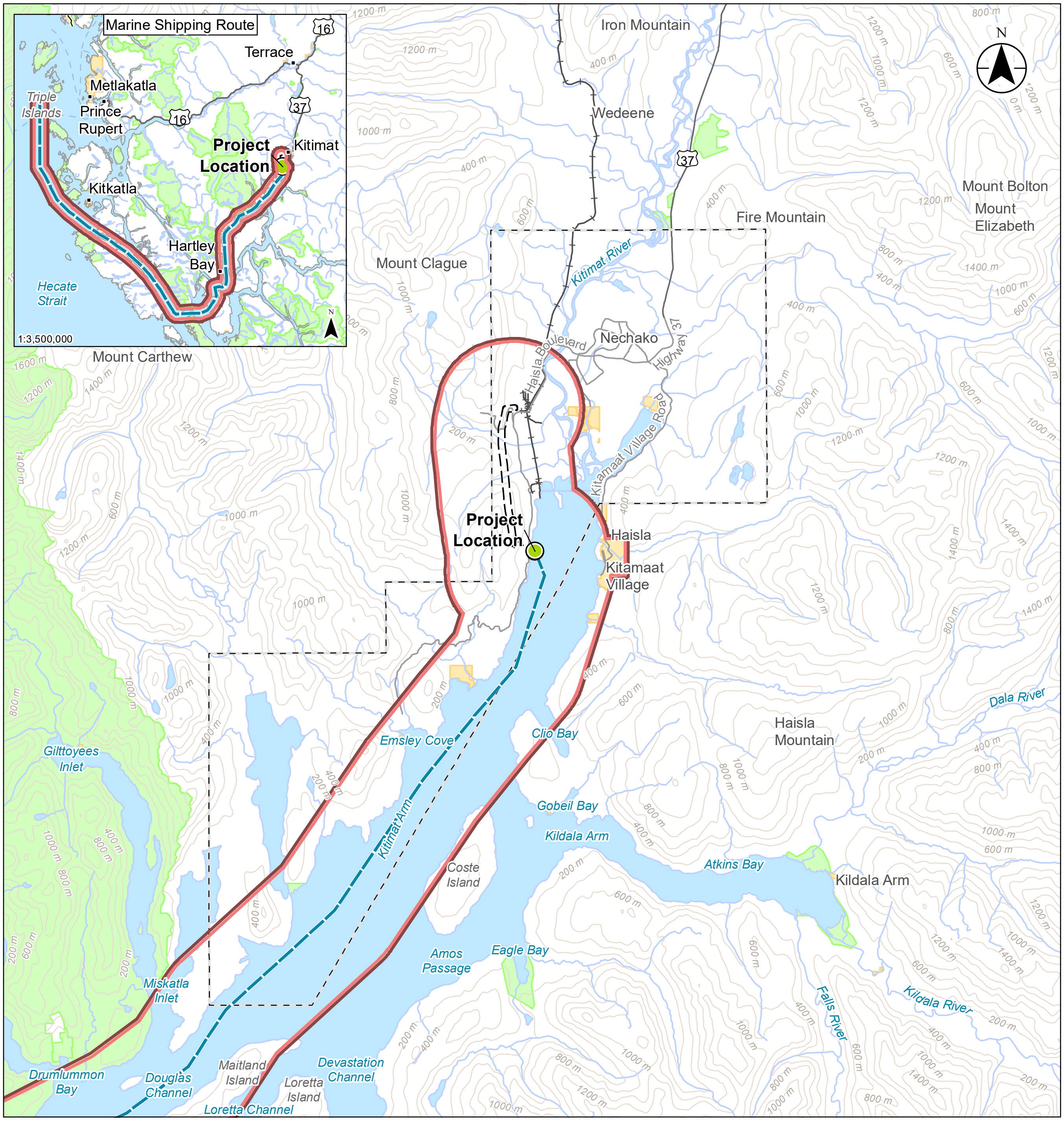
Project Location:
Kitimat, British Columbia

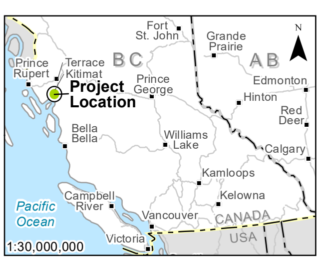
Project Number 123221953
Prepared by WWU on 20211126
Discipline Review by SZABANI on 20211126
GIS Review by LTRUDELL on 20211126

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project
Environmental Assessment Certificate Application

Figure No.
7.12.1

Title
Local and Regional Assessment Area for Human Health from Air Quality Effects





- Highway
- Road
- Railway
- Topographic Contour
- Watercourse
- Waterbody
- Reserve Land
- Park or Protected Area
- District of Kitimat Municipal Boundary
- Project Location
- Transmission Line Permitting Corridor
- Marine Shipping Route (Approximate Location)

Noise (Marine Terminal)

- Local Assessment Area
- Regional Assessment Area

0 2 4 6 8 10 km

1:270,000 (at original document size of 8.5x11)

Stantec CEDAR LNG

Project Location: Kitimat, British Columbia

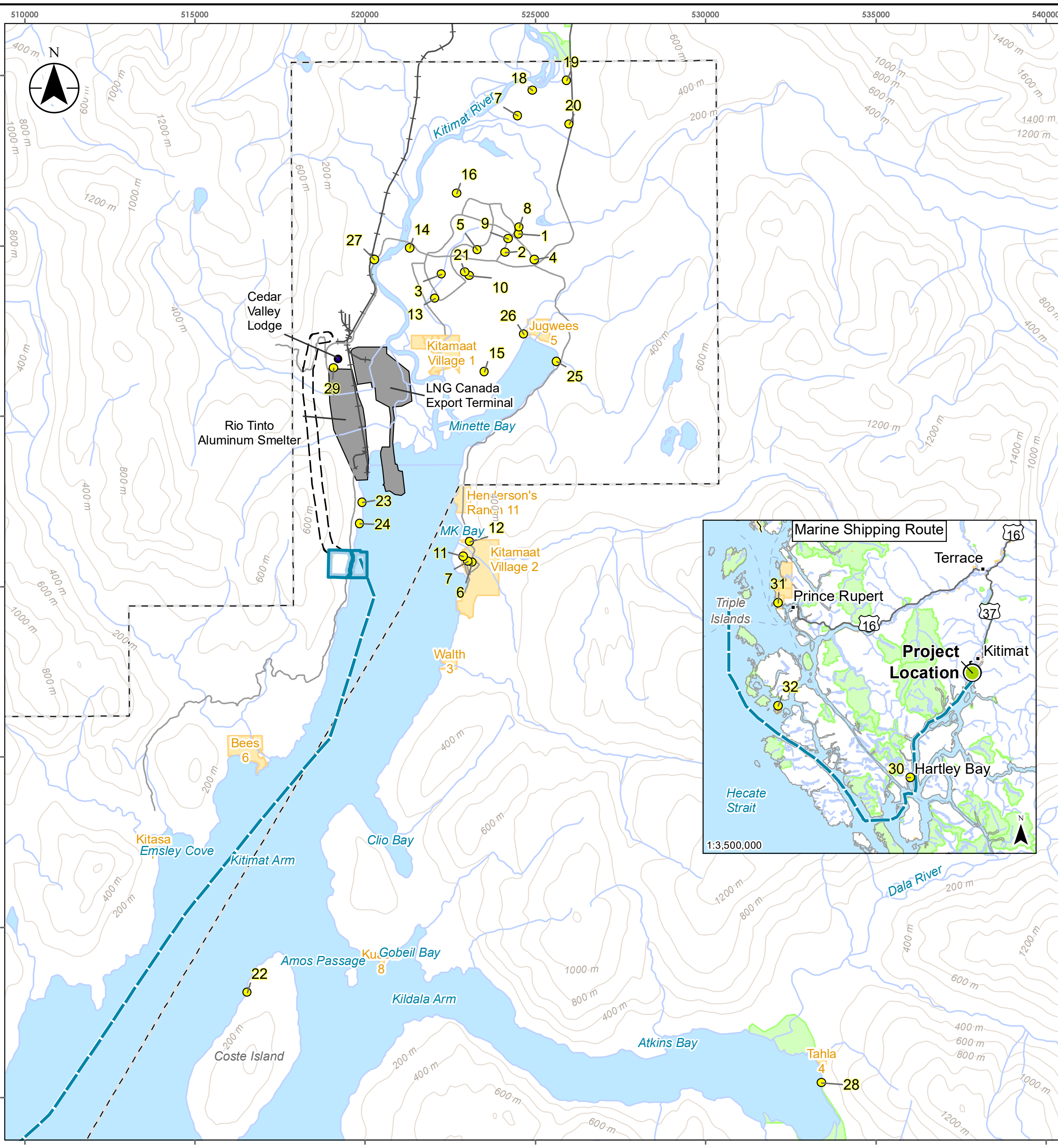
Project Number 123221953
Prepared by WWU on 20211126
Discipline Review by SZABANI on 20211126
GIS Review by LTRUDELL on 20211126

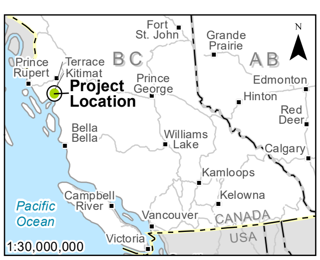
Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project
Environmental Assessment Certificate Application

Figure No.
7.12.2

Title
Local and Regional Assessment Area for Human Health from Noise Effects

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service





- Highway
- Road
- Railway
- Topographic Contour
- Watercourse
- Waterbody
- Reserve Land
- Park or Protected Area
- District of Kitimat Municipal Boundary
- Project Area
- Transmission Line Permitting Corridor
- Marine Shipping Route (Approximate Location)
- Project Boundary
- Human Receptor Location for Air Quality Effects
- Cedar Valley Lodge

0 1 2 3 4 5 km

1:175,000 (at original document size of 8.5x11)

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec CEDAR LNG

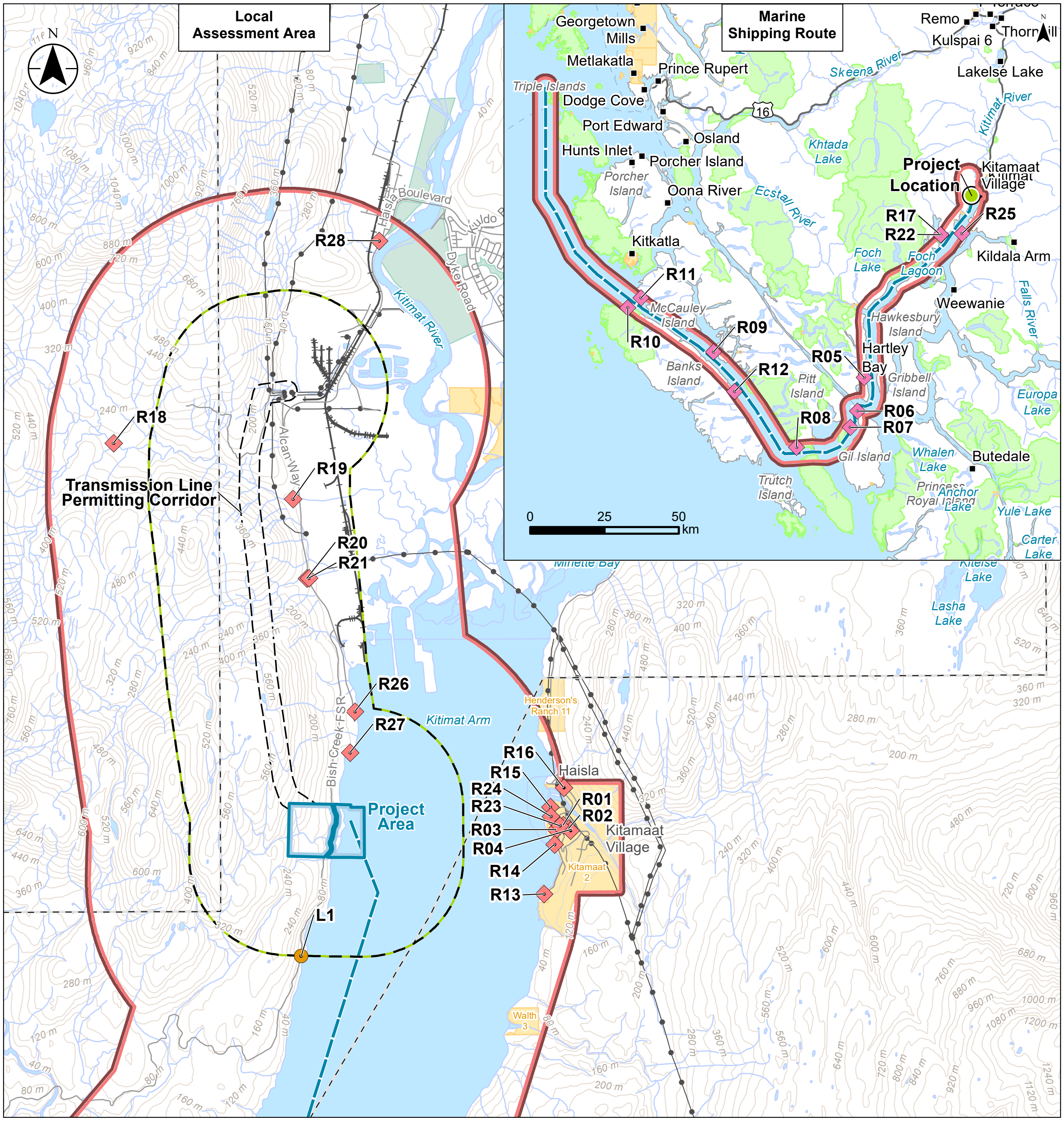
Project Location:
Kitimat, British Columbia

