Environmental Assessment Certificate Application

LNG Canada Export Terminal

Section 9 – Human Health Effects

October 2014

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Mitsubishi Corporation

9 ASSESSMENT OF POTENTIAL HEALTH EFFECTS

9.1 Health Background

Existing industrial and transportation activities (road, rail, and shipping) in the Kitimat area release contaminants to the atmosphere that affect air quality. Contaminants released to the environment by these activities have the potential to affect human health. Chemicals released to the atmosphere also might alter the quality of locally harvested terrestrial country foods (both plants and animals) if the chemicals settle out of the air onto local plants and soils in the Kitimat airshed and are consumed by people. People might also be exposed to these chemicals by consuming animals that have consumed affected plants. Although chemicals released to surface water from current industrial operations could be present in the raw water entering the municipal water treatment system, treated municipal supply water is required to meet drinking water standards. Therefore, the releases to surface water are not expected to represent a potential concern for human health.

Marine sediment quality in Kitimat Arm has been influenced by past and current industries or activities, including the Methanex Corporation methanol and ammonia production facility (operational from 1982 to 2005, now closed), the Eurocan pulp and paper mill (operational from 1969 to 2010, now closed), the District of Kitimat wastewater treatment plant, the RTA facility (operational from the early 1950's to present day), and log handling and storage activities. Polycyclic aromatic hydrocarbons (PAHs) in the sediment are the most studied of contaminants in Kitimat Arm. Additional contaminants of potential concern in Kitimat Arm are metals, dioxins and furans, and fluoride from a variety of sources. Contaminants in the sediment might be taken up by fish, mussels, clams, or other marine aquatic species that are used as sources of country foods in the Kitimat area. The presence of contaminants in the tissue of marine country foods might present a potential concern for people who consume these foods on a regular basis.

9.2 Human Health

9.2.1 Introduction

Human health is a VC because there is potential for the Project to change the chemical conditions of the environment (air, water, soil, sediment, and country foods). The Project might interact with human health in the following ways:

- Changes in ambient air quality could result in changes in health risks associated with inhalation exposures.

- Changes in ambient air quality could result in acidification of surface waterbodies altering water quality, which could result in changes in health risks associated with consumption of, or contact with, surface water.
- Changes in ambient air quality could result in changes in the quality of terrestrial country foods.
- Resuspension of historical sediment-bound contaminants during dredging and construction of marine wharves could lead to contaminant uptake in marine biota that might be consumed by people.

Chemicals in the environment could be transferred to human receptors through direct exposure or through the consumption of country foods.

The HHRA evaluates the relationship between exposure to chemical stressors and potential effects on health. Project stressors include chemical emissions into the terrestrial, aquatic, and atmospheric environments.

Potential effects on human health arising from accidents or malfunctions are addressed separately in Section 10.

9.2.2 Scope of Assessment

This assessment evaluates potential changes in human health resulting from exposures to chemicals released to the environment as a result of Project activities. The assessment of human health uses the analytical and modelling results from the air quality assessment (Section 5.2) and the marine resources assessment (Section 5.8).

Other aspects of health, such as community health and well-being, and Aboriginal health related to traditional and cultural practices, are discussed in Sections 7.5, 14, and 15, respectively. Worker health and safety is addressed through compliance with the relevant occupational health and safety laws.

9.2.2.1 Regulatory and Policy Setting

In BC, public health is the responsibility of the Minister of Health in accordance with the *Public Health Act*. Health Canada also has a mandate to protect humans from exposure to chemicals. Health Canada provides guidance on human health risk assessments and evaluates human health issues for major projects regulated under the *Canadian Environmental Assessment Act*.

In this assessment, provincial and federal standards and guidelines are used including from the MOE; Alberta ESRD; U.S. EPA; WHO; Health Canada; and CCME:

- Air Quality: Ambient Air Quality Objectives (MOE 2013; ESRD 2013), National Ambient Air Quality Standards (U.S. EPA 2010), and Ambient Air Quality Guidelines (WHO 2005)

- Water Quality: Drinking water quality guidelines (Health Canada 2012; CCME 2014)
- Soil Quality: Soil quality guidelines (CCME 2007); soil screening guidance (U.S. EPA 1996)
- Sediment Quality**:** Sediment quality guidelines for the protection of aquatic life (CCME 2014); Working Guidelines for Sediment (MOE 2006), and
- Food Quality: Canadian Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota (CCME 1999); *Contaminated Sites Regulation* (MOE 2014); and Supplemental Guidance on Human Health Risk Assessment for Country Foods (Health Canada 2010a).

9.2.2.1.1 Air Quality

Human health-based air quality standards and objectives are used to screen against potential health risks from inhalation of criteria air contaminants (CAC), which include particulate matter (PM), sulphur dioxide (SO_2), hydrogen sulphide (H_2S), nitrogen dioxide (NO_2), and carbon monoxide (CO). Human health-based air quality standards and objectives are developed for the protection of the most sensitive receptors in a population, such as young children, the elderly, and people with pre-existing health conditions (e.g., asthma or chronic obstructive pulmonary disease [COPD]). Although MOE provides provincial ambient air quality objectives (AAQO), many of these are pollution control objectives and are not based on the protection of human health; therefore, they are not appropriate for evaluating potential human health risks associated with inhalation exposures. The MOE is updating the AAQOs to include human health-based ambient air quality limits. Where these human health-based AAQO are available for Project-related chemicals, they have been used to assess potential human health risks associated with inhalation exposures. Where human health-based air quality criteria are not available from MOE, human health-based criteria developed by U.S. EPA and WHO have been used.

9.2.2.1.2 Water Quality

Drinking water quality guidelines provided by Health Canada and CCME are used to screen against potential chemical health risks to people consuming local stream water or well water, or coming in contact with water through various recreational water uses (e.g., boating, swimming, fishing). Ecological health risks linked to potential water quality degradation are screened using provincial and CCME water quality guidelines for the protection of freshwater and marine aquatic life.

9.2.2.1.3 Soil Quality

Soil quality guidelines for residential/parkland, industrial, commercial, and agricultural use are provided by CCME. The BC *Contaminated Sites Regulation* and U.S. EPA set levels to screen for potential health risks to soil invertebrates, plants, wildlife, and people following direct contact or ingestion of chemicals in soil. However, the soil-quality guidelines developed by these agencies do not consider the consumption of plants and animals by people; therefore, they do not provide protection for this human exposure pathway. Consequently, they are not used in this assessment of human health.

9.2.2.1.4 Sediment Quality

Sediment quality guidelines from CCME and MOE are used to evaluate for potential health risks to aquatic benthic invertebrates, fish, and algae following direct contact with sediment-based chemicals. However, the sediment quality guidelines developed by these agencies do not consider consumption of marine plants or animals by people; therefore, they do not provide protection for this human exposure pathway. Consequently, they are not used in this assessment of human health.

9.2.2.1.5 Food Quality

Dietary exposures to various contaminants of concern include metals, extractable petroleum hydrocarbons, PAHs, and polychlorinated dibenzo-para-dioxins and furans (PCDD/F). Health Canada has calculated tolerable daily intakes to be used in assessing potential human health risks, which are used in the country foods risk assessment.

9.2.2.2 Consultations' Influence on the Identification of Issues and the Assessment Process

LNG Canada consulted with Aboriginal Groups, the public, the EAO Working Group, Health Canada, the BC Ministry of Health, Northern Health, and other interested parties throughout the pre-Application period and development of the AIR. More detailed discussions of the process, the groups consulted, and the information obtained through the process is provided in Section 13.2 and Section 18. The following changes were made to the human health environmental assessment as a result of consultation:

- assessment of potential human health effects associated with simultaneous exposures to SO_2 and NO_2
- assessment of the potential health risk associated with ingestion of contaminated terrestrial country foods, and
- assessment of the potential health risk associated with ingestion of contaminated marine country foods as a result of dredging activities.

In addition, through LNG Canada's consultation program, potentially affected Aboriginal Groups have identified issues and concerns with respect to potential adverse effects on human health, which are addressed in this assessment as well as in Part C of this Application as they relate to potential adverse effects on Aboriginal Interests (Section 14) or Other Matters of Concern to Aboriginals (Section 16).

9.2.2.3 Traditional Knowledge and Traditional Use Incorporation

TK and TU information was gathered from Project studies submitted to LNG Canada and from publicly available sources. Project studies undertaken as part of the Application are discussed in Section 6, 7.2, and 7.5. This information informed the baseline conditions for the assessment. Information from these studies also contributed to the identification of the marine country foods considered in this assessment.

9.2.2.4 Selection of Effects

Potential effects on human health are based on Project activities and works; legislative and regulatory requirements (Section 9.2.2.1); issues identified through consultation with Aboriginal Groups, the public, the Working Group, and other interested parties (Section 9.2.2.2); and the professional judgment and experience of the environmental assessment team. The following potential effects on human health are assessed:

- change in human health risk from degraded air quality
- change in human health risk from degraded drinking water quality, and
- change in human health risk from ingestion of contaminated country foods.

Change in human health as a result of changes in country food quality addresses the potential effects associated with changes in the chemical levels in terrestrial country foods (plant and animal) that might result from facility emissions and in marine country foods that might occur as a result of the resuspension of sediments during dredging activities.

9.2.2.5 Selection of Measurable Parameters

Measurable parameters facilitate quantitative or qualitative measurement of potential effects based on standards or guidelines, legislative and regulatory requirements, and the professional judgment of the assessment team (Table 9.2-1).

Table 9.2-1: Potential Project Effects on Human Health and Measurable Parameters

Potential Adverse Project Effects	Measurable Parameters
Change in human health risk from degraded air quality	▪ CRs for non-carcinogenic chemicals of concern ▪ ILCR for carcinogenic chemicals of concern
Change in human health risk from degraded drinking water quality	▪ CRs for non-carcinogenic chemicals of concern ▪ ILCR for carcinogenic chemicals of concern
Change in human health risk from ingestion of contaminated country foods	▪ HQ for non-carcinogenic chemicals of concern ▪ ILCR for carcinogenic chemicals of concern

NOTES:
CR – concentration ration
ILCR – incremental lifetime cancer risk
HQ – hazard quotient

For changes in human health associated with changes in air quality, the concentration ratio (CR) is the ratio between the modelled air concentration and the human health-based air quality criterion for a given non-carcinogenic chemical. The incremental lifetime cancer risk (ILCR) represents the additional increase in lifetime cancer risk that would be predicted as a result of exposure to a given carcinogenic chemical at the modelled air concentration of the chemical.

For changes in human health associated with changes in the quality of country foods, the hazard quotient (HQ) represents the difference between the predicted daily intake of a chemical and its acceptable daily intake level established by regulatory agencies such as Health Canada. The regulatory acceptable daily intakes are established as toxicity reference values (TRVs), which are the maximum daily exposures that a person could experience without there being a concern for adverse health effects. The ILCR associated with the consumption of country foods represents the potential increase in lifetime cancer risk that would be predicted as a result of exposure to a given chemical at the modelled concentration of the chemical in country foods.

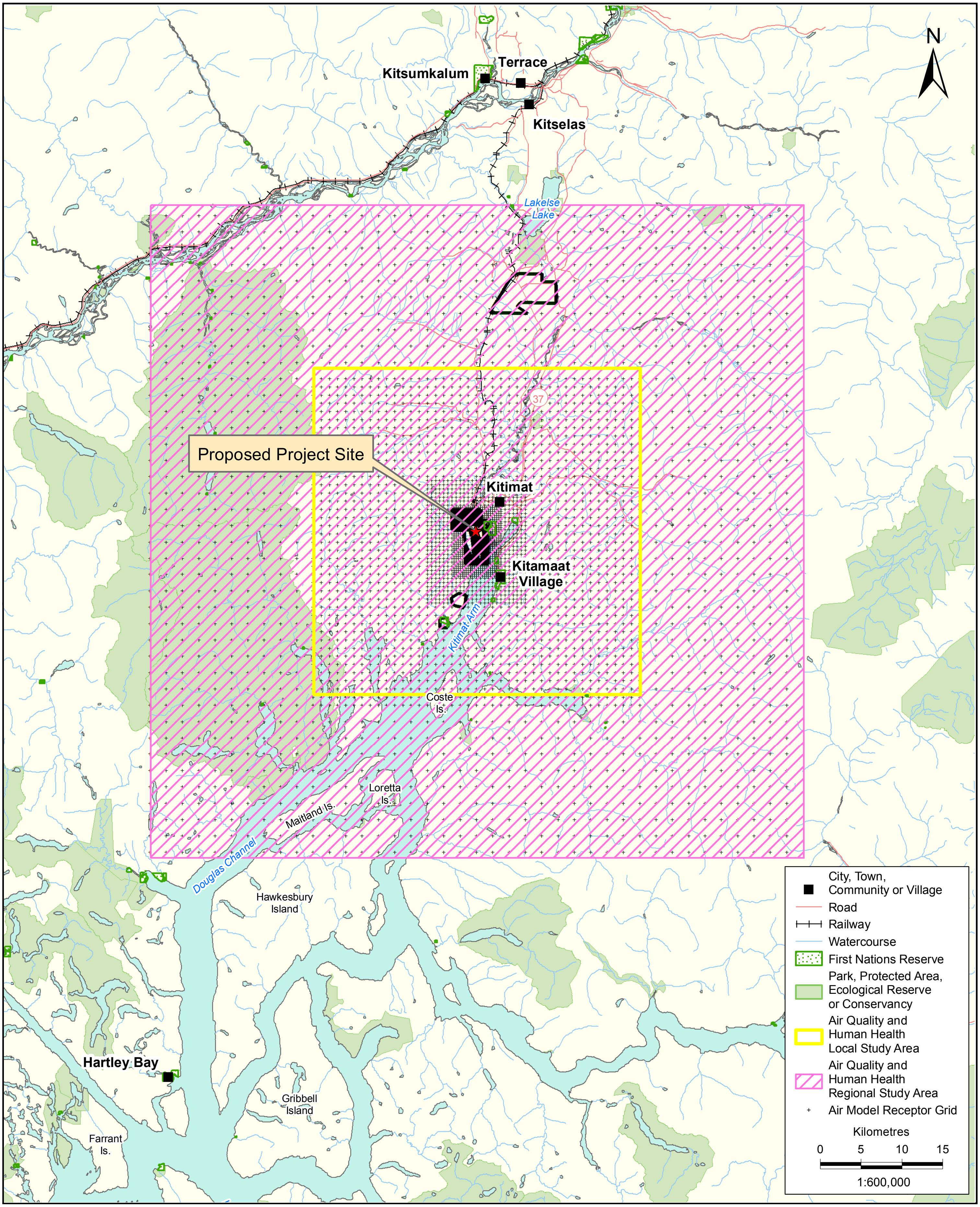
9.2.2.6 Boundaries

9.2.2.6.1 Spatial Boundaries

The LSA for the assessment of potential health risks to humans from potential changes in ambient air quality from facility emissions of CACs is a 40 km x 40 km square centred on the LNG facility (Figure 9.2-1). A detailed analysis of acute inhalation effects from short-term SO_2 exposure is also conducted within five grid areas covering sections of Kitimat and Kitamaat Village. Potential effects are assessed for marine coastal communities included in the LSA for air quality.

The LSA for the assessment of potential health risks to humans from redistribution of historically contaminated sediment and potential uptake to marine country foods (mussels, clams, crabs, fish), which are consumed by local people, is the same as the LSA for marine resources for the LNG facility and encompasses a 500 m buffer around the marine terminal footprint. The 500 m buffer is based on the professional judgment of the environmental assessment team (Section 5.8.2.6).

The LSA for the potential uptake of CACs into terrestrial and freshwater and estuarine aquatic country foods, which are consumed by local people, is the same as combining the RSA for vegetation resources, wildlife resources, and freshwater and estuarine fish and fish habitat.