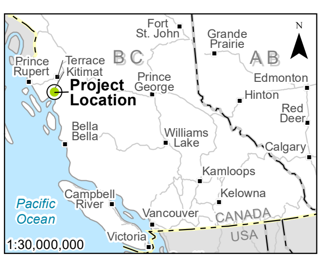
Project Number 123221953
Prepared by PKASIANCHUK on 20211126
Discipline Review by RLEE on 20211126
GIS Review by LTRUDELL on 20211126

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project
Environmental Assessment Certificate Application

Figure No.
7.12.3

Title
Human Receptor Locations for Air Quality





- Highway
- Road
- Railway
- Transmission Line
- Topographic Contour (40 m)
- Waterbody
- Reserve Land
- Local Greenspace
- District of Kitimat Municipal Boundary
- Project Area
- Transmission Line Permitting Corridor
- Marine Shipping Route (Approximate Location)
- Cedar LNG Criteria Boundary (1.5 km)
- Noise Sensitive Receptor
- Assesment Location

0 1 2 3 km

1:90,000 (at original document size of 8.5x11)

Stantec CEDAR LNG

Project Location:
Kitimat,
British Columbia

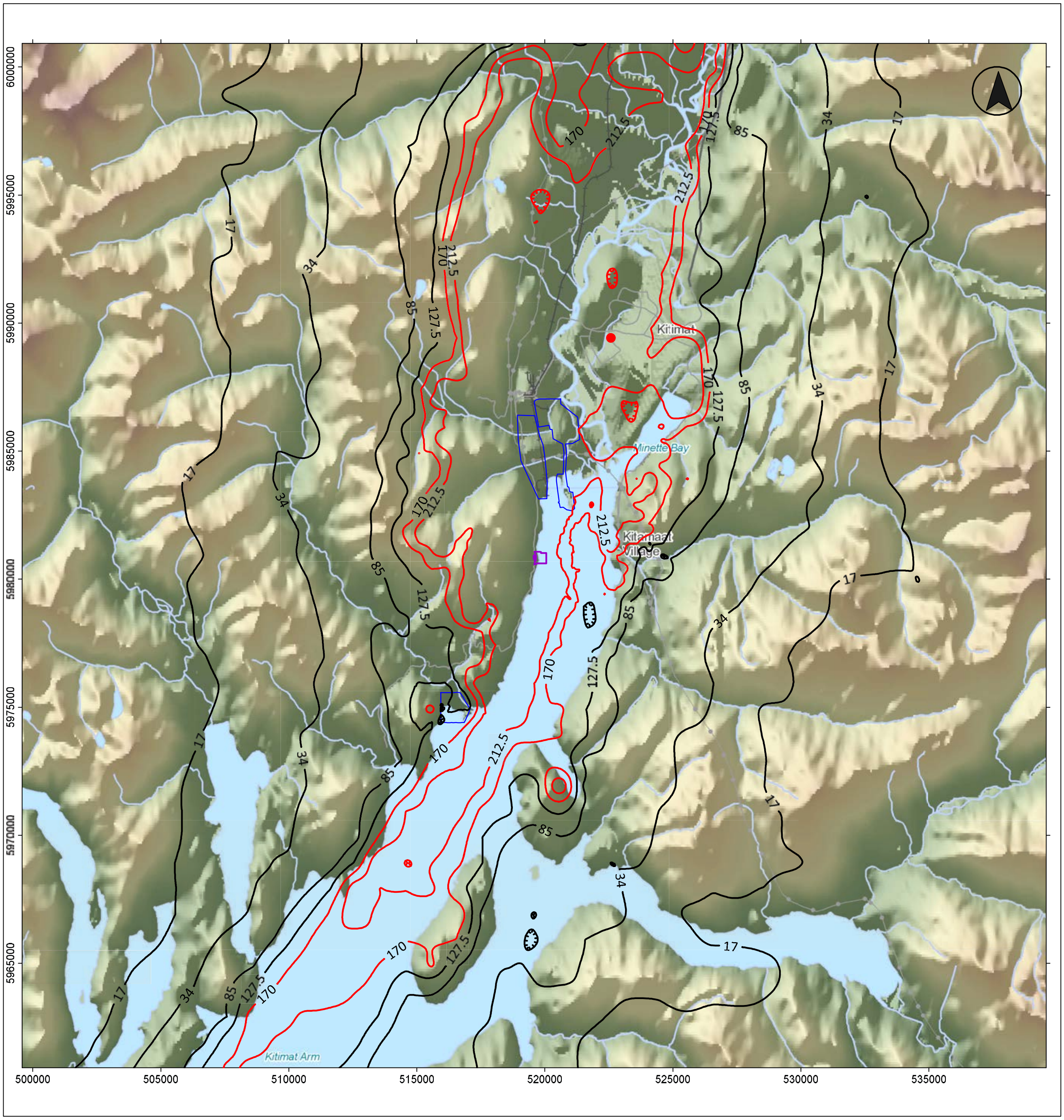
Project Number 123221953
Prepared by LTRUDELL on20211126
Discipline Review by SZABANI on 20211126
GIS Review by SFORTAIS on 20211126

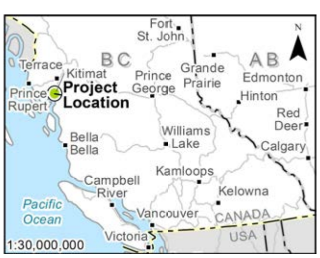
Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project
Environmental Assessment Certificate Application

Figure No.
7.12.4

Title
Noise Sensitive Receptor Locations

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service





Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Cedar LNG Boundary
Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: **1,176 μg/m³**
1-hour SO_2 CAAQS: 170 μg/m³ (——)
Contour Levels: 17, 34, 85, 127.5, 170, 212.5 μg/m³
Baseline: Not added
Concentrations based on the 99th percentile of the 1-hour daily maximum

0 5000 10000

Stantec
CEDAR LNG

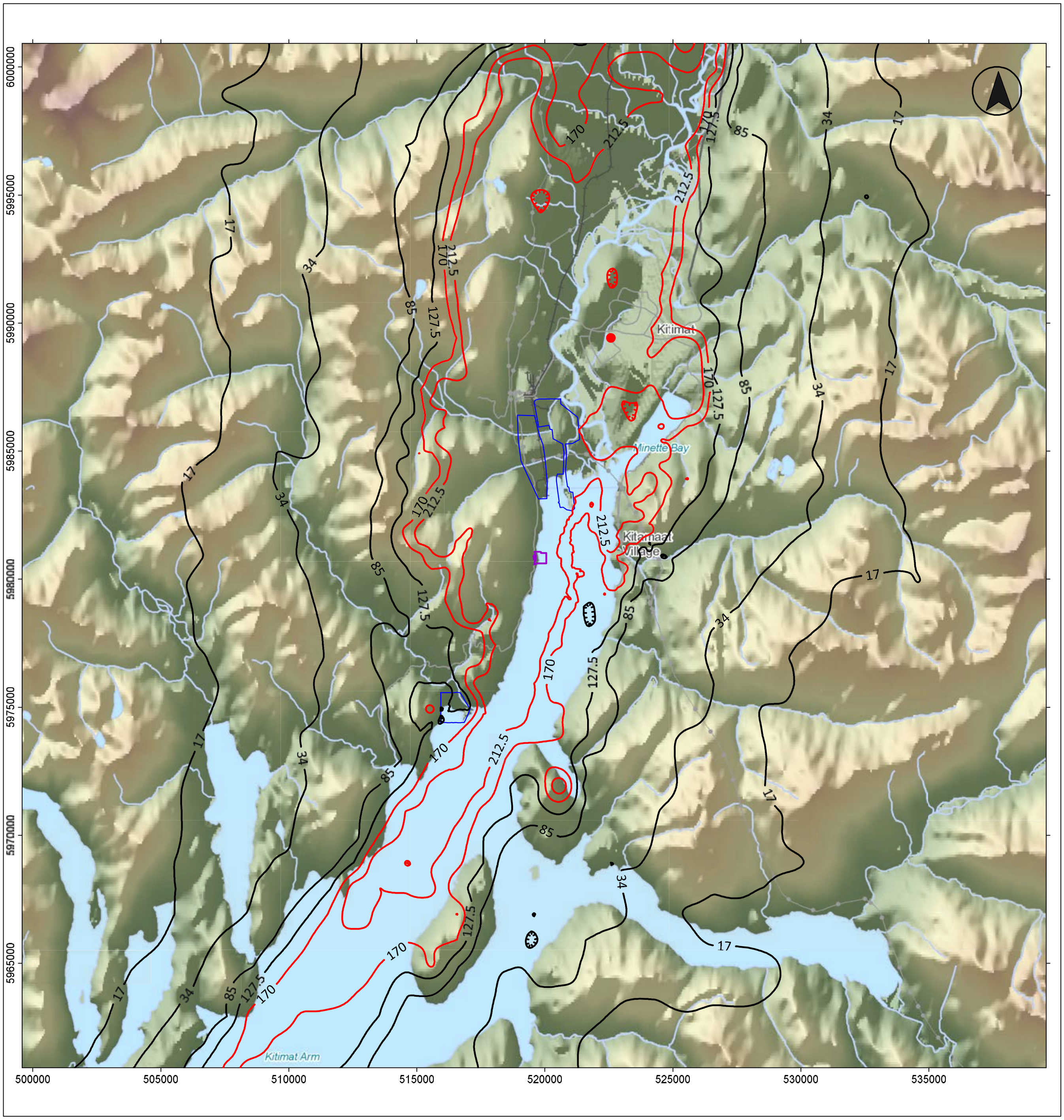
Project Location
Kitimat, British Columbia

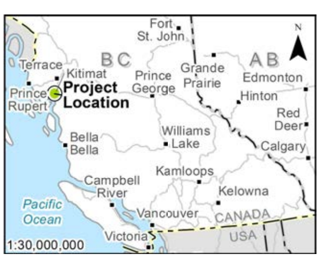
Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.5

Title
1-hour SO_2 Concentrations (Base Case) (μg/m³)





Cedar LNG Boundary

Regional Facility Boundary

Highway

Road

Railway

Transmission Line

Watercourse

Waterbody

Elevation (m)

2026
2000
1500
1000
500
0

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: **1,177 µg/m³**

1-hour SO_2 CAAQS: 170 µg/m³ (—)

Contour Levels: 17, 34, 85, 127.5, 170, 212.5 µg/m³

Baseline: Not added

Concentrations based on the 99th percentile of the 1-hour daily maximum

0 5000 10000

Notes

1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec

CEDAR LNG

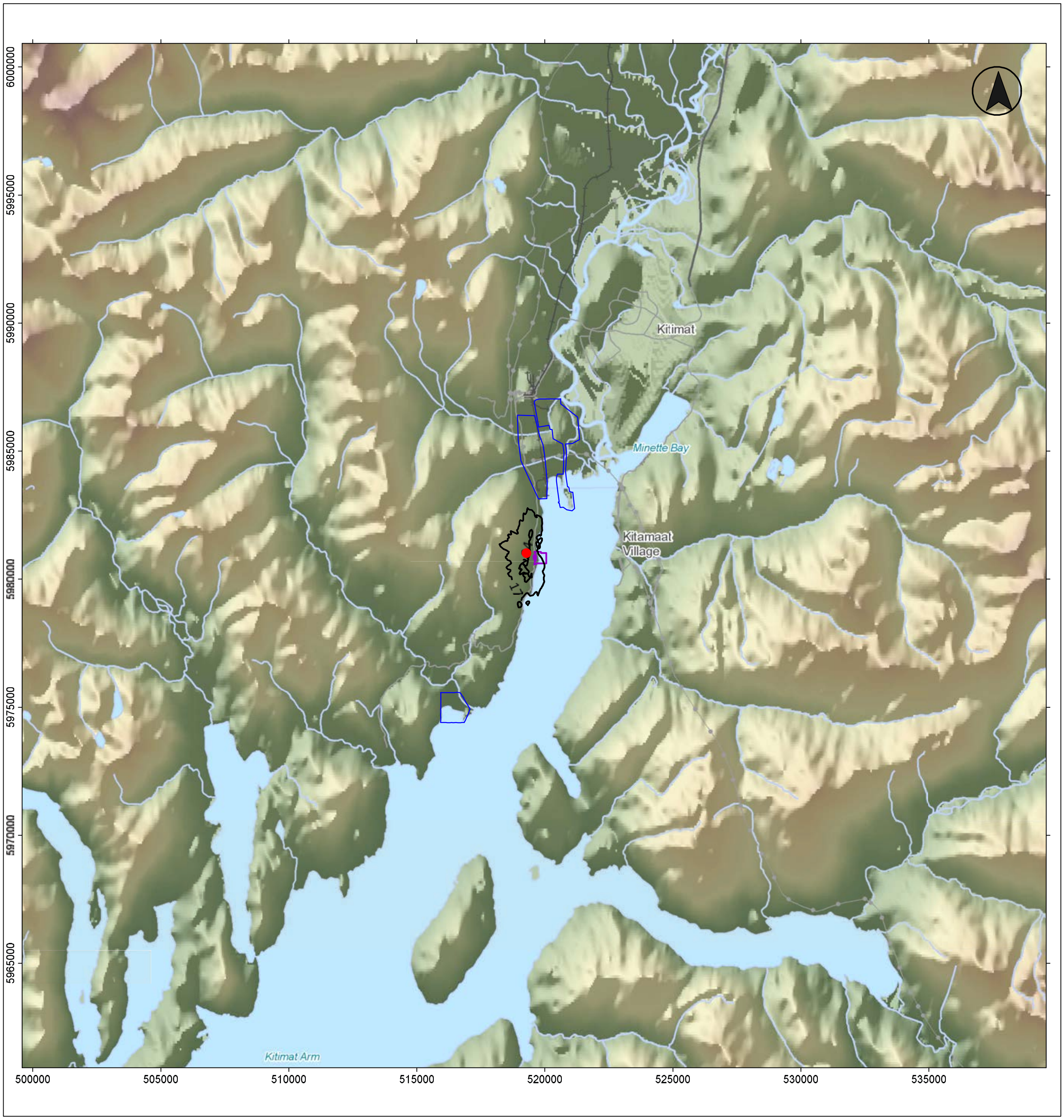
Project Location
Kitimat,
British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.6

Title
1-hour SO_2 Concentrations
(Application Case) (µg/m³)



Cedar LNG Boundary

Regional Facility Boundary

Highway

Road

Railway

Transmission Line

Watercourse

Waterbody

Elevation (m)

2026
2000
1500
1000
500
0

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 55.6 μg/m3

1-hour SO_2 CAAQS: 170 μg/m3

Contour Levels: 17, 34, 85, 127.5, 170 μg/m3

Baseline: Not added

Concentrations based on the 99th percentile of the 1-hour daily maximum

0 5000 10000

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec

CEDAR LNG

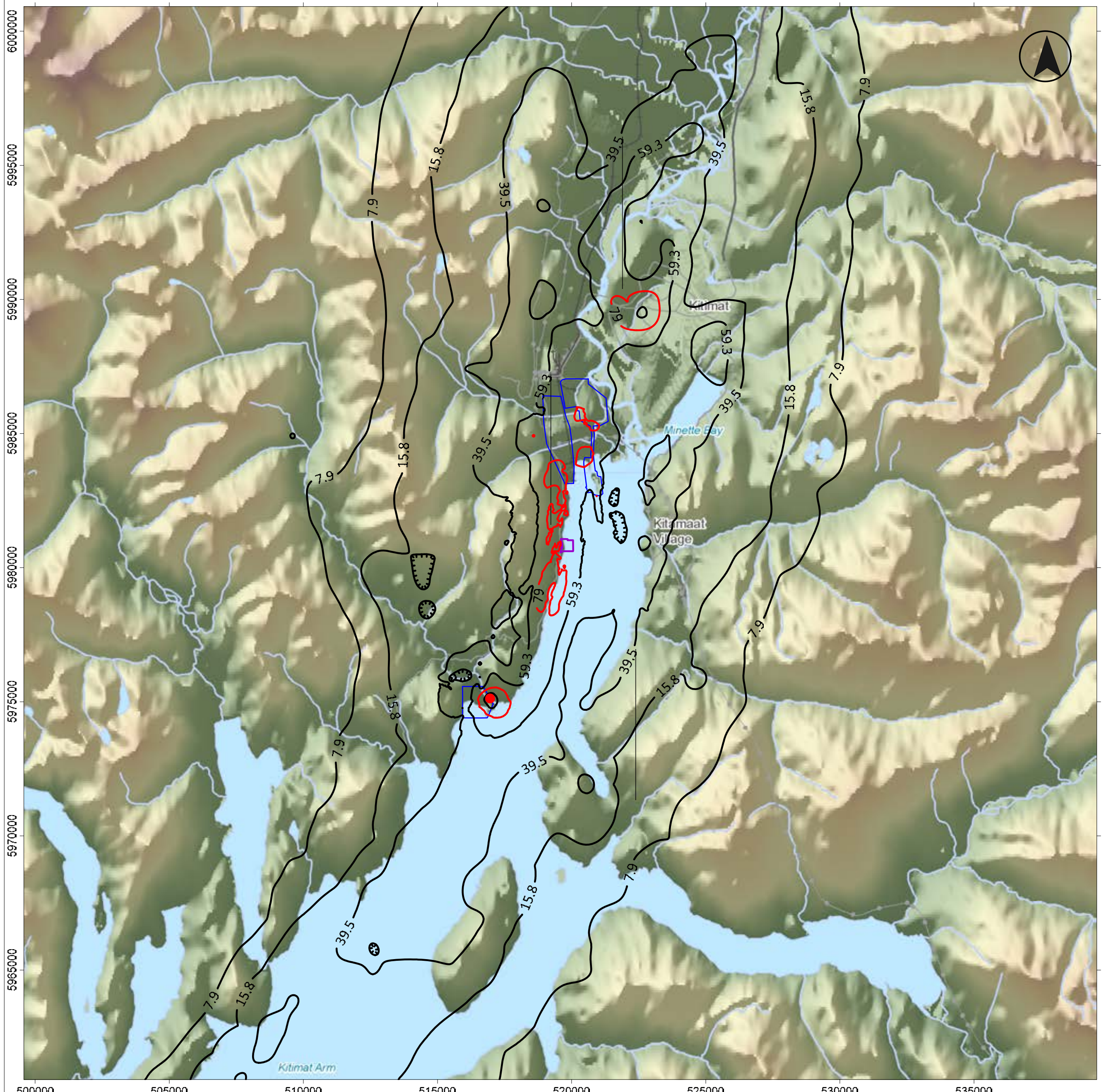
Project Location
Kitimat,
British Columbia

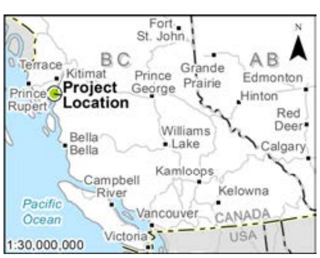
Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.7

Title
1-hour SO_2 Concentrations
(Project-Alone Case)(μg/m3)





Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Cedar LNG Boundary

Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 118.6 µg/m³

1-hour NO_2 BC AQO: 79 µg/m³ (——)

Contour Levels: 7.9, 15.8, 39.5, 59.3, 79, 98.8 µg/m³

Baseline: Not added

Concentrations based on the 98th percentile of the daily 1-hour maximum

0 5000 10000

Stantec
CEDAR LNG

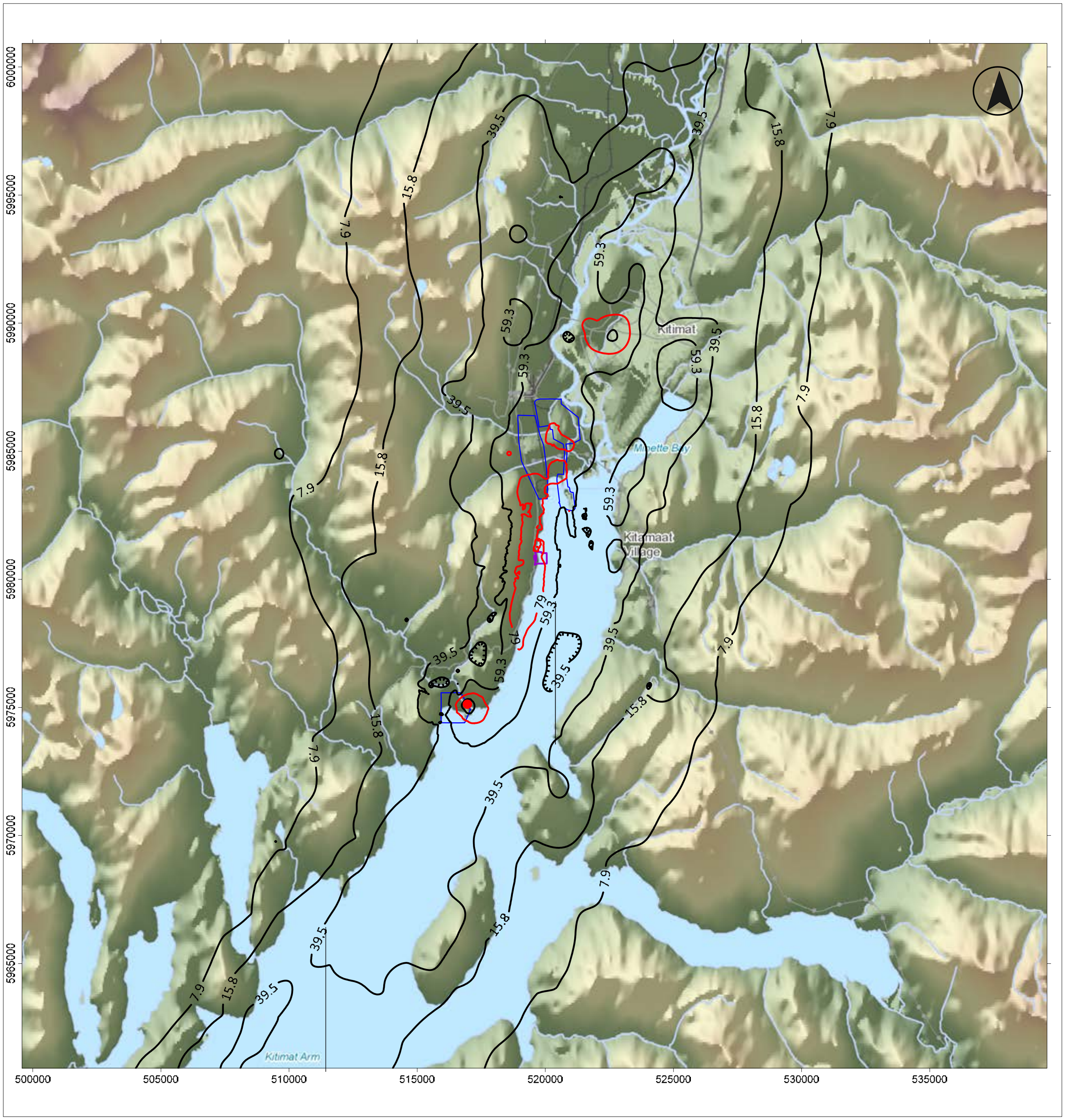
Project Location
Kitimat,
British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.8

Title
1-hour NO_2 Concentrations
(Base Case) (µg/m³)



Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Cedar LNG Boundary
Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 118.6 µg/m³
1-hour NO_2 CAAQS: 79 µg/m³ ( )
Contour Levels: 7.9, 15.8, 39.5, 59.3, 79, 98.8 µg/m³
Baseline: Not added
Concentrations based on the 98th percentile of the daily 1-hour maximum