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HUMAN HEALTH ENVIRONMENTAL EFFECTS ASSESSMENT

AIR QUALITY AND HUMAN HEALTH LSA AND RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
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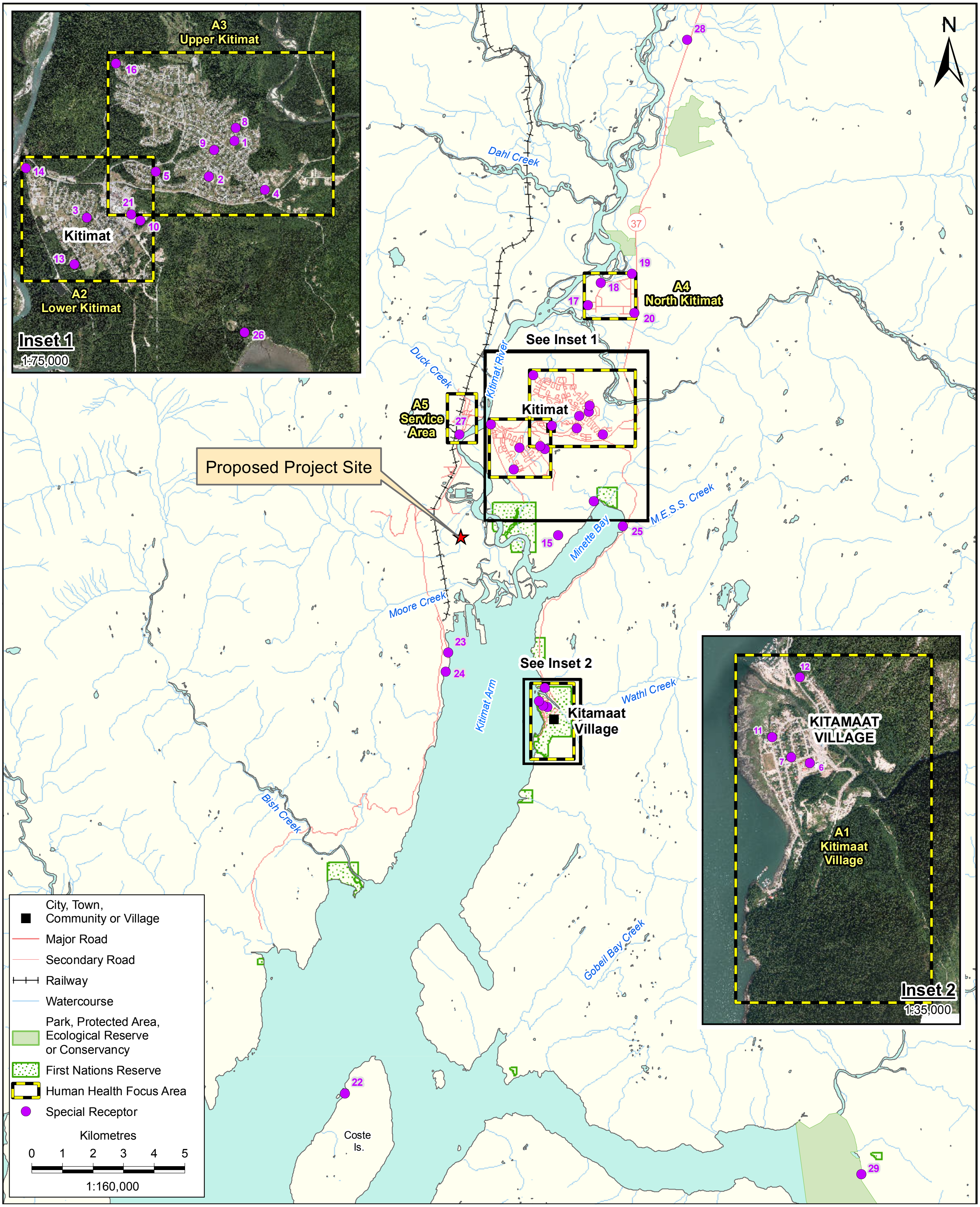
The spatial boundaries for the human health assessment of the LNG facility are based on the boundaries used for the air quality assessment of facility emissions of CACs (Section 5.2.2.5). The RSA is a 60 km x 60 km area centred on the facility (Figure 9.2-1). The RSA boundaries to assess air quality effects of shipping on human health are the same as those used to assess shipping effects on air quality and extend 5 km on either side of the entirety of the marine access route (Section 5.2.2.5).

The RSA to assess marine contaminant exposure on human health is the same as for marine resources (Section 5.8.2.6). The RSA to assess effects of human exposures to CACs in terrestrial and freshwater and estuarine aquatic country foods is the combined RSAs for vegetation resources (1,279 km^2; Section 5.5.2.6), wildlife resources (31,000 km^2, extending from lower Kitimat River to high alpine habitat; Section 5.6.2.6), and freshwater and estuarine fish and fish habitat (3,780 km^2; Section 5.9.2.5).

The LSA for the assessment of potential health risks to humans arising from the redistribution of historically contaminated sediment and potential uptake in marine country foods consumed by local people is the same as the LSA for marine resources for the LNG facility. The LSA for the potential uptake of CACs in terrestrial and freshwater aquatic country foods consumed by local people is the combined LSAs for vegetation resources, wildlife resources, and freshwater and estuarine fish and fish habitat. The RSA to assess human exposures to CACs in terrestrial and freshwater and estuarine aquatic country foods is the combined RSAs for vegetation resources, wildlife resources, and freshwater and estuarine fish and fish habitat.

Human Receptor Locations

Human receptor locations are sites where people are more likely to be located or a location of interest that could be related to health effects (see the Human Health Risk Assessment Technical Data Report [HHRA TDR] Stantec 2014a). These locations, identified as human health focus areas, are used to assess potential health risks to human receptors from inhalation of CACs. The HHRA focuses on five areas—four residential areas (Kitamaat Village, lower Kitimat, upper Kitimat, and north Kitimat), and the service area (defined as the commercial/industrial area located across the Kitimat River from lower Kitimat)—that represent the locations in the LSA where most of the population is expected to live and work and where the greatest potential for exposure to the CAC emissions from the facility is expected to occur (see Figure 9.2-2). In addition to these general areas, potential exposures to CACs at 29 special receptor locations are identified as being of particular concern to the communities (Table 9.2-2). These include schools, daycares, seniors’ care facilities, health care facilities, and recreational areas.



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HUMAN HEALTH ENVIRONMENTAL EFFECTS ASSESSMENT

HUMAN HEALTH FOCUS AREAS AND SPECIAL RECEPTOR LOCATIONS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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Table 9.2-2: Special Receptor Locations

Receptor Number	Receptor Name	Outside Human Health focus Areas (Y/N)
Schools		
1	Mount Elizabeth Secondary School	N
2	Nechako Elementary School	N
3	Kildala Elementary School	N
4	St. Anthony's Catholic Elementary School	N
5	Kitimat City High School	N
6	Haisla Community School	N
Daycares		
7	C'Imo'Ca Child Care Centre	N
8	Kitimat Child Development Centre	N
9	Stepping Stones Preschool	N
Health Care		
10	Kitimat General Hospital and Health Centre	N
11	Haisla Recovery Centre - Kitamaat Village	N
Residential/Recreational		
12	Nearest resident - Kitamaat Village (Haisla)	N
13	Nearest resident - Kitimat town	N
14	Kitimat residence(2)	N
15	Southeast residence	Y
16	Kitimat residence (N)	N
17	N Kitimat (SW)	N
18	N Kitimat (NW)	N
19	N Kitimat (NE)	N
20	N Kitimat (SE)	N
Senior Centres		
21	Kiwanis Senior Society	N
Other		
22	Coste Island	Y
23	Southwest dockyard	Y
24	Half Moon Bay	Y
25	Minette Bay1	Y
26	Minette Bay Lodge	Y
27	Kitimat Service Area	N
28	Kitimat Airport	Y
29	Kildala Beach	Y

9.2.2.6.2 Temporal Boundaries

Based on the current Project schedule, the temporal boundaries are:

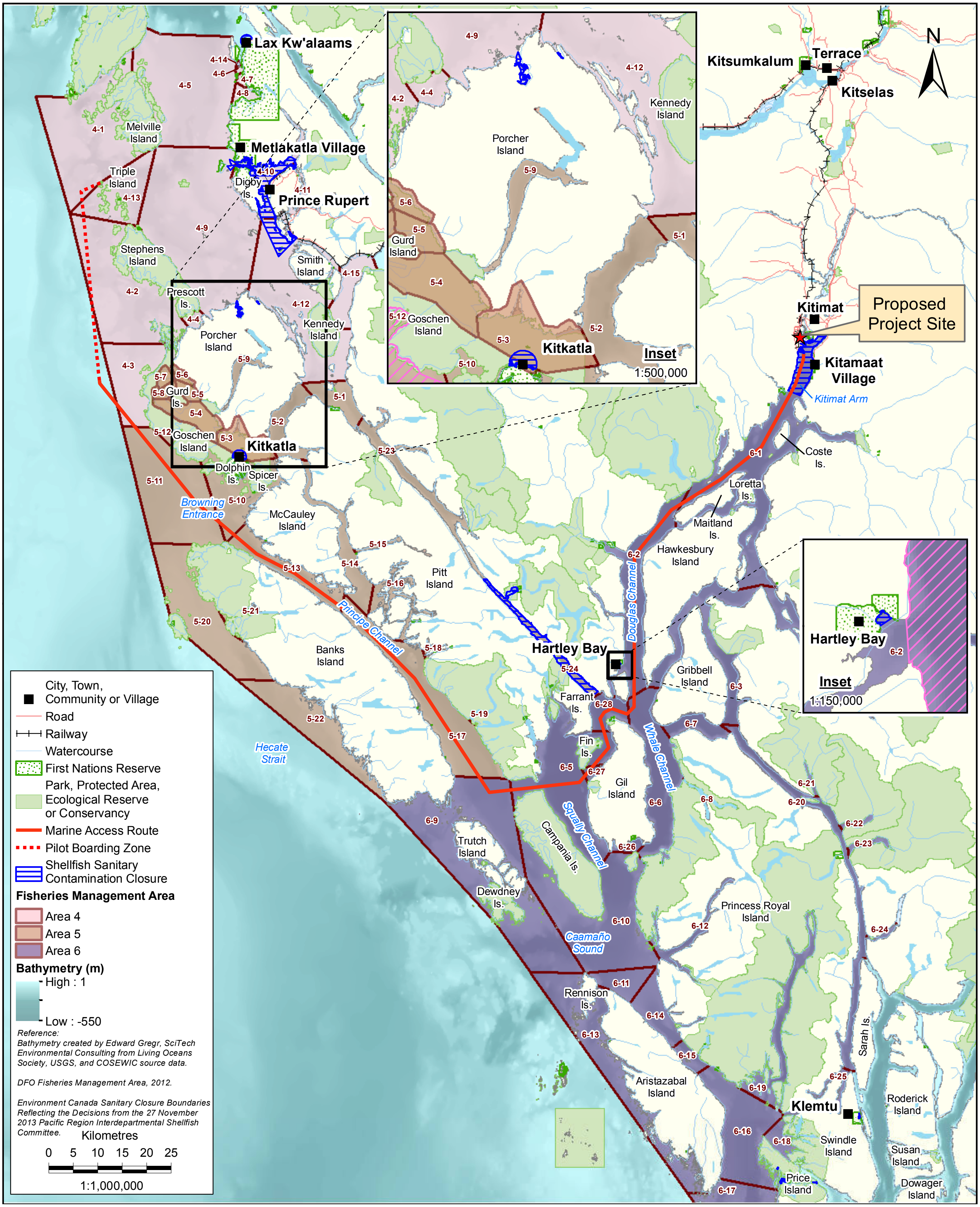
- construction, Phase 1 (trains 1 and 2) to be completed approximately five to six years following issuance of permits, the subsequent phase(s) (trains 3, 4) to be determined based on market demand
- operation, minimum of 25 years after commissioning, and
- decommissioning, approximately two years at the end of the Project life.

9.2.2.6.3 Administrative and Technical Boundaries

Administrative boundaries for the HHRA are:

- legislative and regulatory requirements prescribed in statutes and regulations (see Section 9.2.2.1), and
- Fisheries and Oceans Canada bivalve shellfish biotoxin and sanitary contamination closures (Figure 9.2-3 and Figure 9.2-4).

Technical boundaries include the applicable guidelines for the completion of HHRAs established by regulatory agencies such as Health Canada and U.S. EPA. Health Canada guidelines have been used as the primary sources of technical methods for assessing human health risk associated with exposure to chemicals in air and country foods (Health Canada 2010a). Provincial, federal, and international agencies provide exposure benchmarks that are based on the protection of human health (including sensitive sub-populations) that can be used to assess potential health risks associated with human exposure to Project-related chemicals. Where human health-based exposure limits are available from provincial agencies, these values have been used in the HHRA. When exposure limits are not available from provincial agencies, human health-based exposure limits developed by Health Canada or internationally recognized organizations (i.e., U.S. EPA and WHO) are used.



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HUMAN HEALTH ENVIRONMENTAL EFFECTS ASSESSMENT

ADMINISTRATIVE BOUNDARIES IN THE SHIPPING RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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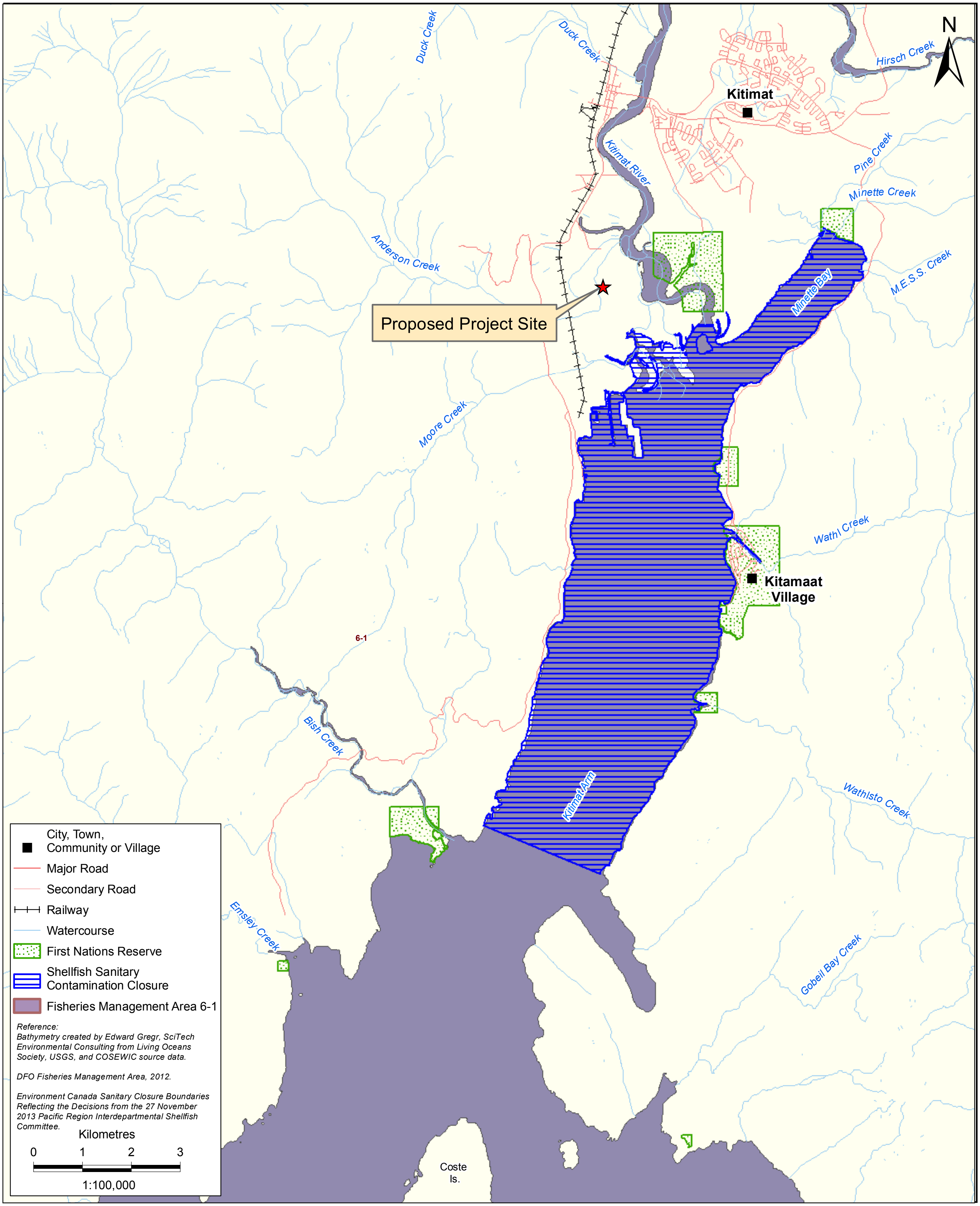

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HUMAN HEALTH ENVIRONMENTAL EFFECTS ASSESSMENT

ADMINISTRATIVE BOUNDARIES IN THE FACILITY RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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The regulations, guidelines, and standards used in the HHRA include:

- CCME water, sediment and soil quality, and tissue residue guidelines (CCME 1999, 2007, 2014)
- Health Canada Toxicological Reference Values (Health Canada 2010b)
- BC (MOE 2014) Drinking Water Quality Standards contained in the BC *Contaminated Sites Regulation*
- BC (MOE 2013) and National Ambient Air Quality Objectives (U.S. EPA 2010)
- *Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment* (Health Canada 2010c)
- *Federal Contaminated Site Risk Assessment in Canada, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals* (Health Canada 2010d)
- *Supplemental Guidance on Human Health Risk Assessment for Country Foods* (Health Canada 2010a)
- *Supplemental Guidance on Human Health Risk Assessment for Air Quality* (Health Canada 2009), and
- *First Nations and Inuit Health – Food Safety* (Health Canada 2010e).

Guidance on the evaluation of potential human health risks associated with environmental exposures to chemicals typically focuses on assessing these risks on an individual chemical basis. Procedures for assessing health risks associated with exposure to chemical mixtures are available for a limited number of specific chemical groups that have the same biochemical mechanism of action and that cause the same biological effect. These approaches are limited to the assessment of exposure to PCDD/F, PAHs, and polychlorinated biphenyls (PCBs). Although specific technical guidance on the assessment of simultaneous exposures to other chemicals is not available, Health Canada and other regulatory agencies recognize that in specific cases, human health risks associated with simultaneous exposures to chemicals that cause similar biological effects should be considered. When inhaled, SO_2 and NO_2 have the potential to cause respiratory effects. Because SO_2 and NO_2 are associated with Project emissions, this assessment evaluates the potential health risks associated with combined inhalation exposures to SO_2 and NO_2. The methods developed for completing this evaluation are discussed in detail in the HHRA TDR (Stantec 2014a).

9.2.2.7 Residual Effects Description Criteria

The criteria used to characterize residual effects on human health are listed in Table 9.2-3.