0 5000 10000

Stantec
CEDAR LNG

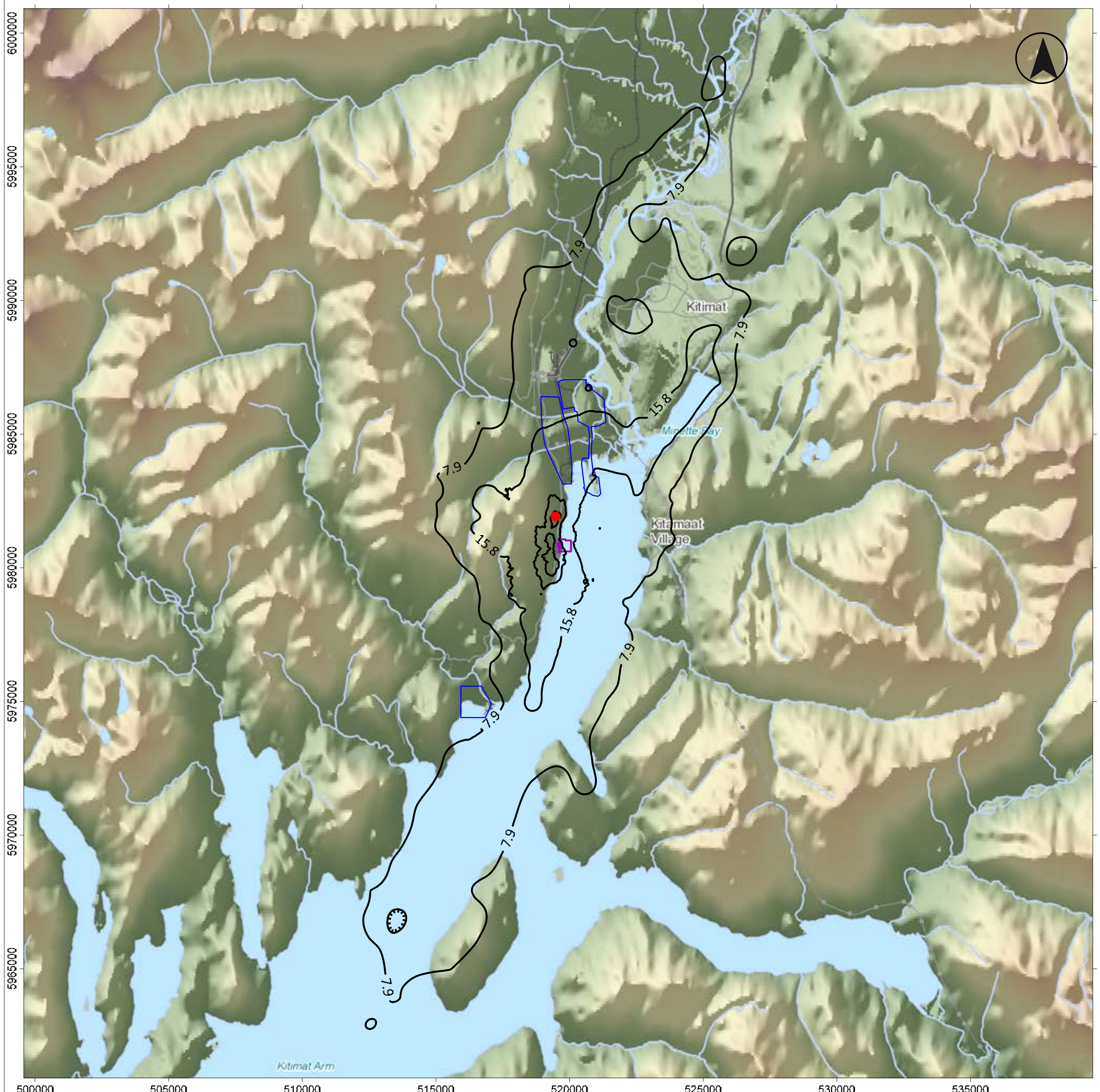
Project Location
Kitimat,
British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.9

Title
1-hour NO_2 Concentrations (Application Case) (µg/m³)



Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Cedar LNG Boundary
Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 73.5 μg/m³
1-hour NO_2 CAAQS: 79 μg/m³
Contour Levels: 7.9, 15.8, 39.5, 59.3, 79 μg/m³
Baseline: Not added
Concentrations based on the 98th percentile of the daily 1-hour maximum

0 5000 10000

Stantec
CEDAR LNG

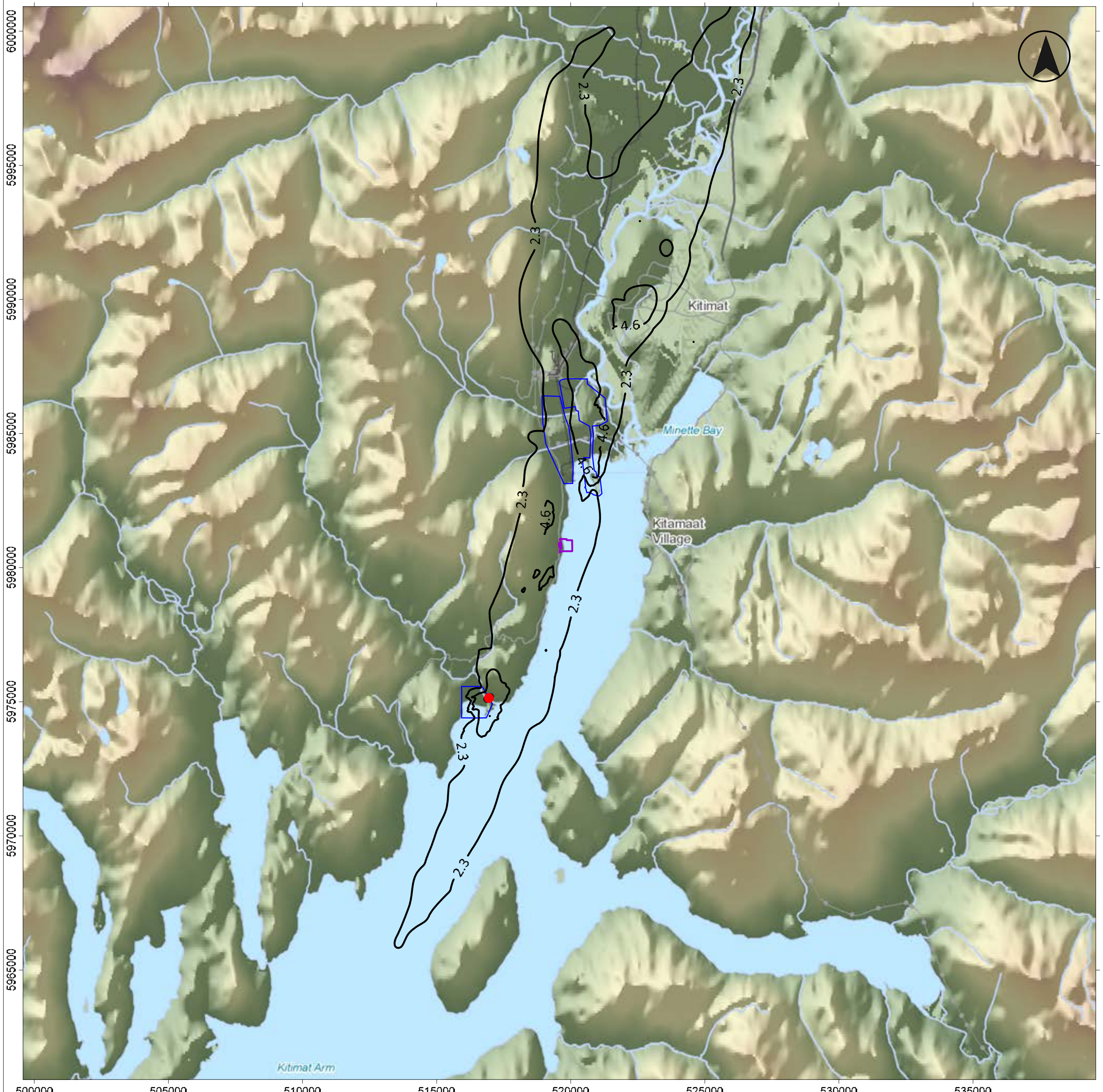
Project Location
Kitimat,
British Columbia

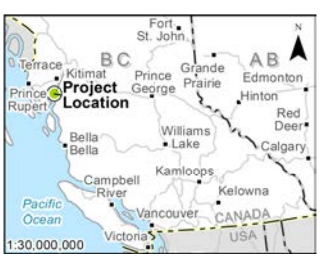
Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.10

Title
1-hour NO_2 Concentrations
(Project-Alone Case) (μg/m³)





Cedar LNG Boundary

Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum Annual Average NO_2 Concentration: 23.0 μg/m³

Annual NO_2 BC AQO: 23 μg/m³ (——)

Contour Levels: 2.3, 4.6, 11.5, 17.3, 23 μg/m³

Baseline: Not added

Based on the 1-hour average concentration over 3 years

0 5000 10000

Notes

1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec | CEDAR LNG

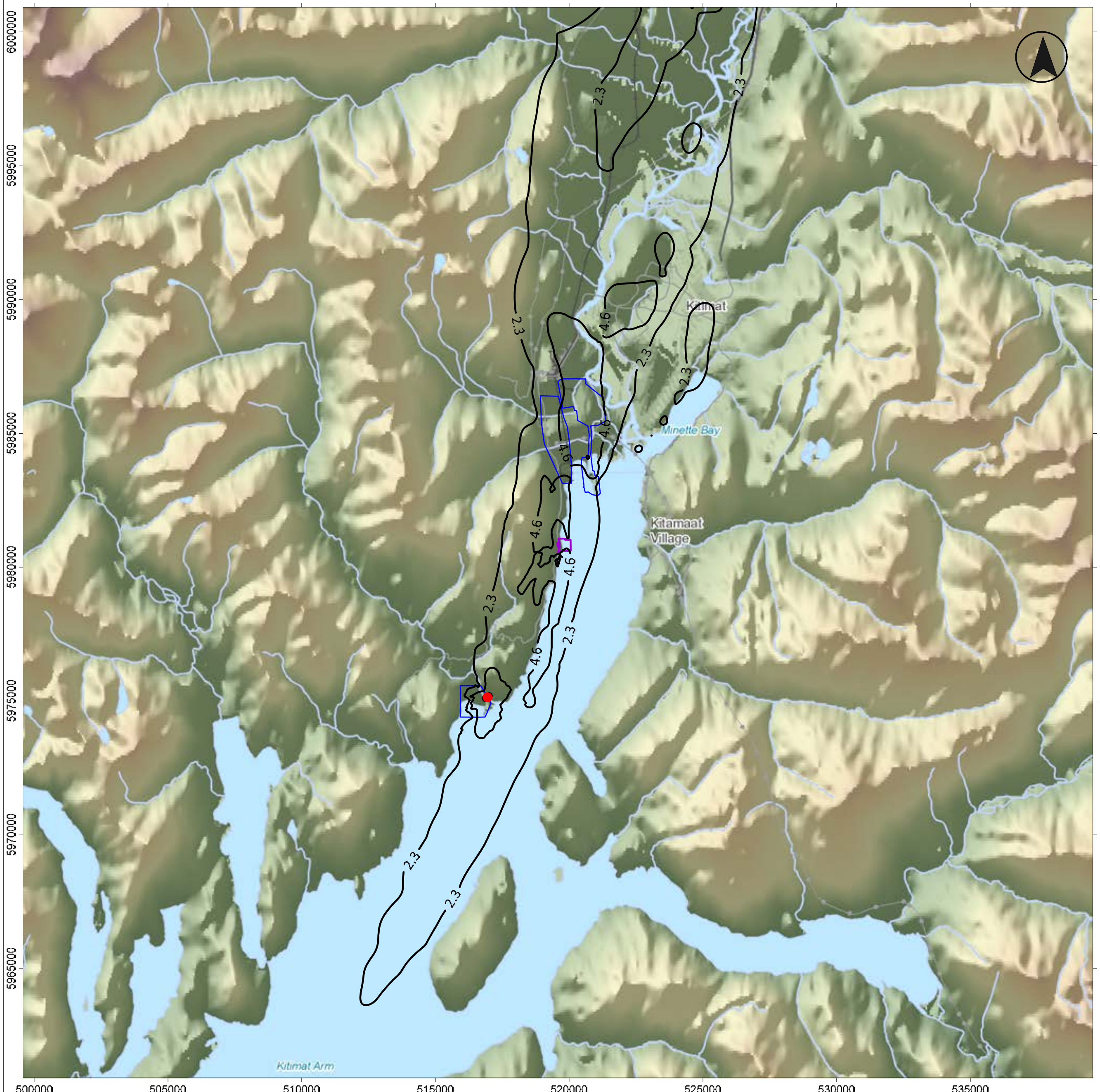
Project Location
Kitimat,
British Columbia

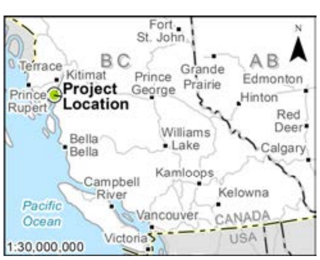
Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.11

Title
Annual Average NO_2 Concentrations (Base Case) (μg/m³)





Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Cedar LNG Boundary
Regional Facility Boundary

Maximum Annual Average NO_2 Concentration: 23.1 μg/m³
Annual NO_2 CAAQS: 23 μg/m³ (——)
Contour Levels: 2.3, 4.6, 11.5, 17.3, 23 μg/m³
Baseline: Not added
Based on the 1-hour average concentration over 3 years

0 5000 10000

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Stantec
CEDAR LNG

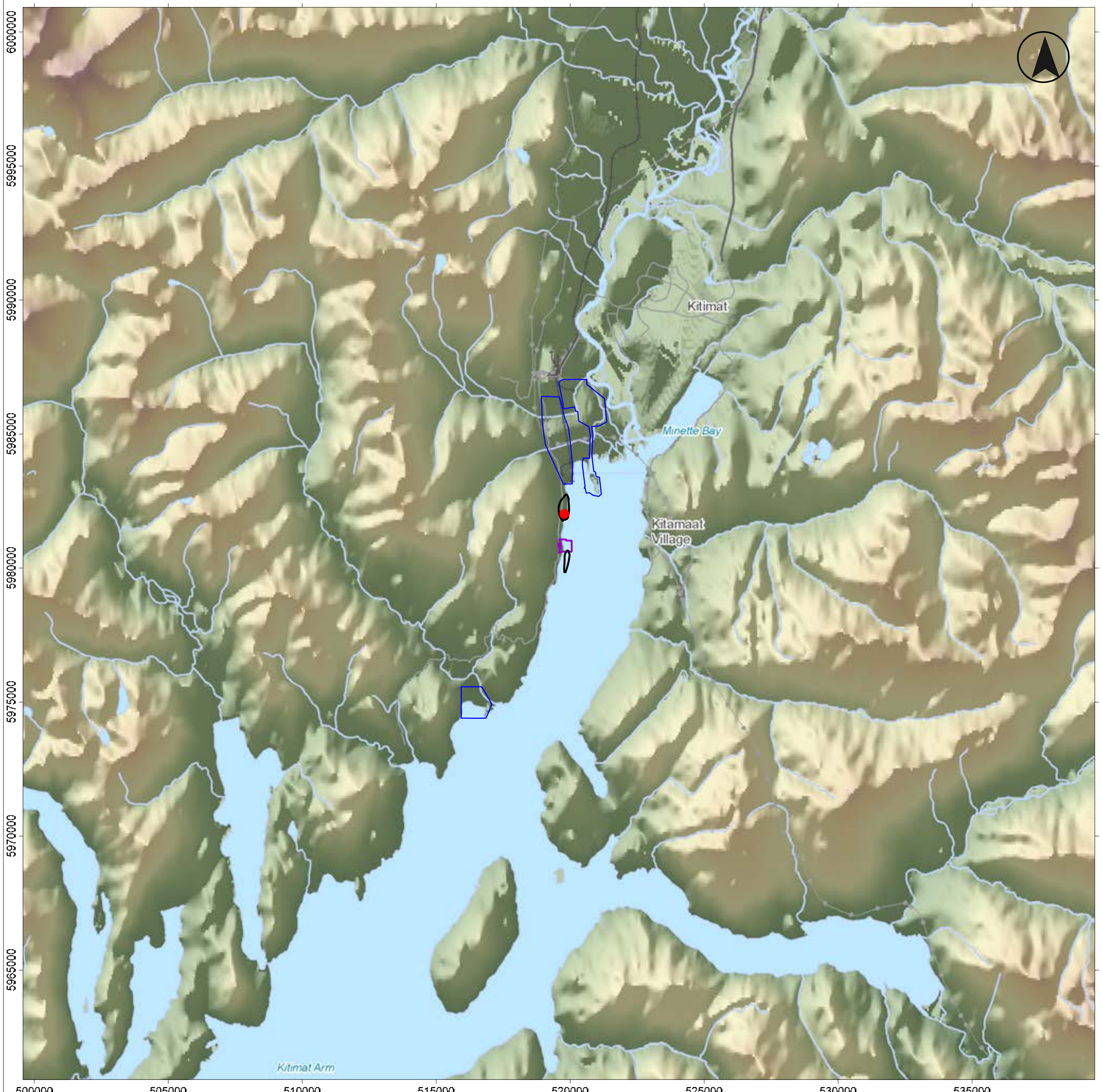
Project Location
Kitimat,
British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.12

Title
Annual Average NO_2 Concentrations (Application Case) (μg/m³)



Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Cedar LNG Boundary
Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum Annual Average NO_2 Concentration: 4.2 μg/m³
Annual NO_2 CAAQS: 23 μg/m³
Contour Levels: 2.3, 4.6, 11.5, 17.3, 23 μg/m³
Baseline: Not added
Based on the 1-hour average concentration over 3 years

0 5000 10000

Stantec
CEDAR LNG

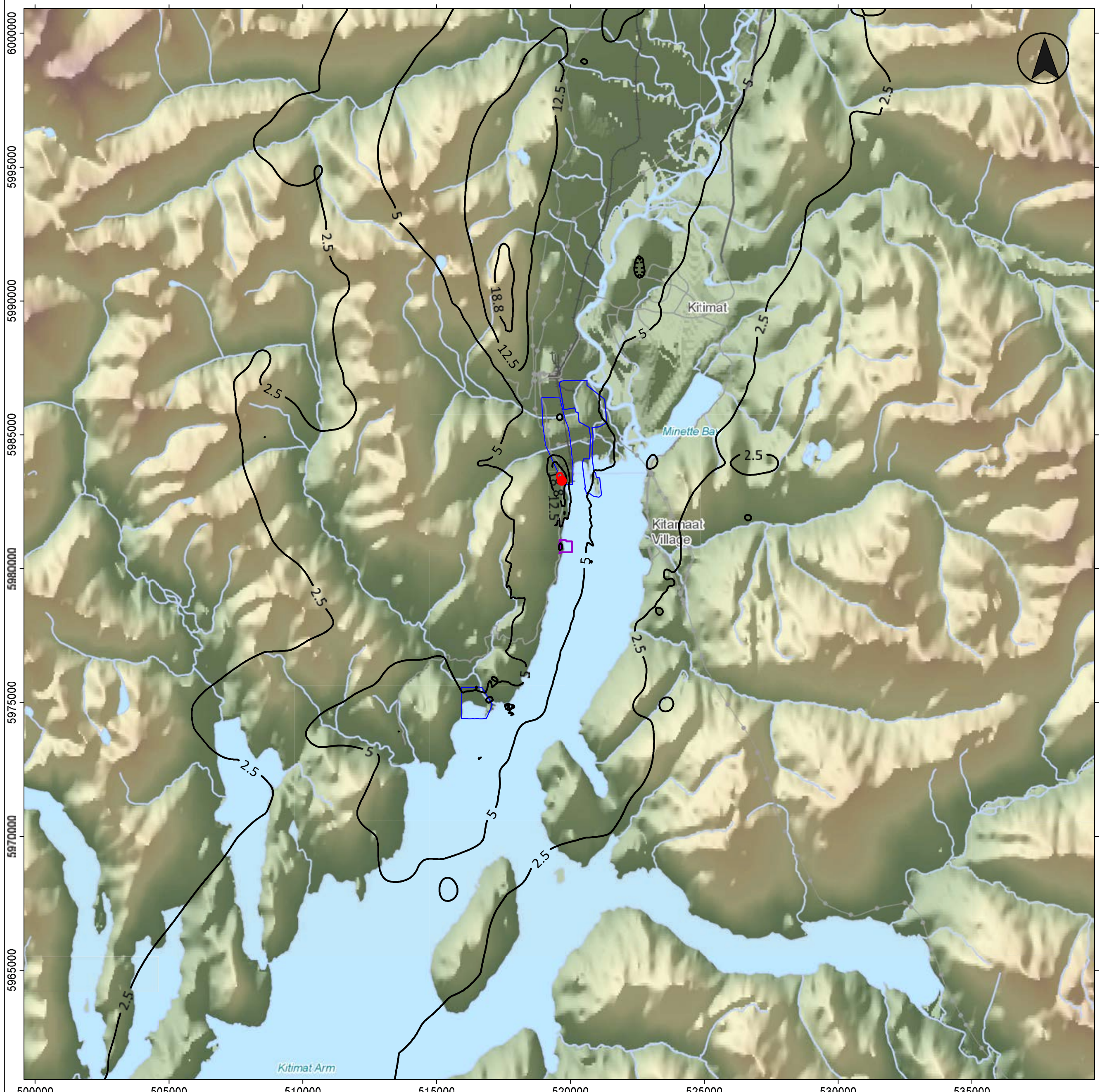
Project Location
Kitimat,
British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.13

Title
Annual Average NO_2 Concentrations (Project-Alone Case) (μg/m³)



Cedar LNG Boundary

Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum 24-Hour Average $PM_{2.5}$ Concentration: 29.5 µg/m³

24-Hour $PM_{2.5}$ BC AQO: 25 µg/m³ (——)

Contour Levels: 2.5, 5, 12.5, 18.8, 25 µg/m³

Baseline: Not added

Concentrations based on 98th percentile of the daily average over 3 years

0 5000 10000

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec
CEDAR LNG

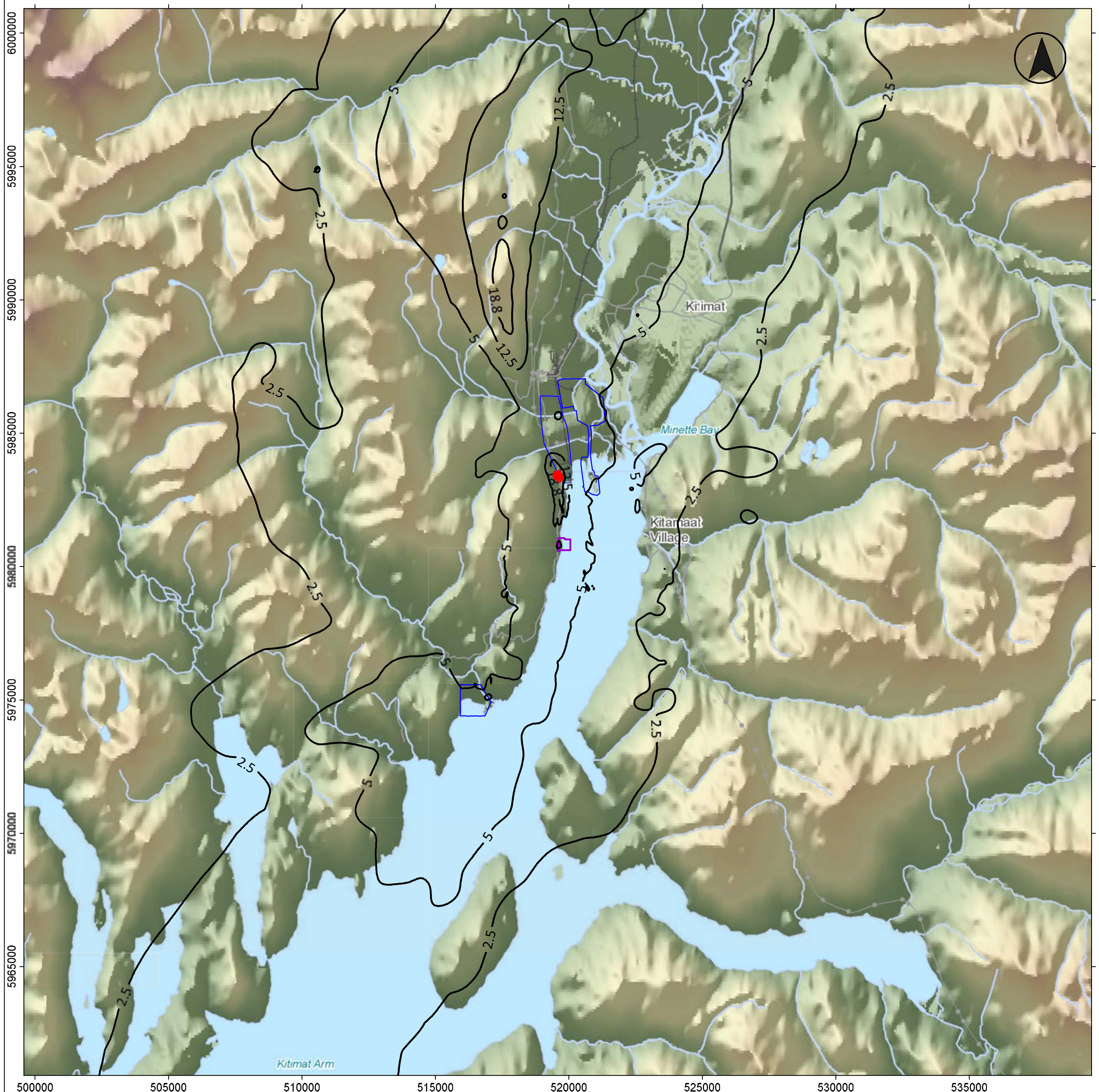
Project Location
Kitimat,
British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.14