Table 9.2-3: Characterization of Residual Effects on Human Health

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Characterization of Residual Effects		
Magnitude	The expected size or severity of effect. Low magnitude effects may have negligible to little effect, while high magnitude effects may have a substantial effect.	**Negligible**—no detectable or measurable change from existing baseline conditions **Low**—a measurable change from existing baseline conditions but is below environmental and/or regulatory thresholds and does not represent an unacceptable change in human health risk **Moderate**—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds but does not affect human health **High**—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds and represents potentially unacceptable change in human health risk
Geographic Extent	The spatial scale over which the residual effects of the Project are expected to occur. The geographic extent of effects can be local or regional. Local effects may have a lower effect than regional effects.	**Project Footprint**—residual effects are restricted to the Project footprint **LSA**—residual effects extend into the LSA **RSA**—residual effects extend into the RSA
Duration	The length of time the residual effect persists. The duration of an effect can be short term or longer term.	**Short-term**—residual effect restricted to project construction and/or decommissioning phases and is predicted to return to existing baseline conditions with no lasting effect. **Medium-term**—residual effect continues for up to two years following project construction or decommissioning phases before returning to existing baseline conditions. **Long-term**—residual effect continues for more than two years after the project decommissioning phase, before returning to existing baseline conditions. **Permanent**—residual effect unlikely to return to existing baseline conditions.
Frequency	How often the effect occurs. The frequency of an effect can be frequent or infrequent. Short term and/or infrequent effects may have a lower effect than long term and/or infrequent effects.	**Single event**—occurs once **Multiple irregular event (no set schedule)**—occurs sporadically at irregular intervals throughout construction, operation, or decommissioning **Multiple regular event**—occurs on a regular basis and at regular intervals throughout construction, operation, or decommissioning **Continuous**—occurs continuously throughout the life of the Project
Reversibility	Whether or not the residual effect on the VC can be reversed once the physical work or activity causing the disturbance ceases. Effects can be reversible or permanent. Reversible effects may have lower effect than irreversible or permanent effects.	**Reversible**—potential human health risks will return to existing baseline levels after decommissioning. **Irreversible**—effect is permanent.

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Context	Refers primarily to the sensitivity and resilience of the VC. Consideration of context draws heavily on the description of existing conditions of the VC, which reflect cumulative effects of other projects and activities that have been carried out, and information about the impact of natural and human-caused trends on the condition of the VC. Project effects may have a higher effect if they occur in areas or regions that have already been adversely affected by human activities (i.e., disturbed or undisturbed) or are ecologically fragile and have little resilience to imposed stresses (i.e., fragile)	**Low resilience**—low capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance. **Moderate resilience**—moderate capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance. **High resilience**—high capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance.
Likelihood of Residual Effects		
Likelihood	Whether or not a residual effect is likely to occur	**Low—**low likelihood that there will be a residual effect. **Medium—**moderate likelihood that there will be a residual effect. **High—**high likelihood that there will be a residual effect.

9.2.2.8 Significance Thresholds for Residual Effects

Significance threshold criteria and standards are based on applicable federal and provincial regulatory requirements, standards, guidelines, and objectives (see Section 9.2.2.1), and reflect the limits of acceptable levels of human exposure to chemicals in the environment. Where these do not exist, acceptable exposure limits are based on scientific literature and the professional judgment and experience of the assessment team.

The significance thresholds for residual effects on human health are listed in Table 9.2-4.

Table 9.2-4: Significance Thresholds for Residual Effects

Potential Effect	Threshold
Change to human health	The significance thresholds for CR and HQ are relative to the baseline CR or HQ. If the baseline CR is *less than* 1.0, the significance threshold is reached when: ▪ predicted application case CR or HQ is greater than 1.0. If the baseline CR or HQ is *greater than* 1.0, the significance threshold is reached when: ▪ predicted application case CR or HQ is greater than baseline CR + 1.0. An ILCR greater than 1 in 100,000 indicates the potential for cancer health risks, or: ▪ predicted application case ILCR that is greater than 10^{-5}.

9.2.3 Baseline Conditions

9.2.3.1 Baseline Data Sources

To support the evaluation of Project effects on human health, baseline conditions were identified using multiple sources, including technical reports and other available literature. TK information was acquired from a variety of sources, such as TK studies provided by potentially affected Aboriginal Groups, ethnographic and ethno-historic sources (Section 13 and Section 14), academic papers, and sources from other environmental assessments.

9.2.3.2 Baseline Overview

9.2.3.2.1 Air Quality

Baseline conditions for air quality are described in detail in the Air Quality TDR (Stantec 2014b). Baseline air quality for the Kitimat area was modelled to incorporate the anticipated modernization of the (RTA facility in Kitimat. The air quality modelling incorporated the CACs (PM, SO_2, H_2S, NO_2, and CO).

Predictions of baseline air quality are based on three years of air quality modelling results (January 1, 2008, to December 31, 2010). Details on the modelling approach and results are provided in Section 5.2.

9.2.3.2.2 Marine Water Quality

Baseline conditions for marine water quality are described in detail in the Marine Resources TDR (Stantec 2014c).

Since the 1950s, air emissions and effluent discharges from the various industrial activities around Kitimat Arm have influenced water quality, with concentrations of fluoride, metals, and PAHs surpassing the BC water quality guidelines during the 1970s and 1980s (Warrington 1987; Harris 1999). At eight sites in the region south of Kitimat and on the west and east shores, contaminant levels were generally below the BC water quality guidelines with the exceptions of cadmium (slightly above the BC guideline of 0.00012 mg/L at five sites), zinc (above the guideline of 0.01 mg/L at one site), and the PAHs chrysene (1 µg/L) and benzo(a)pyrene (0.1 µg/L) at several sites in 2009 (Whitford 2010).

9.2.3.2.3 Sediment Quality

Baseline conditions for marine sediment quality are described in the Marine Resources TDR (Stantec 2014c). Sediment quality in the lower Kitimat River and estuary has been influenced by industrial activities since the 1950s, including an aluminum smelter, pulp and paper mill, methanol plant, and a log storage area (Levings 1976; MacDonald and Shepherd 1983). The municipal wastewater treatment plant also discharges effluent in lower Kitimat River. These facilities have been known to input PAHs and certain metals into the marine environment of Kitimat Arm since the 1950s. However, recently PAH concentrations have declined, particularly near the smelter (NOAA 2009).

Golder Associates Ltd (2013, 2014) conducted a marine sediment study (PAHs, PCBs, PCDD/F metals) on behalf of LNG Canada to support the analysis of dredging and spoil disposal options (Table 9.2-5). Sixty-four evenly distributed cores were collected in the proposed dredge area at a depth ranging from 0.3 m to 2.5 m below the mudline (for a total of 133 samples) (Golder Associated Ltd. 2013). Additional samples were taken at depths down to 14.3 m at five locations (for a total of 26 samples) (Golder Associated Ltd. 2013). Samples were collected at an additional 42 sites within the proposed dredge area in 2014 (Golder Associates Ltd. 2014). The CCME interim sediment quality guideline (ISQG), probable effects level (PEL), and Canadian Disposal at Sea criteria were used to screen against chemical concentrations in the sediment samples. The PEL is an indicator that potential adverse effects could exist for aquatic life, and the disposal at sea criteria are used to screen sediments to help establish whether dredged material could be suitable for disposal at sea.

Table 9.2-5: Summary Results of Surface and Deep Core Sediments for PAHs, PCBs, PCDD/F, and Metals

Contaminants	Guidelines	Surficial Sediment (0.3-2.5 m below mudline) (175 locations)	Deep sediment (2.5m - 14.3 m below mudline) (26 locations)
PAHs (mg/kg)		<0.05–163.4	1.37–5.86
Guideline Exceedances:	Disposal at Sea = 2.5	46 locations	1 location
	CCME PEL[a]	3 locations	0 locations
PCBs (mg/kg)		<0.03	<0.03
Guideline Exceedances:	Disposal at Sea = 0.1	0 locations	0 locations
	CCME PEL = 0.189	0 locations	0 locations
	CCME ISQG = 0.0215	0 locations	0 locations
PCDD/F (ng/kg TEQ)		0.01–5.89	Not analyzed
Guideline Exceedances:	CCME PEL = 21.5	0 locations	Not analyzed
	CCME ISQG = 0.85	3 locations	Not analyzed
Cadmium (mg/kg)		<0.05–1.62	<0.05–0.205
Guideline Exceedances:	Disposal at Sea = 0.6	3 locations	0 locations
	CCME PEL = 4.2	none	0 locations
	CCME ISQG = 0.7	3 locations	0 locations
Copper (mg/kg)		11.2–176	14.1–42.1
Guideline Exceedances:	Disposal at Sea = 18.7	64 locations	5 locations
	CCME PEL = 108	2 locations	0 locations
	CCME ISQG = 18.7	64 locations	5 locations
Zinc (mg/kg)		27.2–391	29.3–62.6
Guideline Exceedances:	Disposal at Sea = 124	2 locations	0 locations
	CCME PEL = 271	1 location	0 locations
	CCME ISQG = 124	2 locations	0 locations

NOTES:
[a] CCME PEL values are not reported because there are multiple values for individual PAHs.
TEQ – toxic equivalency

Overall, sediment quality was characterized by higher concentrations of PAHs and some metals in the surface sediments to a depth of 2.5 m. Sediments from 2.5 m to 14.3 m had substantially lower concentrations of these substances.

Total PAHs were highest in the surface sediments and decreased with depth. Approximately 35% of sediment samples in the upper 2.5 m exceeded disposal at sea criteria. Among these surface samples, 3 of 133 samples were above the PEL. Sediment samples from 2.5 m to 14.3 m did not exceed any of the applicable guidelines with the exception of one sample.

Polychlorinated biphenyls concentrations were analyzed in all sediment samples collected by Golder Associates Ltd. (2013) and contained concentrations below the reported detection limit of 0.030 mg/kg. This detection limit is greater than the IQSG; however, it is below all other relevant provincial and federal sediment quality guidelines. Golder Associates Ltd. (2014) submitted 10 sediment samples for analysis of PCB concentrations. All samples submitted for analysis contained concentrations below the reported detection limit of <0.020 mg/kg, with the exception of one sample collected between 0 m and 0.25 m below mudline, which contained PCB concentrations greater than the IQSG of 0.0215 mg/kg.

Polychlorinated dibenzo-para-dioxins and furans (PCDD/F) were analyzed in six sediment samples collected by Golder Associates Ltd. (2013), and seven samples collected by Golder Associates Ltd.(2014). Nine of the 13 samples submitted for analysis contained concentrations greater than the ISQG (0.85 pg/g TEQ) but well below the PEL guideline (21.5 pg/g TEQ).

All sediment samples were analyzed for a suite of 30 metals. Most metals were below the detection limit; however, cadmium, copper, and zinc were detected at concentrations that exceeded the disposal at sea criteria. Cadmium and zinc concentrations from 0.0 m to 2.5 m exceeded disposal at sea criteria in less than 3% of samples, with none above any guidelines in deeper samples to a depth of 14.3 m. Copper is naturally elevated in the region when compared with reference sites. Approximately 34% of surface sediment samples had copper concentrations above disposal at sea criteria. Less than 2% of samples exceeded the PEL. In sediments to a depth of 14.3 m, copper concentrations occasionally exceeded the ISQG and disposal at sea criteria but were well below the PEL.

9.2.3.2.4 Country foods

Information on the current use of country foods for traditional purposes is described in Section 13 and Section 14.

The area includes the traditional territories of Haisla Nation, Gitga'at First Nation, Gitxaala Nation, Kitselas First Nation, Kitsumkalum First Nation, Lax Kw'alaams First Nation, and Metlakatla First Nation. For these Aboriginal communities, terrestrial wildlife, marine wildlife, and vegetation are important ecological, cultural, and economic resources. In addition, traditional use activities such as gathering and consumption of country foods are important for nutritional health. Species richness is therefore inherently linked to the health and well-being of the communities. The marine and terrestrial environments provide a variety of species for harvest; the terrestrial environment also provides various medicinal plants.

Terrestrial animals used by Aboriginal communities for food include deer, moose, mountain goat, mountain sheep, black bear, duck, goose, swan, quail, and small furbearing animals (beaver, marten, fisher, land otter, mink, weasel, and muskrat) (see Section 14, Tables 14.3-1 through 14.3-7).

Vegetation collected for food, medicinal, or cultural purposes includes berries, crab apples, wild rice, various tubers, and roots.

Marine fish harvested for food include salmon, herring, eulachon, halibut, and cod; marine invertebrates include shellfish, octopus, shrimp, prawn, and crab. Aboriginal communities also use seaweed and kelp (see Section 14, Tables 14.3-1 through 14.3-7). Some marine mammal species, such as sea lions, river otters, porpoises, grey sharks, orcas, and other whale species (fin, grey, sperm and humpback), have a spiritual and cultural use, but only harbour seals and sea lions are hunted by some of the communities. Levels of PAHs reported in Kitimat Arm had raised concerns in the local communities regarding the potential effect on the quality of marine country foods, resulting in several studies on contaminant levels in the tissue of marine organisms. Pelagic fish (e.g., juvenile chinook salmon), demersal fish (e.g., yellowfin sole, English sole), and benthic organisms that live in or on sediments or filter feed near the benthos (e.g., clams, mussels, crabs) are considered most likely to be exposed to and accumulate contaminants. Several studies conducted since the 1990s have shown that the contaminants, in particular PAHs associated with the smelter operations, are tightly bound to the coarser particulates in sediments and that the bioavailability of these contaminants is considered low (Paine et al. 1996; NOAA 2009; Yunker et al. 2011). However, PAH associated with effluent from the pulp mill which closed in 2010, were found to accumulate in soft-shell clams (Yunker et al. 2011). The low bioavailability of the smelter-derived PAH from the coarser sediment particles and the fact that PAH associated with pulp mill effluent are no longer being discharged means that these contaminants would not be readily absorbed by organisms that live in or on the sediments, limiting or eliminating potential exposure for people who consume marine country foods harvested in the RSA.

9.2.4 Project Interactions

Table 4.4–1 (Section 4) identifies potential interactions of concern between Project activities and each of the selected VCs that are carried forward in the assessment. The potential effects identified in Section 9.2.2.4 that might result in an adverse effect as a result of interactions with Project activities are assessed. The extent to which the interactions will be considered is ranked in Table 9.2-6.

A conservative approach is taken in assigning a Rank of 1, whereby interactions with a meaningful degree of uncertainty are assigned Rank 2 so that a detailed effects assessment is conducted.

Table 9.2-6: Potential Project Effects on Human Health

Project Activities and Physical Works	Potential Effects		
	Change in human health risk from degraded air quality	Change in human health risk from degraded drinking water quality	Change in human health risk from ingestion of contaminated country foods
Facility Activities and Works			
Construction			
Site preparation (clearing, grubbing, grading, levelling, and set-up of temporary facilities)	1	0	1
Onshore construction (installation of LNG facility, utilities, ancillary support facilities, access roads, and includes hydrotesting)	1	0	1
Dredging (includes disposal)	1	0	1
Marine terminal construction (modifications to existing wharf, installation of sheet piling, material offloading and laydown areas, transfer piping and electrical installations)	1	0	1
Waste management (waste collection and treatment)	1	0	1
Vehicle and rail traffic (haul road upgrades, road use, vehicle traffic)	1	0	1
Commissioning and start-up	1	0	1
Operation			
LNG production (including natural gas treatment, condensate extraction, storage, and transfer), storage and loading	2	1	0
Waste management (solid and liquid waste collection and disposal, wastewater effluent collection and treatment, site storm water management)	1	0	1
Vehicle and rail traffic (haul road upgrades, road use, vehicle traffic)	1	0	1
Decommissioning			
Dismantling of land-based and marine infrastructure	1	0	0
Remediation and reclamation of the site	1	0	0
Waste management	1	0	0
Post-closure monitoring and follow-up	1	0	0
Shipping Activities			
Construction			
Shipping equipment and materials	1	0	0
Operation			
LNG shipping	1	0	0
Decommissioning			
Shipping equipment and materials	1	0	0

KEY:

0 = No interaction.

1 = Adverse effect requiring mitigation, but further consideration determines that any residual adverse effects will be eliminated or reduced to negligible levels by existing codified practices, proven mitigation measures, or BMPs.

2 = Interaction may occur and the resulting effect may exceed negligible or acceptable levels without implementation of project-specific mitigation. Further assessment is warranted.

NOTE: Only activities with an interaction of 1 or 2 for at least one effect are shown.

9.2.4.1 Justification of Interaction Rankings

Activities that will not result in changes in the quality of marine country foods or drinking water and, therefore, have no interactions with human health related to the consumption of drinking water or of marine country foods include:

- dismantling of land-based and marine infrastructure
- remediation and reclamation of the site
- waste management
- post-closure monitoring and follow-up
- construction shipping (shipping equipment and materials)
- operation shipping (LNG shipping), and
- decommissioning (shipping equipment and materials).

9.2.4.1.1 Change in Human Health Risk from Degraded Drinking Water Quality

The quality of drinking water refers to the levels of chemicals in water that is used as a source of potable water compared with the BC drinking water standards as defined under the BC *Contaminated Sites Regulation* (MOE 2014). The interactions that might occur between Project activities (LNG production) and changes in surface water quality related to the potable use of the water are ranked as 1. The CACs released to the environment by the Project will not directly contribute to changes in water quality that would affect its suitability as a source of potable water. Emissions of SO_2 and NO_2 by the Project have the potential to alter the acidity of surface waterbodies (e.g., lakes), which in turn could mobilize metals from sediments and other materials in the lakes, resulting in increases in metal levels in the surface water. This potential increase in metal concentrations could alter human health risks should these waterbodies be used as a daily supply of potable water. However, the water quality assessment (Section 5.9) determines that the acidification potential between base and application cases is not significant (see Section 5.9.5.2). These results suggest that changes in acidification related to the Project will not alter the metal concentrations in surface water from what exists under baseline conditions. Therefore, use of surface waters for drinking water represents a very limited exposure that does not represent a potential to risk human health.

In areas where municipal drinking water is provided, the municipal supply is required to meet the established drinking water quality standards, so the raw water is processed to meet these standards. As a result, changes in metal levels in the raw surface water attributable to Project emissions will not alter the metal concentrations in the final processed water and, therefore, will not result in a change in human health risk for people using the municipal water supply for potable water. Consequently, this interaction is ranked as 1. Drinking water sourced from groundwater likewise will not be a concern for human health.

Potential acidification of water resulting from Project activities will be limited to effects on surface water and will not alter the quality of groundwater-sourced drinking water. Therefore, the Project residual effects are negligible and do not contribute to cumulative effects. Therefore, this interaction is ranked as 1 and is not assessed further.

9.2.4.1.2 Change in Human Health Risk from Ingestion of Contaminated Country Foods

The quality of country foods refers to the chemical content in the tissues that are consumed. High-quality country foods are those with lower concentrations of PAHs, PCDD/Fs, and metals in their tissues.

Several activities might interact with the quality of country foods during the construction and operation phases, including site preparation, onshore construction, dredging, marine terminal construction, waste management, vehicle and rail traffic, the initial commissioning and start-up of the facilities, and LNG production.

Terrestrial Country Foods

Interactions that might occur between Project construction activities and the quality of terrestrial country foods and those that might occur between vehicle traffic during operation and the quality of country foods are ranked as 1. These interactions include land-based activities such as construction and the use of roads and rail lines. These activities might generate fugitive dust that could settle on the surrounding area, including on vegetation used as a country food. Coarse dust particles generated at ground level will not be transport over long distances, but fine dust particles can deposit a few hundred metres downwind of the source (Countess et al. 2001).

Road dust is composed of inert earthen material that is chemically similar to the surrounding soils and ground material. Therefore, ingestion of this material with vegetation poses no greater human health risk than that posed by the ingestion of vegetation collected from the surrounding soils. Project activities will not appreciably change the quality of the soil or road material from which dust may be mechanically generated. Washing all types of country foods is recommended by Health Canada and is sufficient to remove dust particulates on vegetative country foods (Health Canada 2010a).

Terrestrial animals hunted as country food might ingest dust particles on vegetation. This pathway will not alter the quality of their tissue because the material is inert ground material and animals naturally consume a much larger quantity of soil from consuming vegetation and soil adhered to prey items.

Based on this rationale, the Project residual effects are negligible and do not contribute to cumulative effects. Therefore, these interactions with consumption of terrestrial country foods are ranked as 1 and are not assessed further.

Marine Country Foods

Interactions between Project dredging activities and the quality of marine country foods are ranked as 1. These interactions include marine-based activities that will disturb and resuspend sediments that contain pollutants into the water column or introduce chemicals into the marine environment from hydrostatic testing and waste treatment.

During the construction phase, the Eurocan Basin will be dredged to accommodate LNG carriers and support vessels. A sheet pile wall constructed along RTA Wharf “B” will require in-water construction and pile driving that will also disturb sediments. Most surface sediments that contain industrial pollutants will be removed from the marine environment during the initial dredging period. Sediments dredged from the upper 2.5 m layer that do not meet disposal at sea criteria will be disposed of on land that is zoned for industrial use, thereby sequestering them from interactions with marine country foods. This will expose the underlying clean sediments that will be dredged and disposed at sea.

Two mechanisms of interaction could affect the quality of marine country foods. The first mechanism involves dredging and pile driving, which will generate a plume of suspended sediments in the water column to which pelagic species of country food (e.g., fish) might be exposed. Pelagic species exposed to the plume could take up chemicals through their gills or skin, or could ingest suspended sediment particles. The degree of uptake and retention depends on factors such as the physiochemical properties of a chemical, bioavailability, and concentration in the water column.

The potential change in fish health as a result of exposure to sediment-bound pollutants is assessed in marine resources (Section 5.8.5.3). Disturbance of sediments containing PAHs represents the highest potential for a change in the quality of marine country foods. The PAHs in Kitimat Arm have low bioavailability because they are chemically bound to sediment particles (Section 9.2.3.2). Although dredging might increase the degree to which marine country foods are exposed to sediment particles, the PAHs will remain bound to the sediments.

Short-term exposure to suspended sediments originating from the initial dredging of the upper layer of sediment might result in a temporary increase in PAH concentrations in the water column. However, these increases are not anticipated to result in long-term changes in PAH levels in fish tissue. Fish have high rates of PAH metabolism and low rates of bioaccumulation where tissue concentrations do not reflect environmental exposure levels (Dunn 1991; van der Oost et al. 2003). Dredging below the depths of the PAH-affected sediment layer will not adversely affect the quality of fish tissue because increases in PAHs in the water column that result from dredging will be temporary and, therefore, are not anticipated to alter tissue PAH concentrations in fish in the area where dredging occurs.

The second mechanism involves suspended sediments depositing onto the surrounding area to which benthic species (e.g., prawns, clams, and crabs) might be exposed. These species already interact closely with the sediment; filter-feeding organisms such as bivalves could ingest suspended sediment particles containing PAHs.

During dredging activities, most of the coarse sediment particles escaping the dredge bucket will deposit in the immediate dredge zone. The benthic species in the dredge zone are not considered because they will be taken up as part of the dredged material during dredging. The potential for increased PAH exposures will be to benthic organisms outside of the dredging zone, where finer sediment particles may disperse longer distances before settling. Because of the low bioavailability of PAHs in these sediments, benthic organisms will not take up these chemicals. The exposure duration is short term because, after the surface layer of sediment has been removed, the underlying layers of sediment contain PAH concentrations that are below the ISQG. Suspended sediments that travel outside the dredge zone and settle on the surrounding benthic environment will contain lower concentrations of PAHs than the existing surface sediments. Mitigation measures to reduce the range the sediment plume may travel and deposit outside of the dredge zone will be implemented.

Kitimat Arm is in Area 6, designated by Fisheries and Oceans Canada, for which there is a permanent year-round ban on shellfish harvesting and consumption. This ban results from the potential for domoic acid and paralytic shellfish poisoning, which are marine biotoxins unrelated to industrial pollutants (DFO 2013a). Area 6-1 also has an additional permanent ban on all harvested marine country foods (DFO 2013b).

During construction, some facility components will require hydrostatic testing to test for leaks before operations commence. Hydrostatic testing might involve the use of inert nitrogen gas and water mixed with biocides. Following completion of hydrostatic testing, the test water will be treated and released to the marine environment in accordance with the relevant discharge regulations.

During the operation phase, the natural process of sedimentation over time from upstream processes will gradually fill the dredged berth pocket. The Kitimat River estuary is strongly influenced by heavy sediment loads carried by the river during spring freshet and periods of high precipitation, which increase turbidity and sediment deposition (MacDonald and Shepherd 1983). Maintenance dredging approximately every 10 years is expected to maintain the berth pocket depth. The dredge volume will be substantially lower than during the construction phase and will only remove newly deposited sediments, which are predicted to have a more limited exposure to those containing historical contaminants.

Hydrostatic testing might involve the use of inert nitrogen gas and biocides to test for leaks in the facility infrastructure. Use of biocides will follow manufacturer's instructions for safe handling, and they will be neutralized before being released into the environment.

No interactions with the quality of marine country foods are anticipated for the decommissioning phase.

Based on this rationale, the Project residual effects are negligible and do not contribute to cumulative effects. Therefore, the consumption of marine country foods is ranked as 1 and is not assessed further.

9.2.4.1.3 Human Health Effects from a Change in Air Quality Change in Human Health Risk from Degraded Air Quality

Activities that could result in changes in air quality and, therefore, interact with human health related to inhalation exposures to CACs include:

- natural gas treatment and natural gas liquids extraction (including storage and transfer onto rail cars)
- LNG production (including transfer to storage tanks), and
- vehicle and rail traffic (haul road upgrades, road use, vehicle traffic).

These interactions are ranked as 2 and are further assessed in Section 9.2.5.

Interactions between shipping activities and potential human health effects from change in air quality are ranked 1. The assessment of residual effects from shipping include the potential change in ambient air quality from stack emissions generated by Project vessels (e.g., LNG carriers, escort tugs, support vessels) during the construction, operation, and decommissioning phases, which will be expected to increase shipping traffic in Kitimat Arm. Based on the results of the air quality assessment (Section 5.2.5), there is no potential interaction between shipping and human health beyond what has already been incorporated into the assessment of air quality. Therefore, further assessment of potential residual effects of shipping on human health is not necessary. The contribution of shipping to air quality in the Kitimat region is incorporated into the air quality dispersion modelling and is included in the assessment in Section 9.2.5.

9.2.5 Assessment of Residual Effects from the LNG Facility

9.2.5.1 Analytical Methods

9.2.5.1.1 Analytical Assessment Techniques

The assessment of residual effects on human health associated with the LNG facility is based on an industry standard HHRA approach that is consistent with federal and provincial regulatory guidance. The HHRA evaluates the potential for human receptors to experience exposure to Project-related chemicals in excess of what is considered to be acceptable, tolerable, or of negligible risk. The potential for adverse human health effects is quantified by determining the difference between the predicted amount of a chemical that a receptor could be exposed to on an hourly, daily, or annual basis, and the amount of that substance that can be tolerated (i.e., below which adverse human health effects are not expected), referred to as the TRV or toxicity benchmark.

The HHRA process follows a widely recognized framework that proceeds as follows:

- Problem formulation (from screening-level evaluation): Information is gathered to describe the site and focus the risk assessment on the critical issues of concern. Chemicals of concern specific to human health are identified, receptors (i.e., people potentially exposed to project-related chemicals) are chosen, and possible exposure pathways (i.e., routes by which receptors might be exposed to project-related chemicals) are determined.
- Exposure assessment: Estimates of the potential chemical exposure that receptors would potentially receive from the predominant exposure pathways are calculated based on measured or predicted project-related chemical concentrations in the environment.
- Toxicity assessment: Health hazards that could result from exposure to the chemicals of concern are identified and considered, based on dose-response principles. Exposure limits, or estimates of the amount of exposure to these chemicals that could occur without significant or unacceptable risks to health, are determined based on a review of information provided by regulatory agencies such as CCME, Health Canada, WHO, and U.S. EPA.
- Risk characterization**:** Potential health risks to receptors are determined by comparing the estimated rates of exposure (from the exposure assessment) with the exposure limits (from the toxicity assessment) for the chemicals of concern.

Following these steps, conclusions and recommendations based on the assessment are discussed. An uncertainty evaluation follows each step to identify uncertainties inherent in the HHRA process. The HHRA is described in greater detail in the HHRA TDR (Stantec 2014a).

The following Health Canada documents guided the HHRA:

- *Federal Contaminated Site Risk Assessment in Canada Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0* (Health Canada 2010b).
- *Federal Contaminated Site Risk Assessment in Canada Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0* (Health Canada 2010c). Revised 2012.
- *Federal Contaminated Site Risk Assessment in Canada Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals* (Health Canada 2010d).

9.2.5.1.2 Assumptions and the Conservative Approach

Atmospheric emissions associated with LNG production, including natural gas treatment and natural gas liquids (condensate) extraction during the operation phase of the facility, are ranked as 2 in Section 9.2.4. These activities are considered to have the greatest potential to result in human exposures that exceed acceptable levels. As a result, the HHRA focuses on evaluating potential health effects associated with atmospheric emissions from the Project using air quality modelling information provided in the air quality assessment (Section 5.2). The HHRA incorporates a number of assumptions to provide conservative estimates of possible exposures and associated potential health risks:

- Baseline atmospheric conditions include the RTA facility in Kitimat, as proposed.
- Residents in the Kitimat District (Kitamaat Village, lower Kitimat, upper Kitimat, north Kitimat) or who work in the Kitimat service area may be exposed to Project atmospheric emissions on a year-round, continuous basis. As a result, exposure will be overestimated.
- No distinction is made between time spent indoors and time spent outdoors. The estimated chemical concentrations in air provided in the air quality assessment are assumed to represent the concentrations of these chemicals in indoor and outdoor air. Decreases in chemical concentrations in air that typically occur between outdoors and indoors have not been incorporated into the assessment. As a result, exposure will be overestimated.
- No distinction has been made for the time of day (i.e., the probability of exposure is assumed to be the same during a 24-hour period). Air quality estimates between 10 p.m. and 6 a.m. have not been removed from the dataset used to estimate possible exposures. As a result, exposure will be overestimated.
- People who have asthma or COPD are expected to be most sensitive to the presence of Project-related chemicals in the air.
- The combined prevalence of asthma and COPD in the Kitimat population is the same as that reported for the general BC population and represents 12% of the population (Public Health Agency of Canada 2010).
- Air quality estimates are compared with human health-based air quality standards or guidelines. Using health-based air quality standards rather than AAQOs that might not be human health-based provides a more appropriate estimate of potential health risks.

9.2.5.2 Assessment of Change in Human Health Risk from Degraded Air Quality

9.2.5.2.1 Project Effect Mechanisms for Change in Human Health Risk from Degraded Air Quality

Atmospheric emissions from the Project and associated transportation activities add to chemicals in the atmosphere from existing industrial activities in the Kitimat region. Changes in air quality related to Project activities might affect the health of people living in the Kitimat region. Direct respiratory tract effects associated with changes in ambient concentrations of SO_2, NO_2, and $PM_{2.}$ are likely to be the most commonly experienced health effects. Although respiratory effects can occur wherever people are present in the Kitimat region, the greatest potential for these effects to occur is in areas of high population density located close to the facility. Therefore, the assessment focuses on residential and commercial areas in the Kitimat region where human exposure to Project-related chemicals in air is expected to be highest and the associated potential for respiratory effects is be greatest. Five focal areas are selected for the assessment: Kitamaat Village (A1); lower Kitimat (A2); upper Kitimat (A3); north Kitimat (A4), and the Kitimat service area (A5) (Figure 9.2-2). Dispersion modelling is also conducted for 29 special receptor locations, which included locations such as schools, residences, and senior centres. All but eight of these receptors are located in one of the five human health areas (Figure 9.2-2). Details on the special receptor locations are provided in the HHRA TDR (Stantec 2014a).

9.2.5.2.2 Mitigation for Change in Human Health Risk from Degraded Air Quality

The assessment of residual effects on human health associated with inhalation exposures to Project-related chemicals is based on CAC concentrations in air predicted by the air quality assessment (Section 5.2). The air quality assessment identified several mitigation measures to reduce the predicted CAC concentrations in air. Additional mitigation measures specific to the protection of human health are not required and have not been incorporated in the human health assessment.

9.2.5.2.3 Characterization of Change in Human Health Risk from Degraded Air Quality

The characterization of residual effects on human health focused on potential changes in exposure and the health risks associated with changes in concentrations of Project-related chemicals in ambient air in the Kitimat region. Project atmospheric emissions that are the focus of this assessment include:

- Particulate matter less than 2.5 microns in diameter**:** Project emissions will be from vehicle exhaust on diesel-fueled equipment. Facility stack emissions might also be a source of PM.
- Carbon monoxide: Construction equipment, gas turbines, and other onsite combustion processes (e.g., incinerator or flare/liquid burner) will be the major sources of CO.
- Nitrogen dioxide: Project emissions of NO_2 will be from gas turbines and other onsite combustion processes. Flaring and marine activities could also lead to small emissions of NO_2.
- Sulphur dioxide: Project emissions of SO_2 will be predominantly from the acid gas incinerator. Small emissions of SO_2 will result from flaring and marine activities. During normal operation, gases are not expected to be routed to the flares, and flare emissions will be limited to the combustion of pilot and purge gas only. Higher SO_2 emissions will occur for short periods of time during emergency or upset flaring.

Air quality changes associated with ozone, volatile organic compounds, and H_2S are not identified in the air quality assessment and, therefore, will not affect human health.

9.2.5.2.3.1 Air Dispersion Modelling Approach

Human Health Areas and Special Receptor Locations

Twenty-one of the special receptor locations are in the five human health focus areas; these locations have been included in the assessment of their respective human health focus area. The assessment of special receptor locations focuses on the eight special receptor locations located outside of the five human health focus areas.

For the five human health focus areas and the eight special receptors located outside of these areas, CAC concentrations are modelled using four scenarios (as outlined in the air quality assessment (Section 5.2):

- base case corresponds to baseline concentrations present in Kitimat region in the absence of the Project, but including the contributions from the RTA facility and Modernization Project
- Project-alone case is associated with increase in concentrations related to Project activities
- application case includes base case concentrations as well as contributions from the Project, and
- cumulative case includes baseline concentrations, contributions from the Project, and contributions from anticipated future developments that might affect air quality in the Kitimat region.

Assessing the potential human health risk associated with the Project-alone case does not provide a conservative evaluation of the potential change in human health associated with the addition of Project emissions to the Kitimat region. Therefore, the HHRA evaluates changes in air quality and associated health risks that could occur between the base and application cases. Cumulative effects are considered in Section 9.2.8.

For the five human health focus areas assessed, air modelling uses a 50 m by 50 m grid spacing. This provided approximately 1,000 grid points in each of the five study areas. Concentrations of CACs ($PM_{2.5}$, CO, NO_2, and SO_2) are modelled for each hour for a period of three years (January 1, 2008, through December 31, 2010), providing 26,304 hourly estimated air concentrations for each CAC for each grid point within each human health focus area and approximately 26,000,000 data points per CAC per study area. Air quality modelling includes each special receptor point over the same three-year period used for the human health focus areas, providing approximately 26,000 data points per CAC per special receptor location.