Title
24-Hour Average $PM_{2.5}$ Concentrations (Base Case) (µg/m³)



Cedar LNG Boundary

Regional Facility Boundary

Highway

Road

Railway

Transmission Line

Watercourse

Waterbody

Elevation (m)

2026
2000
1500
1000
500
0

Maximum 24-Hour Average $PM_{2.5}$ Concentration: 29.7 µg/m³

24-Hour $PM_{2.5}$ BC AQO: 25 µg/m³

Contour Levels: 2.5, 5, 12.5, 18.8, 25 µg/m³

Baseline: Not added

Concentrations based on 98th percentile of the daily average over 3 years

0 5000 10000

Notes

1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec CEDAR LNG

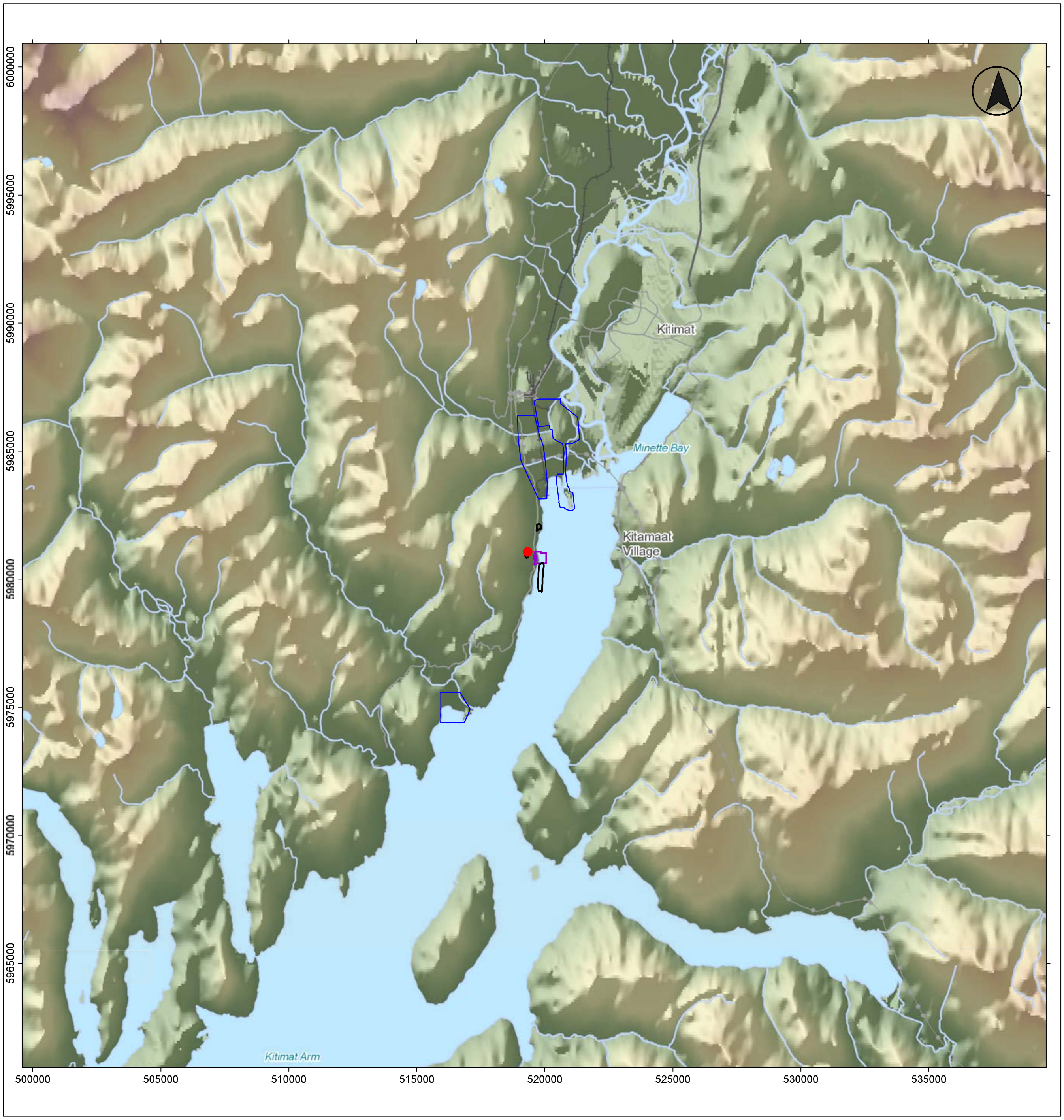
Project Location
Kitimat, British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.15

Title
24-Hour Average $PM_{2.5}$ Concentrations (Application Case) (µg/m³)



Cedar LNG Boundary

Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum 24-Hour Average $PM_{2.5}$ Concentration: 4.2 µg/m³

24-Hour $PM_{2.5}$ BC AQO: 25 µg/m³

Contour Levels: 2.5, 5, 12.5, 18.8, 25 µg/m³

Baseline: Not added

Concentrations based on 98th percentile of the daily average over 3 years

0 5000 10000

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec CEDAR LNG

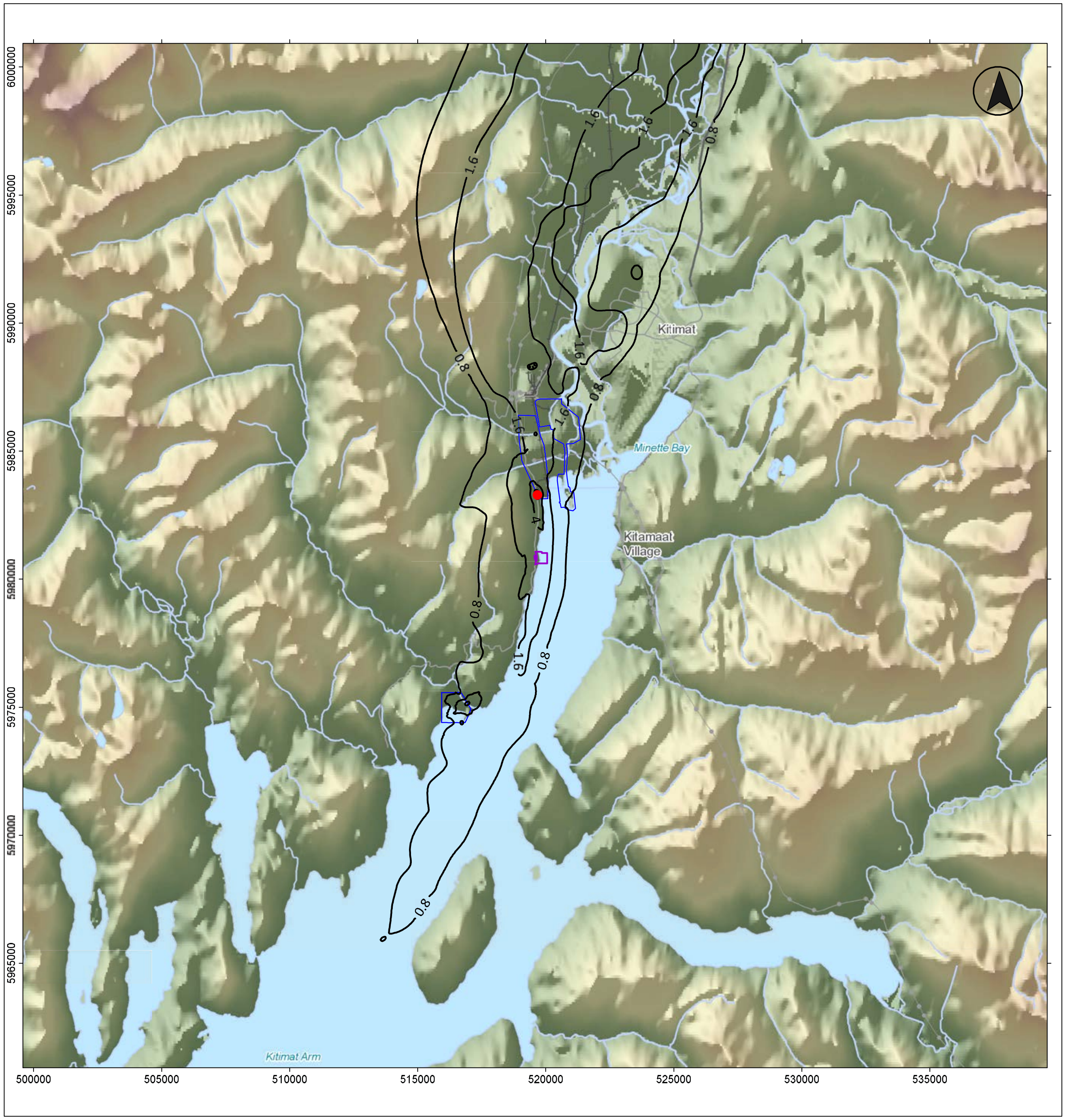
Project Location
Kitimat,
British Columbia

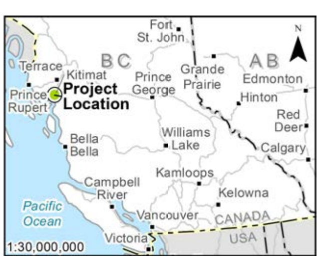
Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.16

Title
24-Hour Average $PM_{2.5}$ Concentrations (Project-Alone Case) (µg/m³)





Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Cedar LNG Boundary
Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum Annual Average $PM_{2.5}$ Concentration: 7.3 µg/m³
Annual $PM_{2.5}$ BC AQO: 8 µg/m³
Contour Levels: 0.8, 1.6, 4, 6, 8 µg/m³
Baseline: Not added
Concentrations based on annual average over one year

0 5000 10000

Stantec
CEDAR LNG

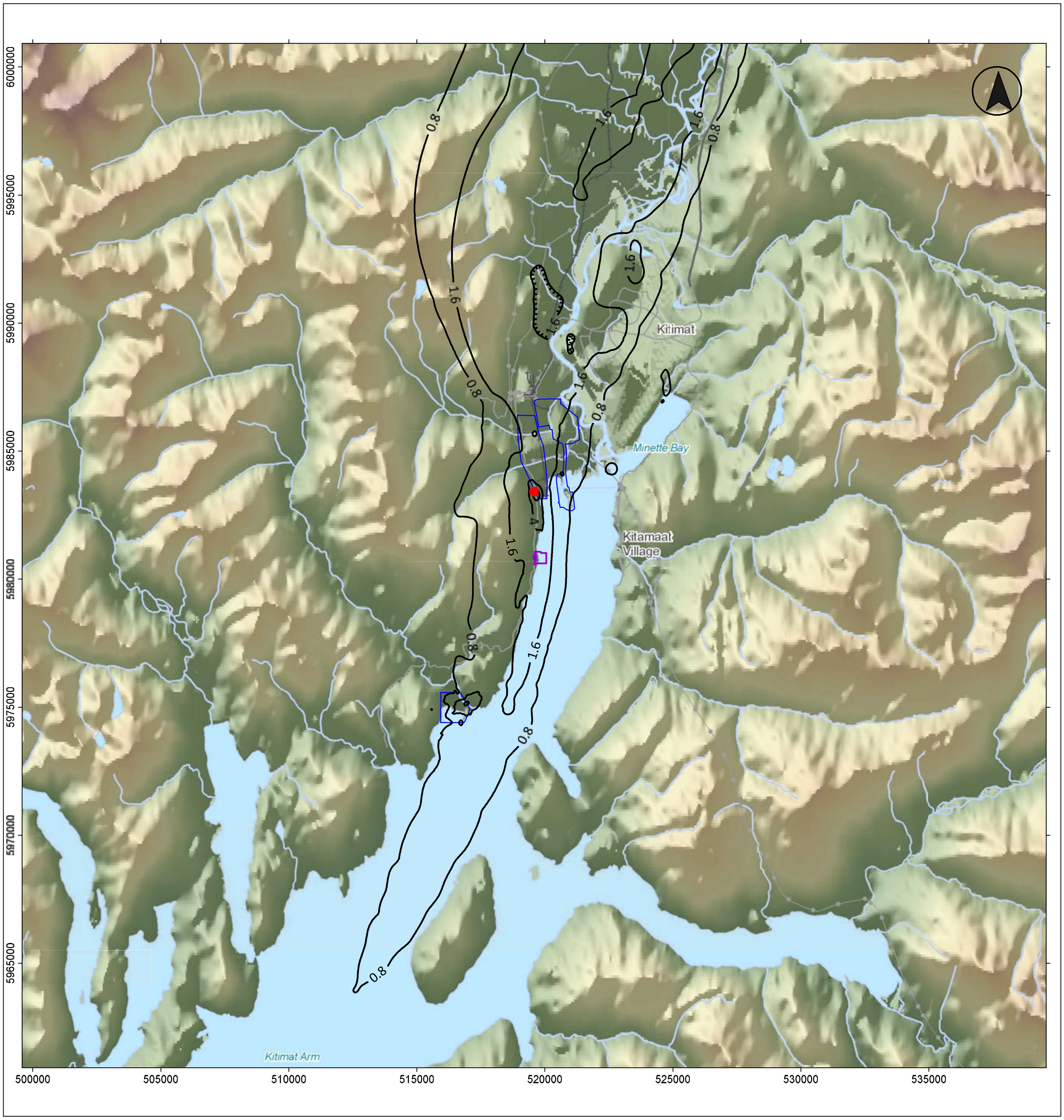
Project Location
Kitimat, British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.17