The 1-hour modelling data are used to provide summary 1-hour, 8-hour, 24-hour, and annual average estimated air concentrations for each of the CACs. The selection of averaging periods used in the HHRA is based on the exposure averaging periods set by regulatory agencies in the derivation of the human health-based exposure limits. The selection of the human health-based air quality criteria used in the HHRA is discussed in the HHRA TDR (Stantec 2014a) and is summarized below. Estimation of time-averaged CAC concentrations is completed for each human health focus areas as well as the special receptor locations, for the four modelling scenarios. However, the discussion of residual effects is limited to the evaluation of changes in air quality and human health risk that occur between the base and application cases.

9.2.5.2.3.2 Selection of Human Health-Based Air Quality Criteria

The human health-based air quality criteria considered applicable for comparison with maximum concentrations of CACs are:

- British Columbia Ambient Air Quality Objectives (BC AAQO; MOE 2013)
- United States National Ambient Air Quality Standards (U.S. NAAQS; U.S. EPA 2010)
- Alberta Ambient Air Quality Guidelines (AB AAQO; ESRD 2013), and
- World Health Organization Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide–Global Update 2005 (WHO AQG; WHO 2005).

For each of the CACs, the most conservative (lowest) criterion listed by these agencies is selected (Table 9.2-7). The BC government is in the process of developing new AAQOs for NO_2 and SO_2 that will be available in 2014. In the interim, the Province has selected a value of 200 µg/m^3 for the 1-hour SO_2 objective.

The human health-based air quality criteria listed in Table 9.2-7 are used in conjunction with the CAC concentrations predicted by air quality modelling to calculate the CR to evaluate whether the predicted CAC concentrations represent a potential concern for human health. The CR is calculated as follows:

$$\text{Concentration Ratio (CR)} = \frac{\text{Predicted CAC Concentration}}{\text{Human Health} - \text{based Air Quality Criterion}}$$

The human health-based air quality criterion represents the level of exposure (for the specified exposure averaging period, for example, 1-hour, 24-hour, or annual average) below which health effects are not expected to occur. If CRs are below the human health-based air quality criterion (CR less than 1.0), health effects are not expected to occur. A CR that exceeds 1 does not indicate that health effects would be expected to occur. However, the potential that a health effect might occur increases the greater that CR is above 1.0. Details on the application of CR are provided in the HHRA TDR (Stantec 2014a). The CR is used to assess the potential for human health effects to occur as a result of Project-related emissions of CACs and to assess potential cumulative human health effects.

Table 9.2-7: Conservative Applicable Criteria for Each CAC

Contaminants	Human Health-Based Air Quality Criteria (µg/m^3)	Reference
$PM_{2.5}$		
24-hour max	25	BC AAQO (2013)
Annual max	8	BC AAQO (2013)
CO		
1-hour max	14,300	BC AAQO (2013)
8-hour max	5,500	BC AAQO (2013)
NO_2		
1-hour max	188	U.S. EPA NAAQS (2010)
Annual max	40	WHO AQG (2005)
SO_2		
1-hour max	200	BC Interim (2014)[a]
24-hour max	20	WHO AQG (2005)
Annual max	20	AB AAQO (2013)
$SO_2 + NO_2$		
1-hour Max for NO_2	188	U.S. EPA NAAQS (2010)

NOTE:
[a] Interim AAQOs for NO_2 and SO_2 will be available for BC in 2014. In the interim, the BC government has selected a value of 200 µg/m^3 for the 1-hour SO_2. In this table, and Tables 9.2-9 and 9.2-11, this guideline has been referenced as BC Interim (2014), but it does not represent an available document.

9.2.5.2.3.3 Primary Screening of Air Quality Data

Air quality modelling identified whether the predicted maximum concentrations of the CACs in the five human health focus areas and the eight special receptor locations outside these study areas represent potential concerns for human health. In each of the five areas, the maximum predicted concentration for each CAC across the approximately 1,000 grid points in that area is selected and compared with the appropriate human health-based air quality criterion. Concentrations of CACs for the five areas are compared with applicable criteria in Table 9.2-8 (for $PM_{2.5}$ and CO) and Table 9.2-9 for NO_2 and SO_2.

The maximum predicted concentrations of $PM_{2.5}$, CO, and NO_2 are below applicable criteria. This assumption represents a worst-case exposure scenario. Thus, the maximum predicted concentrations of $PM_{2.5}$, CO, and NO_2 do not represent a potential concern for human health in the five human health focus areas or in the Kitimat airshed.

Concentration of CACs for the eight special receptors located outside the human health areas are compared with applicable criteria in Table 9.2-10 for $PM_{2.5}$ and CO and criteria in Table 9.2-11 for NO_2 and SO_2. Concentrations of $PM_{2.5}$, CO, and NO_2 predicted for the base, Project-alone, and application cases for the special receptor locations are below applicable criteria, indicating that potential health effects are not expected. Maximum 1-hour concentrations of SO_2 for the base and application cases in Locations 23 to 26 and Location 28 exceed the BC Interim (2014) guideline; CR range from 1.0 to 2.4. Maximum 24-hour concentrations exceed the guideline for Locations 15, 23 to 26, and 28; CR ranged from 1.61 to 3.47.

Similar to the five human health areas, the modelled 1-hour maximum and 24-hour maximum concentrations of SO_2 for the Project-alone case for all locations are below the applicable guidelines for each area, suggesting that the Project on its own will not result in concentrations of SO_2 that constitute a potential health effect.

For the five human health areas, the only CAC that is above criteria is SO_2. With the exception of area A4 (north Kitimat), 1-hour maximum concentrations of SO_2 for the base and application cases exceed the BC Interim (2014) criteria. The CR for the 1-hour max concentrations of SO_2 for the base and application cases for areas A1, A2, A3, and A5 range from 2.31 to 3.68. The 24-hour maximum concentrations of SO_2 exceed the WHO (2005) guideline for the base and application cases for the five areas; CRs range from 2.02 to 4.28. Similar results occur for the eight special receptors located outside the human health areas. The finding that maximum SO_2 concentrations exceed the applicable human health-based air quality criterion does not mean that SO_2 levels in the Kitimat region represent an ongoing concern to human health. Rather, these findings indicate that SO_2 requires further study to determine if the increase attributable to the Project presents a significant adverse effect on respiratory health in Kitimat. Sulphur dioxide is further assessed in Section 9.2.5.2.4.

Table 9.2-8: Screening for $PM_{2.5}$ and CO – Human Health Areas

Area and Scenario	Units	$PM_{2.5}$ Concentrations						CO Concentrations					
		BC AAQO (2013) 24-h	24-h Max Conc.	CR	BC AAQO (2013) Annual	Annual Maximum Conc.	CR	BC AAQO (2013) 1-h	1-h Max Conc.	CR	BC AAQO (2013) 8-h	8-h Max Conc.	CR
A1 - Kitamaat Village													
Base case	µg/m³	25	6.61	0.27	8	0.208	0.026	14,300	34.1	0.0024	5,500	11.5	0.0021
Application case	µg/m³		8.70	0.35		0.272	0.034		249	0.017		62.4	0.011
A2 - lower Kitimat													
Base case	µg/m³	25	4.25	0.17	8	0.514	0.064	14,300	27.2	0.0019	5,500	8.51	0.0015
Application case	µg/m³		5.18	0.207		0.707	0.088		336	0.024		66.3	0.012
A3 - upper Kitimat													
Base case	µg/m³	25	4.39	0.18	8	0.376	0.047	14,300	15.9	0.0011	5,500	7.15	0.0013
Application case	µg/m³		5.46	0.22		0.508	0.063		132	0.0092		42.9	0.0078
A4 - north Kitimat													
Base case	µg/m³	25	2.54	0.10	8	0.260	0.032	14,300	7.22	0.00050	5,500	2.19	0.00040
Application case	µg/m³		3.15	0.13		0.355	0.044		47.9	0.0034		19.0	0.0035
A5 - service area													
Base case	µg/m³	25	4.30	0.17	8	0.832	0.10	14,300	10.1	0.00071	5,500	3.26	0.00059
Application case	µg/m³		4.85	0.19		1.08	0.14		161	0.011		49.7	0.0090

Table 9.2-9: NO_2 and SO_2 – Human Health Areas

Area and Scenario	Units	NO_2 Concentrations						SO_2 Concentrations								
		U.S. EPA NAAQS (2010)	1-h Max Conc.	CR	WHO AQG (2005)	Annual Max Conc.	CR	BC Interim (2014)	1-h Max Conc.	CR	WHO AQG (2005)	24-h Max Conc.	CR	AB AAQO (2013)	Annual Max Conc.	CR
A1 - Kitamaat Village																
Base case	µg/m³	188	27.5	0.15	40	0.237	0.0059	200	***735***	***3.7***	20	***85.3***	***4.3***	20	1.54	0.077
Application case	µg/m³		77.3	0.41		0.667	0.017		***736***	***3.7***		***85.5***	***4.3***		1.64	0.082
A2 - lower Kitimat																
Base case	µg/m³	188	30.2	0.16	40	0.403	0.010	200	***674***	***3.4***	20	***53.5***	***2.7***	20	5.06	0.25
Application case	µg/m³		66.1	0.35		2.83	0.071		***721***	***3.6***		***57.8***	***2.9***		5.55	0.28
A3 - upper Kitimat																
Base case	µg/m³	188	14.8	0.079	40	0.368	0.0092	200	***678***	***3.4***	20	***54.9***	***2.8***	20	4.56	0.23
Application case	µg/m³		65.6	0.35		1.99	0.050		***679***	***3.4***		***59.1***	***3.0***		4.92	0.25
A4 - north Kitimat																
Base case	µg/m³	188	6.73	0.036	40	0.222	0.0055	200	181	0.91	20	***40.5***	***2.0***	20	3.36	0.17
Application case	µg/m³		34.7	0.18		1.13	0.028		184	0.92		***42.7***	***2.1***		3.61	0.18
A5 - service area																
Base case	µg/m³	188	21.1	0.11	40	0.459	0.011	200	***462***	***2.3***	20	***50.3***	***2.5***	20	8.50	0.43
Application case	µg/m³		79.5	0.42		3.42	0.085		***475***	***2.4***		***52.6***	***2.6***		9.23	0.46

NOTE(S)

Bold Italics Concentration exceeds relevant guidelines

Table 9.2-10: $PM_{2.5}$ and CO – Special Receptor Locations

Area	$PM_{2.5}$ Concentrations (µg/m³)						CO Concentrations (µg/m³)					
	BC AAQO (2013) 24-h	24-h Max	CR	BC AAQO (2013) Annual	Annual Max	CR	BC AAQO (2013) 1-h	1-h Max	CR	BC AAQO (2013) 8-h	8-h Max	CR
15 - southeast residence												
Base case	25	2.66	0.11	8	0.160	0.020	14,300	10.4	0.00072	5,500	4.03	0.00073
Application case		4.09	0.16		0.218	0.027		66.9	0.0047		36.4	0.0066
22 - Coste Island												
Base case	25	1.24	0.050	8	0.0744	0.0093	14,300	9.84	0.00069	5,500	2.13	0.00039
Application case		1.48	0.059		0.0935	0.012		34.0	0.0024		8.80	0.0016
23 - southwest dockyard												
Base case	25	10.2	0.41	8	1.14	0.14	14,300	7.43	0.00052	5,500	2.68	0.00049
Application case		10.6	0.43		1.25	0.16		116	0.01		36.3	0.0066
24 - Half Moon Bay												
Base case	25	7.69	0.31	8	0.858	0.11	14,300	8.05	0.00056	5,500	2.93	0.00053
Application case		8.61	0.34		0.963	0.12		95.7	0.01		40.7	0.0074
25 - Minette Bay1												
Base case	25	2.51	0.10	8	0.148	0.018	14,300	16.9	0.0012	5,500	6.40	0.0012
Application case		3.84	0.15		0.197	0.025		115.46	0.01		42.9	0.0078
26 - Minette Bay Lodge												
Base case	25	2.67	0.11	8	0.162	0.020	14,300	15.7	0.0011	5,500	6.23	0.0011
Application case		4.12	0.16		0.225	0.028		102	0.01		41.3	0.0075
28 - Kitimat Airport												
Base case	25	2.86	0.11	8	0.306	0.038	14,300	7.44	0.00052	5,500	4.07	0.00074
Application case		3.84	0.15		0.431	0.054		56.1	0.0039		21.9	0.0040
29 - Kildala Beach												
Base case	25	0.592	0.024	8	0.0226	0.0028	14,300	6.76	0.00047	5,500	1.71	0.00031
Application case		0.670	0.027		0.0284	0.0035		8.16	0.00057		3.86	0.00070

Table 9.2-11: NO_2 and SO_2 – Special Receptor Locations

Area	NO_2 Concentrations (µg/m³)						SO_2 Concentrations (µg/m³)								
	US NAAQS (2010)	1-h Max	CR	WHO AQG (2005)	Annual Max	CR	BC Interim (2014)	1-h Max	CR	WHO AQG (2005)	24-h Max	CR	AB AAQO (2013)	Annual Max	CR
15 - southeast residence															
Base case	188	8.90	0.047	40	0.182	0.0045	200	187	0.93	20	***40.2***	***2.01***	20	1.27	0.06
Application case		47.9	0.25		0.734	0.018		193	0.96		***42.4***	***2.12***		1.35	0.07
22 - Coste Island															
Base case	188	6.05	0.032	40	0.0483	0.0012	200	62.1	0.31	20	10.2	0.51	20	0.492	0.02
Application case		21.9	0.12		0.202	0.0050		65.8	0.33		10.8	0.54		0.523	0.03
23 - southwest dockyard															
Base case	188	23.5	0.12	40	0.310	0.0078	200	***393***	***1.97***	20	***67.3***	***3.37***	20	3.72	0.19
Application case		65.0	0.35		1.42	0.04		***404***	***2.02***		***69.3***	***3.47***		3.89	0.19
24 - Half Moon Bay															
Base case	188	18.0	0.10	40	0.302	0.0075	200	***449***	***2.2***	20	***50.9***	***2.55***	20	3.00	0.15
Application case		58.6	0.31		1.35	0.034		***470***	***2.4***		***52.7***	***2.64***		3.15	0.16
25 - Minette Bay1															
Base case	188	9.00	0.048	40	0.117	0.0029	200	***342***	***1.7***	20	***32.2***	***1.61***	20	1.40	0.07
Application case		42.9	0.23		0.501	0.013		***386***	***1.9***		***34.3***	***1.72***		1.51	0.08
26 - Minette Bay Lodge															
Base case	188	8.43	0.045	40	0.181	0.0045	200	***204***	***1.02***	20	***38.7***	***1.93***	20	1.34	0.07
Application case		44.6	0.24		0.805	0.020		***210***	***1.05***		***41.1***	***2.06***		1.44	0.07

Area	NO_2 Concentrations (µg/m³)						SO_2 Concentrations (µg/m³)								
	US NAAQS (2010)	1-h Max	CR	WHO AQG (2005)	Annual Max	CR	BC Interim (2014)	1-h Max	CR	WHO AQG (2005)	24-h Max	CR	AB AAQO (2013)	Annual Max	CR
28 - Kitimat Airport															
Base case	188	6.37	0.03	40	0.212	0.0053	200	173	0.86	20	***38.3***	***1.92***	20	4.98	0.25
Application case		36.8	0.20		1.20	0.030		184	0.92		***40.5***	***2.02***		5.27	0.26
29 - Kildala Beach															
Base case	188	5.21	0.028	40	0.0217	0.00054	200	20.1	0.101	20	3.92	0.20	20	0.158	0.0079
Application case		8.69	0.046		0.0565	0.0014		20.8	0.104		4.26	0.21		0.166	0.0083

NOTE(S)
Bold Italics Concentration exceeds relevant guidelines

9.2.5.2.4 Assessment of Residual Effects for SO_2

Inhalation of SO_2 can result in respiratory effects particularly in people who have asthma or COPD. A review of the health effects associated with inhalation exposures to SO_2 is provided in the HHRA TDR (Stantec 2014a). Potential health effects resulting from increases in SO_2 concentration associated with the Project are evaluated based on 24-hour, 1-hour, and 5-minute exposures.

9.2.5.2.4.1 Evaluation of Potential Health Effects based on 24-hour Exposures

The maximum reported 24-hour SO_2 concentrations for the base and application cases exceed the 24-hour human health-based air quality criterion of 200 µg/m^3 in all five human health focus areas and in six of the eight special receptor locations outside the five focus areas. The percent increases in CR between the base and application cases for the human health areas range from 0.47% for A1 to 7.8% for A2 (Table 9.2-12), whereas the percent increases for the special receptor locations range from 3.0% at the southwest dockyard to 6.8% at Minette Bay1 (Table 9.2-13). These CRs are based on the maximum modelled SO_2 concentrations, which occur infrequently and represent overestimates of potential human health risks associated with exposure to SO_2 in the Kitimat region.

To understand the range and frequency of 24-hour SO_2 concentrations that could occur in each human health area, an assessment of the reasonable worst-case potential health risk in each area is completed. This is done by identifying the grid point in each area where the maximum modelled SO_2 concentration is identified and extracting the full three years of air quality modelling data for that grid point from the dataset. The 24-hour average SO_2 concentrations are derived from the approximately 26,300 1-hour SO_2 concentration estimates for the maximum SO_2 grid point. The 24-hour average concentrations are grouped into concentration ranges or “bins” of 10 µg/m^3 (e.g., 0 µg/m^3 to 10 µg/m^3, 11 µg/m^3 to 20 µg/m^3, 21 µg/m^3 to 30 µg/m^3) across the entire range of concentration data for each of the five areas. The frequency of occurrence for each predicted 24-hour average SO_2 concentration range is multiplied by the upper concentration limit for each concentration bin to determine a weighted-average 24-hour SO_2 concentration for each of the five areas. The 24-hour weighted-average concentrations for the special receptor locations are calculated in the same manner. A full description of the methods used to process the SO_2 modelling data is provided in the HHRA TDR (Stantec 2014a).

The CRs calculated based on the weighted-average 24-hour SO_2 concentrations for the five areas and the eight special receptor locations are listed in Table 9.2-14 and Table 9.2-15. At all locations for the base and application cases, the weighted-average 24-hour SO_2 concentrations are below the 24-hour human health-based air quality criterion for SO_2. In the five human health focus areas, the CRs for the base and application cases range between 0.52 and 0.68 (Table 9.2-14), indicating that the predicted SO_2 concentrations do not represent a potential concern for human health. Marginal increases in potential human health risks range between 0.27% for Kitamaat Village and 2.7% in the service area and could be attributed to the Project. Similar results occur for the eight special receptor locations (Table 9.2-15).

Table 9.2-12: Concentration Ratios for 24-hour Maximum SO_2 – Human Health Areas

Area	24-hour SO_2 Concentration Ratios		
	Base Case	Application Case	Percent Difference (%)
A1 - Kitamaat Village	***4.26***	***4.28***	0.47
A2 - lower Kitimat	***2.68***	***2.89***	7.8
A3 - upper Kitimat	***2.75***	***2.96***	7.6
A4 - north Kitimat	***2.02***	***2.13***	5.4
A5 - service area	***2.51***	***2.63***	4.8

NOTE(S)
Bold Italics Value exceeds relevant guideline.

Table 9.2-13: Concentration Ratios for 24-hour Maximum SO_2 – Special Receptor Locations

Special Receptor Number	Special Receptor Description	SO_2 Concentration Ratios		
		Base Case	Application Case	Percent Difference (%)
15	Southeast residence	***2.0***	***2.1***	5.5
22	Coste Island	0.51	0.54	5.9
23	Southwest dockyard	***3.4***	***3.5***	3.0
24	Half Moon Bay	***2.6***	***2.6***	3.5
25	Minette Bay1	***1.6***	***1.7***	6.8
26	Minette Bay Lodge	***1.9***	***2.1***	6.7
28	Kitimat Airport	***1.9***	***2.0***	5.2
29	Kildala Beach	0.20	0.21	5.0

NOTE(S)
Bold Italics Value exceeds relevant guideline.

Table 9.2-14: Concentration Ratios for 24-hour Weighted-Average SO_2 – Human Health Areas

Area	WHO AQG (2005)	Base Case		Application Case		Percent Difference (%)
		24-hour Weighted-Average Concentration (µg/m^3)	CR	24-hour Weighted Average Concentration (µg/m^3)	CR	
A1 - Kitamaat Village	*20*	10.42	0.521	10.45	0.522	0.27
A2 - lower Kitimat		11.0	0.55	11.2	0.56	1.7
A3 - upper Kitimat		10.6	0.530	10.7	0.535	0.95
A4 - north Kitimat		10.77	0.538	10.85	0.542	0.76
A5 - service area		13.2	0.66	13.5	0.68	2.7

Table 9.2-15: Concentration Ratios for 24-hour Weighted Average SO_2 – Special Receptor Locations

Special Receptor Number	Sensitive Receptors	WHO Guidelines (2005)	Base Case		Applications Case		CR
			24 Hour Weighted - Average	CR	24-hour Weighted-Average	CR	Percent Difference (%)
15	Southeast residence	*20*	10.2	0.51	10.3	0.51	0.36
22	Coste Island		10.0	0.50	10.0	0.50	0
23	Southwest dockyard		10.97	0.55	11.00	0.55	0.33
24	Half Moon Bay		10.6	0.53	10.7	0.54	1.0
25	Minette Bay1		10.3	0.52	10.4	0.52	0.88
26	Minette Bay Lodge		10.2	0.51	10.3	0.51	0.36
28	Kitimat Airport		12.2	0.61	12.4	0.62	1.4
29	Kildala Beach		10	0.5	10	0.5	0

9.2.5.2.4.2 Evaluation of Potential Health Effects based on 1-Hour Exposures

The maximum reported 1-hour SO_2 concentration for the base and application cases exceed the 1-hour human health-based air quality criterion of 200 µg/m^3 in four of the five human health focus areas (Table 9.2-9) and at five of the eight special receptor locations outside the limits of the five areas (Table 9.2-11). Using the maximum concentrations to evaluate potential health risks greatly overestimates the risks that are likely to be present. When these estimates show that the CACs do not pose a potential human health concern, there is no need for further evaluation. However, when the worst-case exposure scenarios indicate a potential human health concern, it is necessary to refine the exposure scenarios to better represent actual conditions in the areas being considered so that potential health risks is better predicted.

The determination of the range and frequencies of 1-hour SO_2 concentrations that could occur in each human health area and at the eight special receptor locations uses the same methods for calculating the weighted-average 24-hour SO_2 concentrations. The 1-hour weighted average SO_2 concentrations for the five areas are based on the grid point where the maximum 1-hour SO_2 concentration is identified. This provided three years of 1-hour SO_2 data (approximately 26,300 1-hour SO_2 concentrations for each study area). For the eight special receptor locations, calculation of the 1-hour weighted-average concentration is based on the three years of modelling data for that receptor location. For each of the datasets, the extracted 1-hour SO_2 concentration estimates are grouped into concentration ranges or "bins" of 10 µg/m^3 (e.g., 0 µg/m^3 to 10 µg/m^3, 11 µg/m^3 to 20 µg/m^3, 21 µg/m^3 to 30 µg/m^3) across the entire range of concentration data for each of the five areas. The frequency of occurrence for each predicted SO_2 concentration range is multiplied by the upper concentration limit for each concentration bin to determine a weighted average 1-hour SO_2 concentration for each area. A full description of the methods used to process the SO_2 modelling data available for the human health areas is provided in the HHRA TDR (Stantec 2014a).

The 1-hour weighted-average SO_2 concentrations and the associated CRs for each of the five human health areas and the eight special receptor locations are listed in Table 9.2-16 and Table 9.2-17. The CRs for the 1-hour weighted-average concentrations of SO_2 are below the exposure acceptability benchmark of 1.0 for the base and application cases in the five areas and eight special receptor locations, suggesting that health effects related to exposure to the predicted 1-hour weighted-average SO_2 concentrations will not occur.

Table 9.2-16: Concentration Ratios for 1-hour Weighted-Average SO_2 – Human Health Areas

Area	WHO AQG (2005)	Base Case		Application Case		CR
		1-hour Weighted Average Concentration (µg/m^3)	CR	1-hour Weighted Average Concentration (µg/m^3)	CR	Percent Difference (%)
A1- Kitamaat Village	20	10.9	0.54	10.9	0.55	0.46
A2-lower Kitimat		12.4	0.62	12.6	0.63	1.7
A3-upper Kitimat		11.7	0.58	11.8	0.59	1.3
A4-north Kitimat		11.9	0.60	12.1	0.60	1.6
A5-service centre		14.8	0.74	15.1	0.76	2.4

Table 9.2-17: Concentration Ratios for 1-hour Weighted-Average SO_2 – Special Receptor Locations

Special Receptor Number	Sensitive Receptors	WHO AQG (2005)	Base Case		Application Case		CR
			1-hour Weighted Average Concentration	CR	1-hour Weighted Average Concentration	CR	Percent Difference (%)
15	Southeast residence	*20*	10.6	0.53	10.7	0.53	0.52
22	Coste Island		10.1	0.51	10.2	0.51	0.17
23	Southwest dockyard		11.8	0.59	11.9	0.59	0.81
24	Half Moon Bay		11.3	0.56	11.4	0.57	0.83
25	Minette Bay1		10.8	0.54	10.9	0.54	0.75
26	Minette Bay Lodge		10.6	0.53	10.7	0.54	0.52
28	Kitimat Airport		13.5	0.67	13.7	0.69	1.9
29	Kildala Beach		10.0	0.50	10.0	0.50	0.035

In addition, the percent increase in CRs between the base and application cases is less than 3% across the five areas and the eight special receptor locations. These data suggest that Project-related changes in SO_2 concentrations will not result in a measurable change in human health in the Kitimat region.

9.2.5.2.4.3 Evaluation of 5-minute Exposure to SO_2

The standard 24-hour and 1-hour assessments of potential health effects associated with inhalation exposures to SO_2 are based on the assumption that exposure to SO_2 concentrations below the established human health-based air quality standards do not represent potential concerns for human health. Recent evaluations of SO_2 by U.S. EPA and other agencies have suggested that for people with asthma or COPD, respiratory effects can occur even at SO_2 concentrations that are below the established standards (U.S. EPA 2009). As SO_2 concentrations in ambient air decrease, the probability of people with asthma or COPD having a respiratory event decreases (U.S. EPA 2009). The U.S. EPA has used empirical human exposure data to develop an exposure response function to predict the change in respiratory response (includes both asthma and COPD) resulting from changes in exposure to 5-minute SO_2 concentrations (U.S. EPA 2009). Potential changes in respiratory responses for people with asthma or COPD in the Kitimat region are included in the assessment to better represent potential effects the Project could have on human health.

The air quality modelling dataset provides estimates of 1-hour SO_2 concentrations, but it does not provide 5-minute SO_2 concentrations because of the computational complexity of providing such data (see the Air Quality TDR; Stantec 2014b). Because the respiratory response function is based on 5-minute SO_2 concentrations, the hourly modelled SO_2 data are converted to 5-minute SO_2 data using the following relationship (Beychok 1994):

$$\frac{C_x}{C_p} = \left(\frac{tp}{tx}\right)^n$$

Where: C_p and C_x = ground-level centreline concentrations
tp, tx = any two averaging times (min)
n = multiple possible values depending on the practitioner and approach (value of 0.20 selected for this assessment)

This equation is used to convert the approximately 26,300 1-hour SO_2 concentrations from the maximum SO_2 concentration grid point for each of the five human health areas and the eight special receptors located outside these areas. A discussion of the derivation of this equation is provided in the HHRA TDR (Stantec 2014a).

In evaluating the potential for respiratory responses, U.S. EPA considers two different forms of the exposure-response function: a two-parameter logistic model and a probit model (U.S. EPA 2009). Although the limited data used by U.S. EPA fit equally well to both types of functions (Figure 9.2-5), the two-parameter logistic model is used to estimate potential changes in respiratory responses in this assessment because, in the low SO_2 concentration range, it is more conservative (predicts a greater likelihood of response) than the probit model. See Figure 9.2-5 for the equation for the two-parameter logistic model used to predict respiratory responses. A detailed discussion of the derivation of this equation is provided in the HHRA TDR (Stantec 2014a).

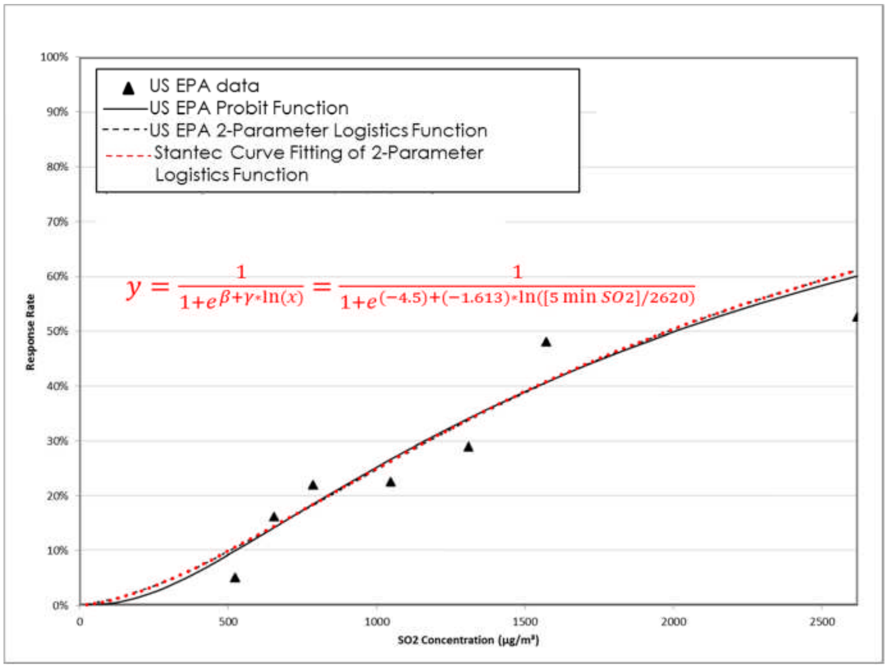

Figure 9.2-5: Respiratory Response Rate Function for 5-minute Exposures to SO_2

To predict the potential change in the frequency of respiratory events experienced by people with asthma or COPD, it is necessary to understand the prevalence of these conditions in the community and the frequency of respiratory events that will typically be expected in a given community in the absence of specific sources of SO_2. For the Kitimat region, the expected frequency of events is estimated based on the information and approach provided in the *Sulphur Dioxide Technical Assessment Report* (STAR) (RTA 2013), which supported the application to modernize the RTA facility. A survey conducted by the Public Health Agency of Canada (2010) indicated that the combined prevalence of asthma and COPD in the general population is 12%. To maintain consistency with the STAR (RTA 2013), Kitimat is assumed to have the same prevalence. Individuals with pre-existing respiratory conditions such as asthma and COPD are considered "well-controlled" if they have less than one event per week (RTA 2013). For the purposes of this assessment and to maintain consistency with the STAR, it is further assumed that the population (12%) in the Kitimat region with asthma or COPD is "well controlled," and individuals are assumed to experience one respiratory event per week 50 weeks per year (50 events per individual per year). Based on these assumptions and the populations of the five human health focus areas, the number of likely respiratory events per year in each of the five areas is predicted (Table 9.2-18). The (A5) service area is an industrial and commercial area and does not contain any residential housing. A population of 100 is assigned to this area for analysis to account for people who work in this area. A more detailed discussion of the derivation of these values is provided in the HHRA TDR (Stantec 2014a).

Table 9.2-18: Frequency of Background Respiratory Events – Human Health Areas

Area	Population	Frequency of Asthma and COPD in Population (%)	Population with Asthma and COPD	No. of Events per Person per Year	Expected No. of Events
A1 - Kitamaat Village	167	12	20	50	1,000
A2 - lower Kitimat	3,338	12	401	50	20,050
A3 - upper Kitimat	4,590	12	551	50	27,550
A4 - north Kitimat	250	12	30	50	1,500
A5 - service area	100	12	12	50	600

To understand and evaluate changes in the frequencies of respiratory events that could occur in the community as a result of Project activities, it is necessary to understand the frequency of respiratory events that might occur in the community under base case conditions (includes operation of the RTA modernization project). The change in respiratory event frequency that might occur as a result of operations of the Project (application case) is then evaluated as the difference in predicted respiratory event frequency between the base and application cases.

For the assessment of potential health effects associated with exposures to the predicted 5-minute SO_2 concentrations, the 5-minute data are grouped using the same concentration ranges used to group the 1-hour data. The predicted frequency of respiratory events for the base and application cases is calculated as a function of the probability of a respiratory response for a given concentration range and the frequency of SO_2 concentrations within a given concentration range. The probability of a respiratory event occurring is determined for the upper limit concentration for each concentration range using the two-parameter logistic equation. The number of predicted respiratory responses in a given human health focus area is calculated by multiplying the probability of response for a given SO_2 concentration by the frequency of occurrence of that concentration and by the predicted population of people with asthma or COPD in each of the five areas. The total number of predicted respiratory responses in a given area is calculated as the sum of the predicted responses for each SO_2 concentration range. Sample calculations are provided in the HHRA TDR (Stantec 2014a). This approach is consistent with the approach used by U.S. EPA (2009).

The predicted number of additional respiratory events for each area under each scenario is provided in Table 9.2-19. The additional number of events expected in each area that result from the Project is estimated by subtracting the number of events predicted under the base case from the number of event predicted under the application case. The percent increase in events resulting from the Project is estimated relative to the sum of the background events and the number of additional events predicted under the base case. The percent increases in respiratory events range from 0.00088% to 0.006704% (Table 9.2-19). These small increases suggest that the contribution of the Project to the overall concentration of SO_2 is inconsequential in comparison to the contributions from the base case. The Project will not result in SO_2 concentrations that lead to potential health concerns greater than what may or may not already be present (in the base case).

The potential increase in respiratory events has not been calculated for the eight special receptor locations that exist outside the five human health focus areas because the calculation is based on the population in a given area. The eight locations are individual locations that do not have populations directly associated with them. Assessment of the potential health effects associated with 24-hour and 1-hour SO_2 concentrations shows that predicted human health risks at these locations are lower than those predicted for the five human health areas. Therefore, it is reasonable to conclude that the increase in respiratory events that could be experienced by people who spend time at the eight locations will be lower than those predicted for the five areas where it has been assumed that people are continuously present.

9.2.5.2.4.4 Assessment for Combined Exposure to SO_2 and NO_2

Air quality modelling shows that the predicted levels of NO_2 are well below the human health-based air quality criterion for the base and application cases. Based on these results, exposure to NO_2 is not a potential concern for human health. However, SO_2 and NO_2 both have the potential to cause respiratory effects when inhaled. Although standard protocols for assessing the potential health effects associated with combined SO_2 and NO_2 exposures have yet to be developed by regulatory agencies in Canada or elsewhere, Northern Health and Health Canada have requested that the report include an assessment of the potential health risks associated with combined inhalation exposures to SO_2 and NO_2. The methods developed for completing this evaluation are detailed in the HHRA TDR (Stantec 2014a).