Title
Annual Average $PM_{2.5}$ Concentrations (Base Case) (µg/m³)



Cedar LNG Boundary

Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum Annual Average $PM_{2.5}$ Concentration: 7.6 µg/m3

Annual $PM_{2.5}$ BC AQO: 8 µg/m3

Contour Levels: 0.8, 1.6, 4, 6, 8 µg/m3

Baseline: Not added

Concentrations based on annual average over one year

0 5000 10000

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec
CEDAR LNG

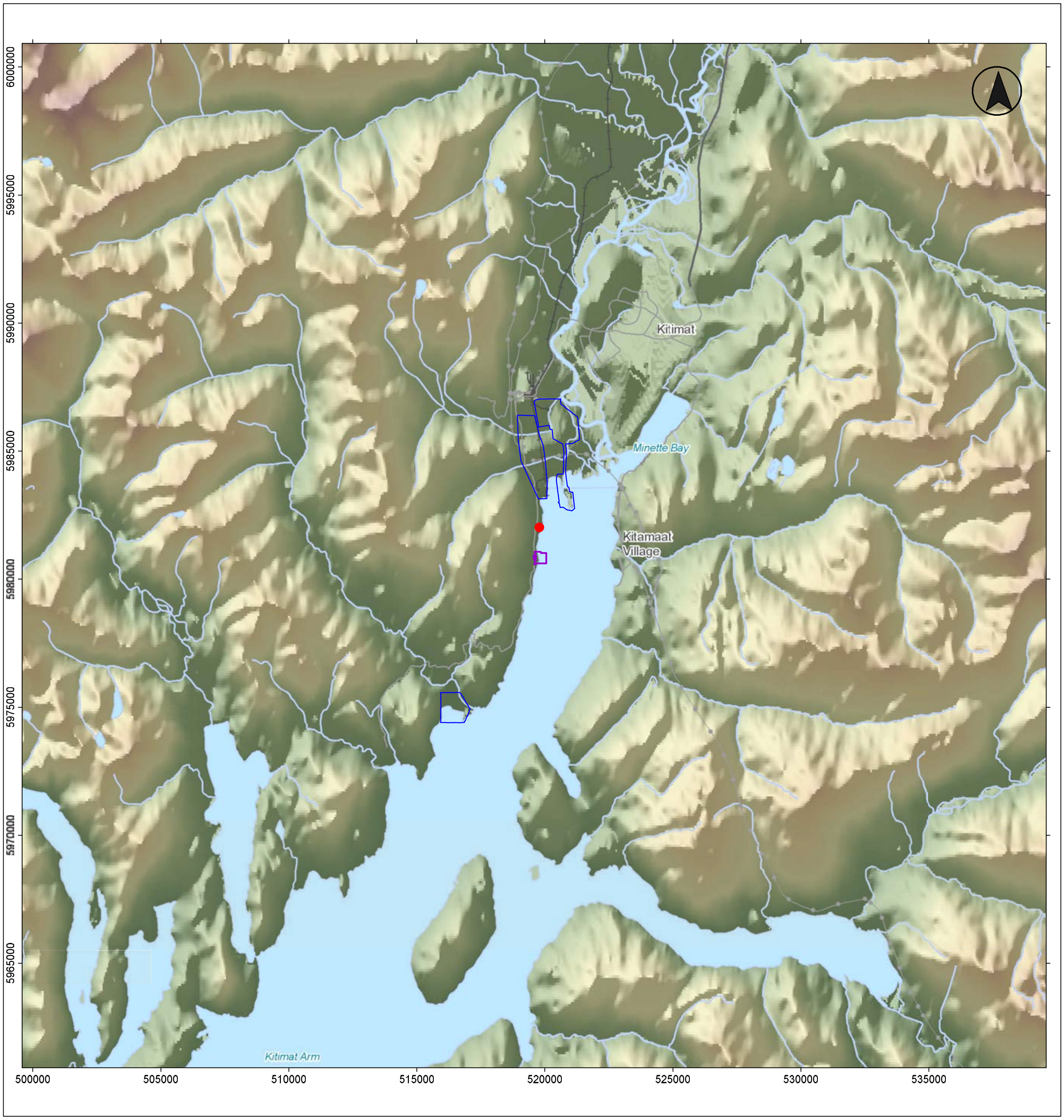
Project Location
Kitimat,
British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.18

Title
Annual Average $PM_{2.5}$ Concentrations (Application Case) (µg/m3)



Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Cedar LNG Boundary

Regional Facility Boundary

Highway
Road
Railway
Transmission Line
Watercourse
Waterbody

Elevation (m)
2026
2000
1500
1000
500
0

Maximum Annual Average $PM_{2.5}$ Concentration: 0.8 μg/m³

Annual $PM_{2.5}$ BC AQO: 8 μg/m³

Contour Levels: 0.8, 1.6, 4, 6, 8 μg/m³

Baseline: Not added

Concentrations based on annual average over one year

0 5000 10000

Stantec

CEDAR LNG

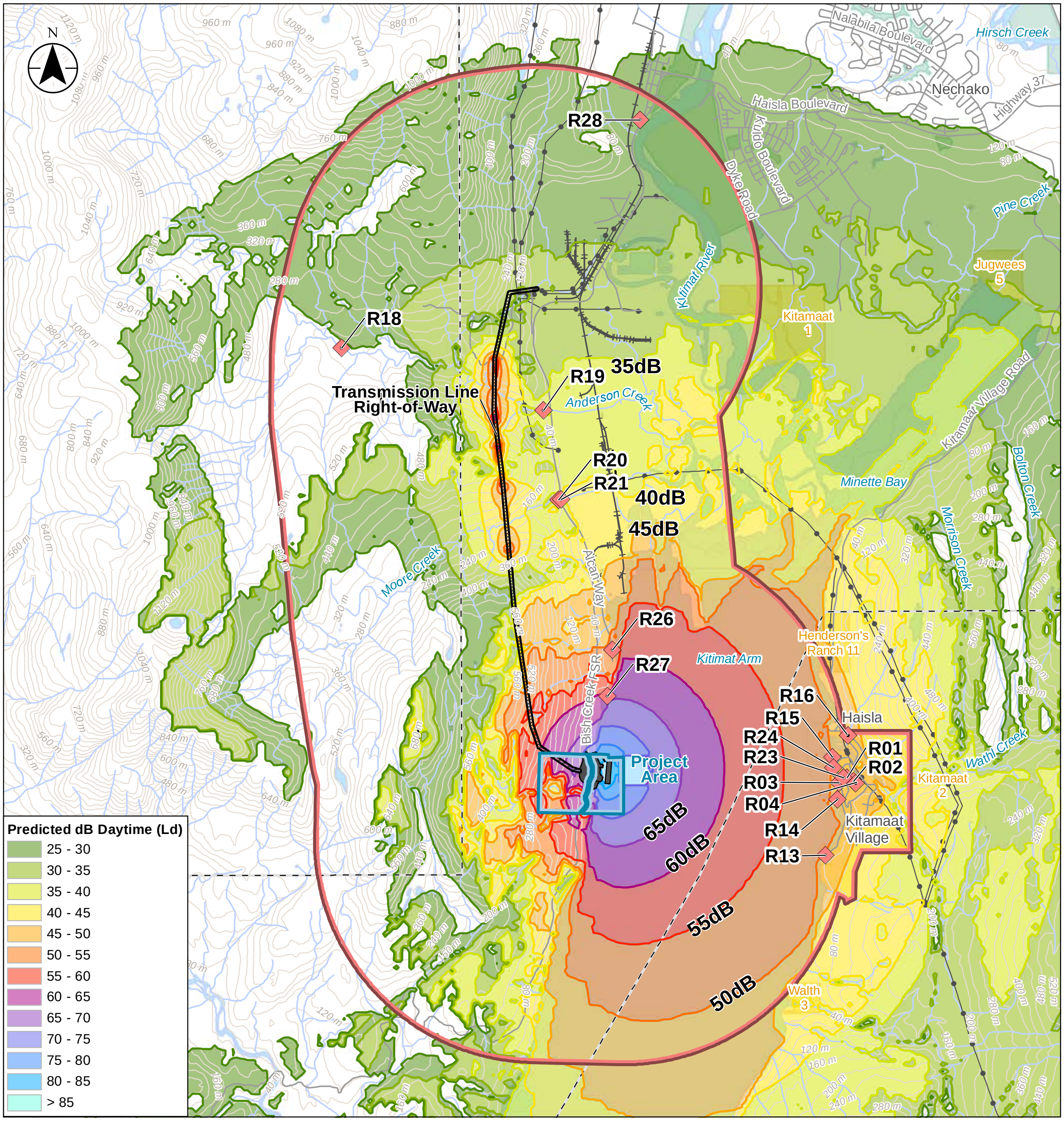
Project Location
Kitimat, British Columbia

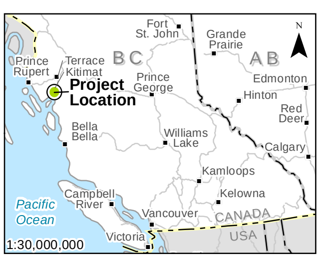
Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.19

Title
Annual Average $PM_{2.5}$ Concentrations (Project-Alone Case) (μg/m³)





- Road
- Railway
- Transmission Line
- Topographic Contour (40 m)
- Watercourse
- Waterbody
- Reserve Land
- Local Greenspace
- District of Kitimat Municipal Boundary
- Project Area
- Transmission Line Right-of-Way
- Marine Terminal Area
- Regional Assessment Area
- Local Assessment Area
- Noise Sensitive Receptor

0 0.5 1 1.5 2 2.5 3 km

1:80,000 (at original document size of 8.5x11)