Table 9.2-19: Increase in Respiratory Response – 5–minute SO_2 Concentration

Area	# of Expected Events[a]	Base Case		Application Case		Predicted Health Effect		
		Increase in Predicted Respiratory Response Rate (%)	Expected # of Events	Increase in Predicted Respiratory Response Rate (%)	Expected # of Events	Increase in # Events between Base and Application	# of Base Events[b]	Percent Increase in Events from Base to Application
A1 - Kitamaat Village	1000	0.00038	0.38	0.00039	0.389	0.009	1000.38	0.00%
A2 - lower Kitimat	20050	0.00061	12.25	0.00066	13.149	0.894	20062.25	0.00%
A3 - upper Kitimat	27550	0.00046	12.67	0.00048	13.34	0.672	27562.67	0.00%
A4 - north Kitimat	1500	0.00046	0.7	0.00049	0.741	0.045	1500.7	0.00%
A5 - service Area	600	0.00095	0.57	0.00101	0.608	0.039	600.57	0.01%

NOTES:

[a] The number of expected events is based on the average number of respiratory response events expected per year for a person with COPD or asthma (50) multiplied by the percentage of people who have a respiratory illnesses (approx. 12% of the population of each area).

[b] The base number of expected respiratory events per year is a function of the expected number of respiratory events with the addition of baseline concentrations of $SO_{2.}$ The probable response curve is used to derive the base response numbers for the Baseline SO_2 concentrations.

The evaluation of potential changes in respiratory health risk associated with combined exposures to SO_2 and NO_2 is based on the 1-hour SO_2 and NO_2 air quality modelling data for each of the five human health focus areas and the eight special receptor locations for base and application cases. For each of the five areas, the 1-hour SO_2 data for the grid point location where the maximum SO_2 concentration is predicted are extracted from the dataset and used in the assessment of 1-hour exposures to SO_2 and NO_2. The NO_2 data used in the assessment are derived in the same manner. In each study area, the grid point where the highest NO_2 concentration is predicted to occur is identified and the full three years of 1-hour modelled NO_2 concentrations for that location are extracted from the dataset. The 1-hour SO_2 and 1-hour NO_2 data from these grid point locations are combined and the SO_2 and NO_2 concentrations are summed for each of the 1-hour time periods across the three years of modelling data, yielding approximately 26,300 estimates of summed SO_2 and NO_2 concentrations. The combined concentrations are grouped into concentration ranges of 10 $\mu g/m^3$ to determine the overall range and frequency of occurrence of the various combined concentrations. The determined frequencies are multiplied by the upper concentration limits of each concentration range to provide a frequency weighting for each concentration range. The individual frequency weightings are combined to provide a weighted-average concentration of combined SO_2 and NO_2 concentrations in each of the five human health areas.

The maximum predicted SO_2 and NO_2 concentrations and the weighted-average SO_2 and NO_2 concentrations are compared with the human health-based air quality criterion for NO_2 (Table 9.2-20). The criterion for NO_2 is chosen because it is lower than the criterion for SO_2 and therefore will provide a more conservative estimate of potential human health risks associated with combined exposures.

The CRs calculated for the 1-hour maximum and the weighted-average combined SO_2 and NO_2 concentrations for the base and application cases are shown in Table 9.2-20. The combined 1-hour maximum SO_2 and NO_2 concentrations exceed the human health-based air quality objective (188 $\mu g/m^3$) for the base and application cases in all five human health focus areas. However, the weighted-average combined SO_2 and NO_2 concentrations are well below the air quality objective for the base and application cases in all five areas (Table 9.2-20).

The CRs calculated for the 1-hour maximum SO_2 and NO_2 concentrations exceed 1.0 for the base and application cases in all five areas (Table 9.2-20). However, the CRs calculated from the weighted-average 1-hour SO_2 and NO_2 concentrations are less than 10% of the exposure acceptability benchmark for the base and application cases in all five human health focus areas. The data presented in Table 9.2-20 demonstrate that the combined exposures to SO_2 and NO_2 are being driven by air quality in the base case and not by the Project contributions to air quality in the application case. To illustrate the overall contribution the Project makes to SO_2 and NO_2 concentrations in the Kitimat region, a summary of the incremental increases in CR between base and application cases for the five areas is provided in

Table 9.2-21. Project-related increases in combined SO_2 and NO_2 exposures range between 0.5% and 15%. A detailed review of the underlying SO_2 and NO_2 data shows that increases in NO_2 levels between base and application cases is the primary contributor to the observed increases (see the HHRA TDR; Stantec 2014a). However, for both base and application cases, predicted NO_2 concentrations are well below the human health-based air quality criterion for NO_2; therefore, the increase in NO_2 is not a concern for human health.

A similar analysis is completed for the eight special receptor locations that lie outside the boundaries of the five human health focus areas (Table 9.2-22). The combined 1-hour maximum SO_2 and NO_2 concentrations exceed the human health-based air quality objective (188 $\mu g/m^3$) for the base and application cases for six of the eight special receptor locations. The weighted-average combined SO_2 and NO_2 concentrations are well below the air quality objective for the base and application cases for all eight locations (Table 9.2-22).

The CRs calculated for the 1-hour maximum SO_2 and NO_2 concentrations exceed 1.0 for the base and application cases in six of the eight special receptor locations. However, the CRs calculated from the weighted-average 1-hour SO_2 and NO_2 concentrations are less than 10% of the exposure acceptability benchmark for the base and application cases for all eight of the special receptor locations. The data listed in Table 9.2-23 indicate that the combined exposures to SO_2 and NO_2 are being driven by air quality in the base case and not by the Project contribution to air quality in the application case. A summary of the incremental increases in CR between base and application cases for the eight special receptor locations is provided in Table 9.2-23. Project-related increases in combined SO_2 and NO_2 exposures range between 5.8% and 35% for the 1-hour maximum SO_2 and NO_2 concentrations and between 0.13% and 8.6% for the 1-hour weighted-average SO_2 and NO_2 concentrations. The increases in combined SO_2 and NO_2 concentrations between base and application cases are driven by Project-related increases in NO_2 emissions (see the HHRA TDR; Stantec 2014a). However, Project-related increases in NO_2 are below the level that could pose a concern for human health.

Based on these results, it is reasonable to conclude that simultaneous exposures to SO_2 and NO_2 will not result in an increase in respiratory events for people living in the Kitimat region.

Table 9.2-20: Combined Concentration of SO_2 and NO_2

Area and Scenario	SO_2 Concentrations (µg/m³)			NO_2 Concentrations (µg/m³)			Combined Concentrations (µg/m³)				
	BC Interim (2014)	1-hr Max	1-h Weighted Avg.	U.S. EPA NAAQS (2010)[a]	1-h Max	1-h Weighted Avg.	U.S. EPA NAAQS (2010)[a]	1-h Max	CR	1-h Weighted Avg.	CR
A1 - Kitamaat Village											
Base case	200	***735***	10.9	188	27.5	10.0	188	***736***	***3.91***	10.9	0.058
Application case		***736***	10.9		77.3	10.1		***739***	***3.93***	11.2	0.060
A2 - lower Kitimat											
Base case	200	***674***	12.4	188	30.2	10	188	***678***	***3.6***	12.5	0.066
Application case		***721***	12.6		66.1	10.5		***756***	***4.0***	13.7	0.073
A3 - upper Kitimat											
Base case	200	***678***	11.7	188	14.8	10.0	188	***679***	***3.6***	11.9	0.063
Application case		***679***	11.8		65.6	10.5		***718***	***3.8***	12.8	0.068
A4 - north Kitimat											
Base case	200	181	11.9	188	6.73	10	188	**183**	1.0	12.0	0.064
Application case		184	12.1		34.7	10.1		***200***	***1.1***	12.8	0.068
A5 - service area											
Base case	200	***462***	14.8	188	21.1	10	188	***463***	***2.5***	15.0	0.080
Application case		***475***	15.1		79.5	11.2		***499***	***2.7***	17.4	0.092

NOTE:
Bold Italics Concentration exceeds relevant guidelines

Table 9.2-21: Concentration Ratios for Combined Concentrations of SO_2 and NO_2 – Human Health Areas

Area	1-hour Max Combined SO_2 and NO_2 Concentration Ratios			1-hour Weighted-Average Combined SO_2 and NO_2 Concentration Ratios		
	Base Case	Application Case	Percent Increase	Base Case	Application Case	Percent Increase
A1 - Kitamaat Village	3.91	3.93	0.51	0.058	0.060	3.45
A2 - lower Kitimat	3.61	4.02	11.36	0.066	0.073	10.61
A3 - upper Kitimat	3.61	3.82	5.82	0.063	0.068	7.94
A4 - north Kitimat	0.97	1.07	10.31	0.064	0.068	6.25
A5 - service area	2.46	2.66	8.13	0.080	0.092	15.00

Table 9.2-22: Combined Concentrations of SO_2 and NO_2 – Special Receptor Locations

Area	Combined SO_2 and NO_2 Concentrations (µg/m^3)				
	U.S. EPA NAAQS (2010)	1-h Max	CR	1-hr Time-Weighted Avg.	1-hr Time-Weighted Avg. CR
15 - southeast residence					
Base case	188	***259***	***1.4***	10.6	0.057
Application case		***350***	***1.9***	11.0	0.059
22 - Coste Island					
Base case	188	137	0.73	10.15	0.0540
Application case		145	0.77	10.22	0.0544
23 - southwest dockyard					
Base case	188	***416***	***2.2***	11.9	0.063
Application case		***451***	***2.4***	12.7	0.068
24 - Half Moon Bay					
Base case	188	***465***	***2.5***	11.3	0.060
Application case		***497***	***2.6***	12.1	0.064
25 - Minette Bay1					
Base case	188	***346***	***1.8***	10.8	0.058
Application case		***399***	***2.1***	11.1	0.059
26 - Minette Bay Lodge					
Base case	188	***219***	***1.2***	10.7	0.057
Application case		***256***	***1.4***	11.1	0.059
28 - Kitimat Airport					
Base case	188	180	1.0	13.6	0.072
Application case		***218***	***1.2***	14.8	0.079

Area	Combined SO_2 and NO_2 Concentrations (µg/m^3)				
	U.S. EPA NAAQS (2010)	1-h Max	CR	1-hr Time-Weighted Avg.	1-hr Time-Weighted Avg. CR
29 - Kildala Beach					
Base case	188	31.0	0.17	10.03	0.05337
Application case		36.7	0.20	10.05	0.05344

NOTE:
Bold Italics Value exceeds relevant guideline/benchmark

Table 9.2-23: Concentration Ratios for Combined Concentrations of SO_2 and NO_2 – Special Receptor Locations

Area	1-hour Max Combined SO_2 and NO_2 Concentration Ratios			1-hour Weighted-Average Combined SO_2 and NO_2 Concentration Ratios		
	Base Case	Application Case	Percent Increase (%)	Base Case	Application Case	Percent Increase (%)
15 - Southeast residence	1.4	1.9	35	10.6	11.0	3.4
22 - Coste Island	0.73	0.77	5.8	10.15	10.22	0.70
23 - Southwest dockyard	2.2	2.4	8.5	12	13	7.3
24 - Half Moon Bay	2.5	2.6	6.9	11	12	6.5
25 - Minette Bay1	1.8	2.1	15	10.8	11.1	3.0
26 - Minette Bay Lodge	1.2	1.4	1.7	10.7	11.1	4.0
28 - Kitimat Airport	0.96	1.2	2.1	14	15	8.6
29 - Kildala Beach	0.17	0.20	18	10.03	10.05	0.13

9.2.5.2.5 Determination of Significance for Change in Human Health Risk from Degraded Air Quality

Project activities are likely to result in a small change in SO_2 concentrations in the Kitimat region. The 1-hour weighted average SO_2 concentrations are predicted to increase by less than 3% between the base case and the application case (which includes project specific additions to the base case) in the five human health focus areas and the eight special receptor locations evaluated (see Table 9.2-16 and Table 9.2-17). In addition, the increase in respiratory events among people with asthma or COPD associated with 5-minute exposures to peak SO_2 concentrations is predicted to be less than 0.01% (see Table 9.2-19). Similar results are noted in the assessment of combined exposures to 1-hour weighted-average SO_2 and NO_2 concentrations (see Table 9.2-22 and Table 9.2-23). Therefore, any changes in human health risk associated with combined SO_2 and NO_2 exposures beyond what already exists under the base case will be negligible. For these reasons, the change in human health risk from degraded air quality due to the Project is assessed as not significant.

9.2.5.3 Summary of Project Residual Effects from the LNG Facility

Project residual effects are not predicted to result in a change in human health as a result of changes in air quality related to SO_2 emissions or changes in air quality related to combined SO_2 and NO_2 emissions. Residual effects from the LNG facility will be negligible, of long-term duration, limited to the LSA, and reversible, and are assessed as not significant.

9.2.6 Assessment of Residual Effects from Shipping

No effects on human health are anticipated from marine shipping. Potential effects due to air emissions related to marine shipping have been incorporated into the dispersion modelling used as a basis to assess effects on human health in Section 9.2.5.

9.2.7 Summary of Project Residual Effects

The residual effects of the Project on human health from the LNG facility and shipping are summarized in Table 9.2-24.

Table 9.2-24: Summary of Project Residual Effects: Human Health

Project Phase	Mitigation Measures	Residual Effects Rating Criteria						Likelihood of Residual Effects	Significance	Prediction Confidence	Follow-up and Monitoring
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context				
Facility Works and Activities											
Construction	None required	N	LSA	ST	MR	R	H	L	N	H	No follow-up programs are proposed for human health.
Operation	None required	L	LSA	LT	C	R	H	L	N	H	
Decommissioning	None required	N	LSA	ST	MR	R	H	L	N	H	
Residual effects for all phases	None required	L	LSA	LT	C	R	H	L	N	H	

KEY

MAGNITUDE:

N = Negligible—no detectable or measurable change from existing baseline conditions

L = Low—a measurable change from existing baseline conditions but is below environmental and/or regulatory thresholds and affect human health

M = Moderate—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds but does not affect human health

H = High—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds and represents a potential concern for human health.

GEOGRAPHIC EXTENT:

PF = Project footprint—residual effects are restricted to the Project footprint

LSA—effects extend into the LSA

RSA—effects extend into the RSA

DURATION:

ST = Short-term—effect restricted to construction phase

MT = Medium-term—effect extends through operations phase

LT = Long-term—effect extends beyond closure

P = Permanent—measurable parameter unlikely to recover to baseline

FREQUENCY:

S = Single event—occurs once

MI = Multiple irregular event—occurs sporadically at irregular intervals throughout construction, operation and/or decommissioning

MR = Multiple regular event—occurs on a regular basis and at regular intervals throughout construction, operation, or decommissioning phases

C = Continuous—occurs continuously throughout the life of the Project

REVERSIBILITY:

R = Reversible—potential human health risks will return to existing baseline levels after decommissioning

I = Irreversible—effect is permanent

CONTEXT:

L = Low resilience—low capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

M = Moderate resilience—moderate capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

H = High resilience—high capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

SIGNIFICANCE:

S = Significant

N = Not Significant

PREDICTION CONFIDENCE:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation, and assumptions made.

L = Low level of confidence

M = Moderate level of confidence

H = High level of confidence

LIKELIHOOD OF RESIDUAL EFFECT OCCURRING:

Based on professional judgment

L = Low likelihood that there will be a residual effect

M = Moderate likelihood that there will be a residual effect

H = High likelihood that there will be a residual effect

9.2.8 Assessment of Cumulative Effects

Cumulative effects are considered for each Project residual effect. Three stages are involved: (1) establishing context by providing an overview of the cumulative effects of other projects and activities on the human health; (2) determining the potential for Project residual effects to interact with the effects of other projects and activities, and if the Project does interact cumulatively with other projects and activities; and (3) if the Project does interact cumulatively with other projects and activities, assessing the significance of the resulting overall cumulative effect, and characterizing the Project's contribution to the change in cumulative effects.

9.2.8.1 Stage 1, Cumulative Effects Context

Other projects have additive effects on the baseline levels for ambient air quality in the region. The largest contributor is the RTA aluminum facility, located at the head of Kitimat Arm. It has been operating since the 1950s and is currently being modernized. Construction of the modernization project is planned for 2013 to 2015, and existing operations will continue during this period and beyond. The modernized infrastructure is expected to increase its overall output of emissions, which might have negative effects on human health in the region. During the course of the HHRA, the projected increase in emissions is incorporated into the air model for base case conditions.

The Kitimat LNG Terminal at Bish Cove, on the west shore of Kitimat Arm, is 11.6 km from Kitimat (BC EAO 2006). Construction is underway (planned for 2012 to 2015/2016) and operations are planned for 2015/2016 to 2040/2041. Infrastructure construction and operation is expected to affect air emissions through the same mechanisms identified for the LNG Canada Export Terminal Project.

The Enbridge Northern Gateway Project, on the west shore of Kitimat Arm, is 8.8 km from the LNG Canada Export Terminal Project. Operations are planned for 2018 to 2048 (Enbridge Northern Gateway Project 2010). Infrastructure construction is expected to affect air emissions through the same mechanisms identified for the LNG Canada Project.

The Douglas Channel LNG Terminal is a small-scale LNG facility proposed for the west shore of Kitimat Arm, near Moon Bay, 5.6 km from the Project. The construction and operation timelines are uncertain, but they are assumed to overlap with the construction phase of the Project.

The Sandhill Materials facility has been included in the assessment of cumulative effects.

Within the HHRA, most activities and works for the facility involve air emissions from infrastructure construction and facility operation that contribute or will contribute to regional ambient air levels.

The cumulative effects of existing projects, including the projected increases from the RTA modernization project, are expected to occur. Baseline maximums from the measured and modelled data from 2006, 2008, and 2009 for SO_2 already exceed the guidelines used to evaluate them, although these exceedances occur very infrequently; further potential for increase in respiratory events is analyzed.