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec

CEDAR LNG

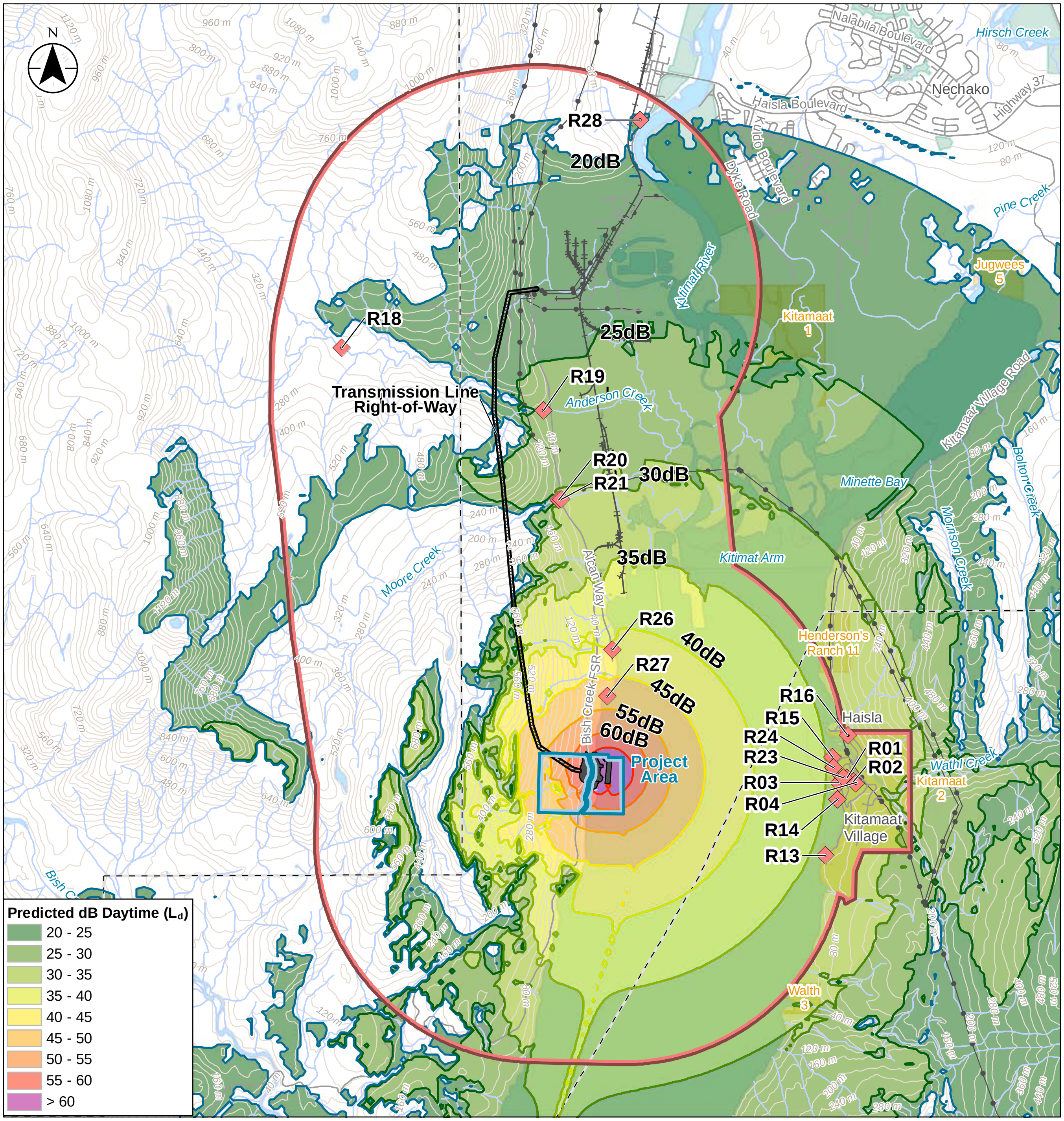
Project Location:
Kitimat,
British Columbia

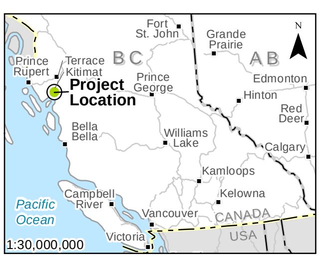
Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.20

Title
Construction Phase Daytime (L_d) Predictive Noise Contour Map





- Road
- Railway
- Transmission Line
- Topographic Contour (40 m)
- Watercourse
- Waterbody
- Reserve Land
- Local Greenspace
- District of Kitimat Municipal Boundary
- Project Area
- Transmission Line Right-of-Way
- Marine Terminal Area
- Regional Assessment Area
- Local Assessment Area
- Noise Sensitive Receptor

0 0.5 1 1.5 2 2.5 3 km

1:80,000 (at original document size of 8.5x11)

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

Stantec CEDAR LNG

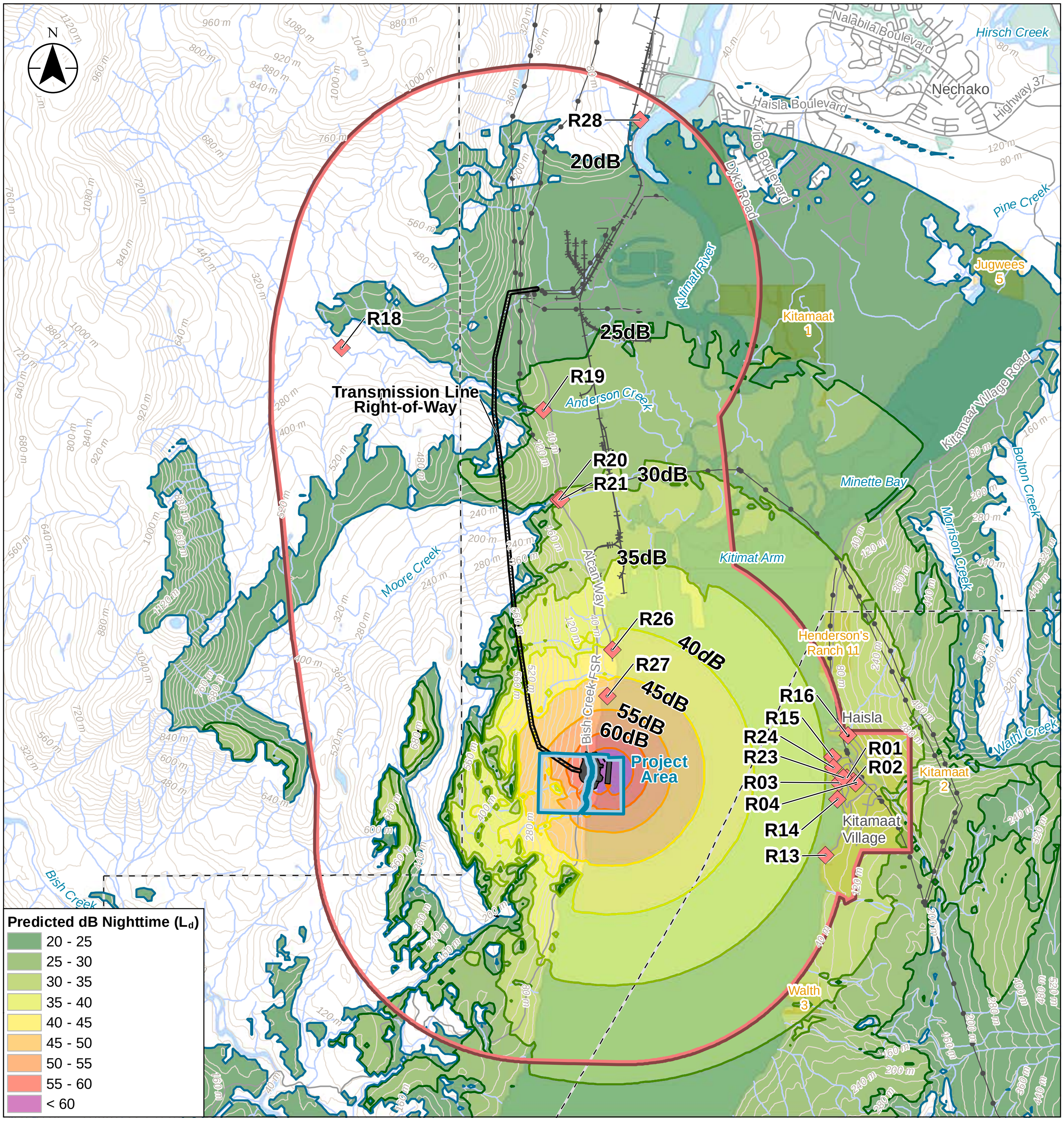
Project Location: Kitimat, British Columbia

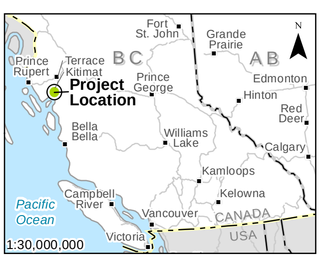
Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.21

Title
Operation Phase Predictive Daytime (L_d) Noise Contour Map





- Road
- Railway
- Transmission Line
- Topographic Contour (40 m)
- Watercourse
- Waterbody
- Reserve Land
- Local Greenspace
- District of Kitimat Municipal Boundary
- Project Area
- Transmission Line Right-of-Way
- Marine Terminal Area
- Regional Assessment Area
- Local Assessment Area
- Noise Sensitive Receptor

0 0.5 1 1.5 2 2.5 3 km

1:80,000 (at original document size of 8.5x11)

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service

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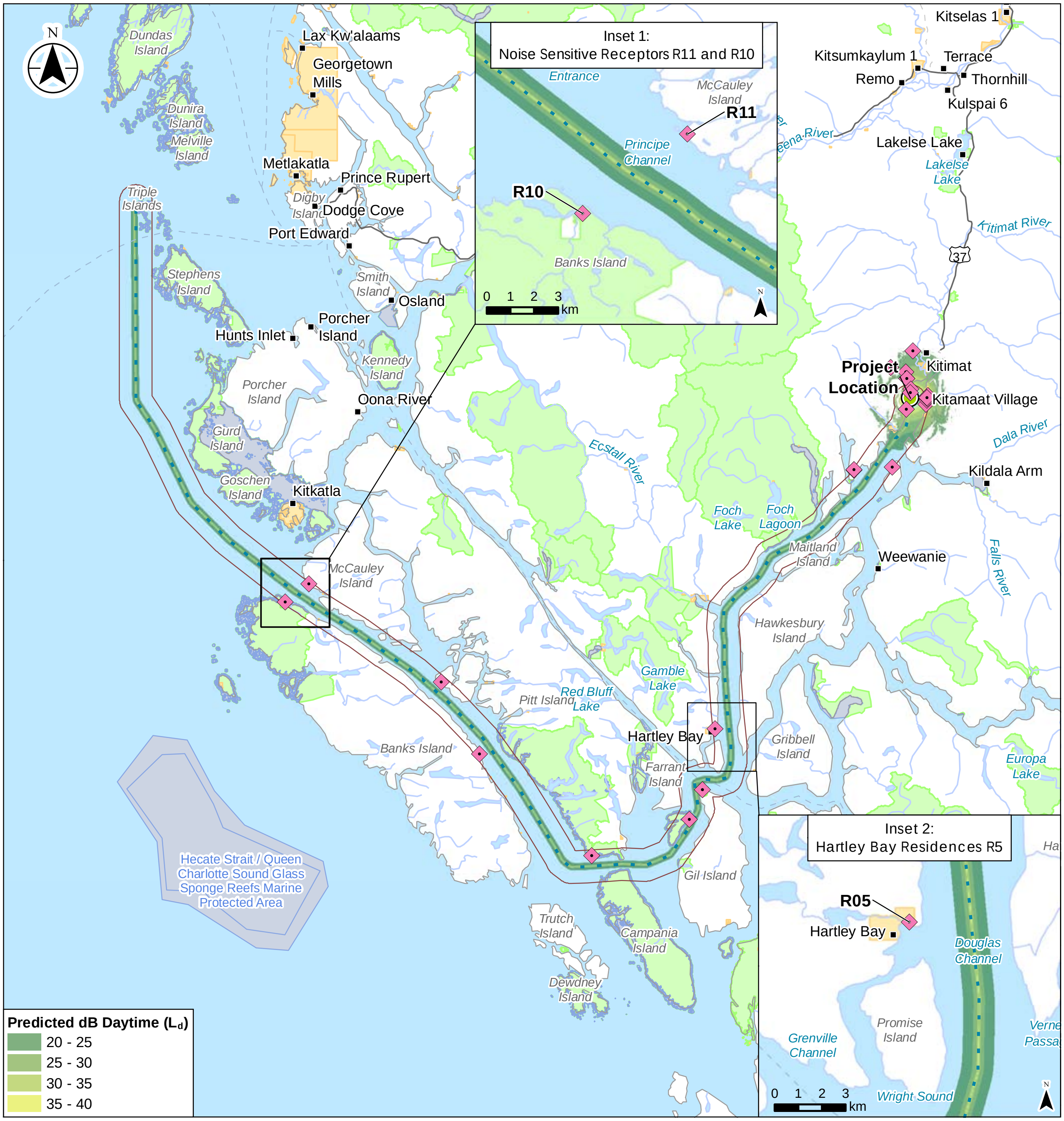
Project Location:
Kitimat,
British Columbia

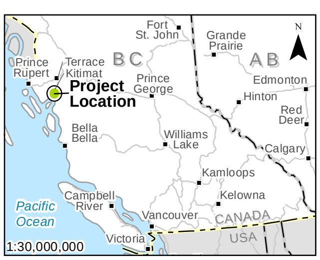
Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.22

Title
Operation Phase Predictive Nighttime (L_n) Noise Contour Map





- Highway
- Resource Road
- Ferry Route
- Waterbody
- Watercourse
- Reserve Land
- Terrestrial Park, Ecological Reserve, Protected Area or Conservancy Area
- Marine Park, Ecological Reserve, Protected Area or Conservancy Area
- Project Location
- Marine Shipping Route (Approximate Location)
- Noise Sensitive Receptor

Human Health (Noise Effects)

- Local and Regional Assessment Area

0 10 20 30 40 50 km

1:1,100,000 (at original document size of 8.5x11)

Stantec CEDAR LNG

Project Location:
Kitimat,
British Columbia

Project Number 123221301

Client/Project/Report
Cedar LNG Partners LP
Cedar LNG Project

Figure No.
7.12.23

Title
Operation Phase Predictive Daytime (L_d) Noise Contour Map - Shipping Route

Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Canadian Hydrographic Service