9.2.8.2 Stage 2, Determination of Potential Cumulative Interactions

Measurable or demonstrable residual effects are identified for a change in ambient air quality (and for cumulative effects from interactions between the baseline operation of other projects whether during construction or operation) and the LNG Canada Export Terminal Project (Section 9.2.5). Measurable or demonstrable residual effects are not identified for changes in the quality of drinking water or terrestrial or marine country foods. The potential for interactions between past, present, and future activities with Project effects is identified in Table 9.2-6.

Table 9.2-25: Potential Cumulative Effects on Human Health

Other Projects and Activities with Potential for Cumulative Effects	Potential Cumulative Effects				
	Changes in human health from changes in SO_2 related air quality	Changes in human health from changes in combined SO_2 and NO_2 air quality	Shipping: Changes in human health risk associated with changes in inhalation exposures to SO_2	Changes in human health from changes in country food quality	Changes in human health from changes in drinking water quality
Kitimat Area Project/Facility					
Coastal GasLink Pipeline Project	✓	✓			
Douglas Channel LNG Terminal (also known as BC LNG)	✓	✓			
Enbridge Northern Gateway Project	✓	✓			
Former Methanex/Cenovus Terminal	✓	✓			
Kitimat Clean	✓	✓			
Kitimat LNG Terminal Project	✓	✓			
Pacific Northern Gas Pipeline	✓	✓			
Pacific Trail Pipelines Project	✓	✓			
Rio Tinto Alcan Facility and Modernization Project	✓	✓			
Sandhill Materials – Aggregate Processing	✓	✓			

Other Projects and Activities with Potential for Cumulative Effects	Potential Cumulative Effects				
	Changes in human health from changes in SO_2 related air quality	Changes in human health from changes in combined SO_2 and NO_2 air quality	Shipping: Changes in human health risk associated with changes in inhalation exposures to SO_2	Changes in human health from changes in country food quality	Changes in human health from changes in drinking water quality
Prince Rupert Area Project/Facility					
BG Group – Prince Rupert LNG Project	✓	✓			
Canpotex – Potash Export Terminal*	✓	✓			
Maher Terminals – Fairview Terminal Phase 2 Expansion Project	✓	✓			
Pinnacle Renewable Resources – Pellet Export Terminal	✓	✓			
Prince Rupert Port Authority –Ridley Island Road, Rail Utility Corridor	✓	✓			
Progress Energy – Pacific Northwest LNG Project	✓	✓			
Spectra Energy – Natural Gas Pipeline	✓	✓			
TransCanada Corporation – Prince Rupert Gas Transmission Project	✓	✓			
Watco – Watson Island Re-Development	✓	✓			

NOTES:
✓ = those ‘other projects and activities’ whose effects have potential to interact cumulatively with the Project’s residual effects.

9.2.8.3 Stage 3, Determining Significance of Cumulative Effects

The initial stage of the assessment of potential cumulative effects used the cumulative effects case air quality modelling results. Maximum predicted air concentrations for $PM_{2.5}$, CO, NO_2, and SO_2 are compared with the human health-based air quality criteria to identity the CACs where the maximum predicted cumulative concentrations are predicted to exceed the human health-based air quality criteria. This is completed for the five human health focus areas and the eight special receptors located outside the boundaries of the five areas. The results for $PM_{2.5}$ and CO are summarized in Table 9.2-26, and the results for NO_2 and SO_2 are summarized in Table 9.2-27. The CRs for $PM_{2.5,}$ calculated for the 24-hour and annual average time periods are well below the CR acceptability benchmark of 1.0. The CRs for CO for the 1-hour and 8-hour averaging periods are also well below the CR benchmark of 1.0 (Table 9.2-26). The CRs for NO_2 for the 1-hour and annual average time periods are also below the CR benchmark of 1.0 (Table 9.2-27). Thus, the maximum predicted cumulative effects case concentrations of $PM_{2.5}$, CO, and

NO_2 do not represent a potential concern for human health in the Kitimat airshed. The 1-hour maximum concentrations for SO_2 exceed the human health based air quality standards in four of the five human health focus areas and four of the eight special receptor locations (Table 9.2-27). The 24-hour maximum concentrations exceed the 24-hour human health-based criterion in all five of the human health focus areas and six of the eight special receptor locations. The CRs for these locations also exceed the benchmark of 1.0. Basing the primary screening for the cumulative effects case on the maximum predicted concentration of each CAC assumes that the maximum predicted concentration represents the CAC concentration typically present in the airshed. This assumption overestimates potential exposures and represents a worst-case exposure scenario.

The finding that maximum predicted cumulative SO_2 concentrations exceed the applicable human health-based air quality criterion does not mean that SO_2 levels in the Kitimat region represent an ongoing concern for human health. Rather, these findings indicate that SO_2 requires a more detailed analysis to determine if the cumulative increase emitted by the identified projects could result in significant adverse respiratory health effects in Kitimat. The assessment of the cumulative effects for SO_2 is based on a comparison of the predicted CRs between the base and cumulative effects cases, and a determination of the incremental increase in SO_2 levels that is predicted to occur between the base and application cases (Table 9.2-28). There is a less than 15% increase in the predicted CR values between the base and cumulative effects cases for the five human health focus areas and eight special receptor locations.

In addition to the direct comparison of predicted exposures to the human health-based 1-hour and 24-hour criteria, the assessment considers potential increases in respiratory events that could be expected to result from changes in the estimated 5-minute SO_2 concentrations between the base and cumulative effects cases. The assessment of changes in respiratory events for people with asthma and or COPD in the cumulative case is conducted as described for the application case (Section 9.2.5.2). The expected increase in the number of respiratory events ranges between less than 1.0 in Kitamaat Village and the service area to approximately 14 additional events in upper and lower Kitimat (Table 9.2-29). When compared with the number of events predicted to occur in these areas under base case conditions, these changes represent a less than 0.01% increase over base case (Table 9.2-29).

Based on these results, it is reasonable to conclude that changes in human health risk associated with changes in SO_2 exposures in the cumulative case, beyond what already exists under the base case, will be negligible. Effects that already exist are reversible should SO_2 emissions decline, either through the closure of industrial facilities or through the application of more stringent SO_2 emission regulations. Therefore, cumulative changes in human health resulting from changes in air quality associated with the residual effects from the Project and other activities incorporated in the cumulative effects assessment are assessed as not significant.

Table 9.2-26: Cumulative Effects Case – Maximum Predicted Concentrations for $PM_{2.5}$ and CO

Area	$PM_{2.5}$ Concentrations (µg/m³)						CO Concentrations (µg/m³)					
	BC AAQO (2013) 24-h	24-h Max	CR	BC AAQO (2013) Annual	Annual Max	CR	BC AAQO (2013) 1-h	1-h Max	CR	BC AAQO (2013) 8-h	8-h Max	CR
A1 - Kitamaat Village	25	8.72	0.35	8	0.286	0.036	14,300	250	0.017	5,500	1.11	0.00020
A2 - lower Kitimat		5.20	0.21		0.735	0.092		336	0.024		66.5	0.012
A3 - upper Kitimat		5.48	0.22		0.534	0.067		132	0.0092		43.0	0.0078
A4 - north Kitimat		3.29	0.13		0.385	0.048		47.9	0.0034		19.0	0.0035
A5 - service area		4.93	0.20		1.11	0.14		161	0.011		50.0	0.0091
15 - southeast residence		4.45	0.18		0.241	0.030		67.0	0.0047		36.9	0.0067
22 - Coste Island		1.58	0.063		0.102	0.013		34.7	0.0024		9.05	0.0017
23 - southwest dockyard		10.7	0.43		1.29	0.16		116	0.0081		36.6	0.0067
24 - Half Moon Bay		8.65	0.35		1.01	0.13		95.8	0.0067		41.0	0.0075
25 - Minette Bay1		4.18	0.17		0.215	0.027		116	0.0081		43.1	0.0078
26 - Minette Bay Lodge		4.48	0.18		0.248	0.031		103	0.0072		41.9	0.0076
28 - Kitimat Airport		3.95	0.16		0.490	0.061		56.2	0.0039		22.1	0.0040
29 - Kildala Beach		0.688	0.028		0.0311	0.0039		8.4	0.00059		4.06	0.00074

Table 9.2-27: Cumulative Effects Case – Maximum Predicted Concentrations for NO_2 and SO_2

Area	NO_2 Concentrations (µg/m³)						SO_2 Concentrations (µg/m³)									
	U.S. EPA NAAQS (2010)	1-h Max	CR	WHO AQG (2005)	Annual Max	CR	U.S. EPA NAAQS (2010)	1-h Max	CR	WHO AQG (2005)	24-hour Max	CR	AB AAQO (2013)	Annual Max	CR
A1 - Kitamaat Village	188	78.32	0.42	40	0.765	0.019	20	***737***	***3.7***	20	***85.6***	***4.3***	20	1.67	0.084
A2 - lower Kitimat		67.6	0.36		3.135	0.078		***721***	***3.6***		***57.8***	***2.9***		5.60	0.28
A3 - upper Kitimat		66.9	0.36		2.25	0.056		***679***	***3.4***		***59.2***	***3.0***		4.98	0.25
A4 - north Kitimat		35.3	0.19		1.275	0.032		184	0.92		***42.8***	***2.1***		3.68	0.18
A5 - service area		79.5	0.42		3.775	0.094		***475***	***2.4***		***52.7***	***2.6***		9.28	0.46
15 - southeast residence		48.6	0.26		0.917	0.023		193	1.0		***43.0***	***2.1***		1.40	0.070
22 - Coste Island		24.0	0.13		0.248	0.0062		66.8	0.33		10.9	0.55		0.536	0.027
23 - southwest dockyard		65.4	0.35		2.12	0.053		***404***	***2.0***		***69.6***	***3.5***		3.95	0.20
24 - Half Moon Bay		58.7	0.31		2.12	0.053		***471***	***2.4***		***53.0***	***2.7***		3.21	0.16
25 - Minette Bay1		44.1	0.23		0.579	0.014		***386***	***1.9***		***34.8***	***1.7***		1.54	0.077
26 - Minette Bay Lodge		44.6	0.24		0.971	0.024		***210***	***1.0***		***41.7***	***2.1***		1.49	0.074
28 - Kitimat Airport		37.8	0.20		1.34	0.033		184	0.92		***40.5***	***2.0***		5.45	0.27
29 - Kildala Beach		9.88	0.053		0.064	0.0016		20.8	0.10		4.32	0.22		0.170	0.0085

NOTE(S)

Bold Italics Value exceeds relevant guideline/benchmark

Table 9.2-28: Comparison of Concentration Ratios between Base and Cumulative Effects Cases

Area	24-hour Max SO_2 CR			1-hour Max SO_2 CR		
	Base 24-h Max CR	Cumulative 24-h Max CR	Percent Increase (%)	Base Case	Cumulative Case	Percent Increase (%)
A1 - Kitamaat Village	4.3	4.3	0.40	3.7	3.7	0.28
A2 - lower Kitimat	2.7	2.9	8.0	3.4	3.6	7.0
A3 - upper Kitimat	2.7	3.0	7.7	3.4	3.4	0.2
A4 - north Kitimat	2.0	2.1	5.8	0.91	0.92	1.4
A5 - service area	2.5	2.6	4.7	2.3	2.4	2.9
15 - southeast residence	2.0	2.1	6.8	1.3	1.4	8.4
22 - Coste Island	0.57	0.60	5.4	0.67	0.70	4.8
23 - southwest dockyard	3.4	3.5	3.4	2.0	2.0	2.8
24 - Half Moon Bay	2.5	2.6	4.1	2.2	2.4	4.8
25 - Minette Bay1	1.6	1.7	8.0	1.7	1.9	13
26 - Minette Bay Lodge	1.9	2.1	7.7	1.1	1.1	0.37
28 - Kitimat Airport	2.6	2.7	6.1	0.89	0.93	4.9
29 - Kildala Beach	0.20	0.22	10	0.15	0.15	1.8

Table 9.2-29: Predicted Increase in Respiratory Events between Base and Cumulative Cases.

Area		Base Case		Cumulative Case		Predicted Health Effect		
	# of Expected Events[a]	Increase in Predicted Respiratory Response Rate (%)	Expected # of Events	Increase in Predicted Respiratory Response Rate (%)	Expected # of Events	Increase in # Events between Base and Cumulative	# of Base Events[b]	Percent Increase in Events from Base to Cumulative
A1 - Kitamaat Village	1000	0.00038	0.38	0.00039	0.39	0.01	1000.38	0.00%
A2 - lower Kitimat	20050	0.00061	12.25	0.00066	13.17	0.916	20062.25	0.00%
A3 - upper Kitimat	27550	0.00046	12.67	0.00049	13.37	0.7	27562.67	0.00%
A4 - north Kitimat	1500	0.00046	0.7	0.00049	0.74	0.046	1500.7	0.00%
A5 - service Area	600	0.00095	0.57	0.00101	0.61	0.04	600.57	0.01%

NOTES:

[a] The number of expected events is based off the average number of respiratory response events expected per year for a person with COPD or asthma (50) multiplied by the percentage of people who have a respiratory illnesses (approx. 12% of the population of each area).

[b] The base number of expected respiratory events per year is a function of the expected number of respiratory events with the addition of baseline concentrations of SO_2. The probable response curve is used to derive the base response numbers for the baseline SO_2 concentrations.

9.2.8.4 Summary of Cumulative Effects

Changes in CAC concentrations in the Kitimat region that occur between the base and cumulative cases do not present potential human health concerns from human exposure to PM, CO, and NO_2. Cumulative effects from existing projects, including the expected increases from the RTA facility and modernization project, will cause an incremental increase in SO_2 concentrations from the base case to the cumulative case. The increase in potential respiratory events from the base case to the cumulative case is anticipated to be less than 0.01%. Therefore, changes in human health associated with changes in SO_2 exposures are low, and the effects will be reversible. Therefore, the Project's contribution to cumulative effects on human health resulting from changes in air quality is assessed as not significant (see Table 9.2-30).

9.2.9 Prediction Confidence and Risk

Confidence in predictions of project residual effects and cumulative effects on human health relies on the quality and quantity of baseline data, understanding of Project mechanisms, and assumptions made. Uncertainties associated with the environmental assessment of human health risks are addressed using conservative assumptions that err on the side of overestimating potential exposures and the associated health effects.

The quality and quantity of available scientific information on the air quality modelling predictions for the base, application, and cumulative effects assessment cases are sufficient to have a high level of confidence in predictions for both residual effects from the Project and cumulative effects from other projects and activities that can reasonably be expected to affect air quality in the Kitimat region.

The health-based criteria used in the assessment have been developed by regulatory agencies and are designed to be protective of sensitive members of the population, including children, the elderly, and people with existing respiratory conditions. In addition, the human health-based air quality criteria established by regulatory agencies incorporate a high degree of scientific scrutiny in their development. Therefore, there is a high degree of confidence that human health-based air quality criteria used in the assessment of residual effects provide conservative estimates (over predict) potential human health risks.

Table 9.2-30: Summary of Cumulative Effects on Human Health

Effect	Other Projects, Activities and Actions	Cumulative Effects Characterization					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context
Facility Works and Activities							
Cumulative Effect on Human Health from Changes in SO_2-Related Air Quality							
Cumulative effect with the Project and other projects, activities and actions • Predicted 1-hour maximum SO_2 concentrations exceed the 1-hour guideline in four of the five human health focus areas and four special receptor locations.	• Coastal GasLink Pipeline Project • Douglas Channel LNG Terminal (also known as BC LNG) • Enbridge Northern Gateway Project • Former Methanex/Cenovus Terminal • Kitimat Clean • Kitimat LNG Terminal Project • Pacific Northern Gas Pipeline (includes proposed looping) • Pacific Trail Pipelines Project • Rio Tinto Alcan Facility and Modernization Project	L	RSA	LT	MR	R	H
Contribution from the Project to the overall cumulative effect • The Project is anticipated to contribute to a less than 0.1% increase in SO_2 concentrations and less than a 0.01% increase in the rate of respiratory events between the base case and cumulative case.		N	LSA	LT	MR	R	H
Cumulative Effect on Human Health from Changes in Combined SO_2 and NO_2 Related Air Quality							
Cumulative effect with the Project and other projects, activities and actions • NO_2 concentrations do not exceed NO_2 health-based criteria in any of the five human health focus areas or at any of the eight special receptor locations outside the human health focus areas. The exceedances noted for the cumulative effects case are due to predicted base case SO_2 levels	• Coastal GasLink Pipeline Project • Douglas Channel LNG Terminal (also known as BC LNG) • Enbridge Northern Gateway Project • Former Methanex/Cenovus Terminal • Kitimat LNG Terminal Project • Pacific Northern Gas Pipeline (includes proposed looping) • Pacific Trail Pipelines Project • Rio Tinto Alcan Facility and Modernization Project	L	RSA	LT	MR	R	H
Contribution from the Project to the cumulative effect • The Project contribution to combined inhalation exposures to SO_2 and NO_2 is negligible.		L	LSA	LT	MR	R	H

KEY

MAGNITUDE:

N = Negligible—no detectable or measurable change from existing baseline conditions

L = Low—a measurable change from existing baseline conditions but is below environmental and/or regulatory thresholds and affect human health

M = Moderate—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds but does not affect human health

H = High—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds and represents a potential concern for human health.

GEOGRAPHIC EXTENT:

PF = Project footprint—residual effects are restricted to the Project footprint

LSA—effects extend into the LSA

RSA—effects extend into the RSA

DURATION:

ST = Short-term—effect restricted to construction phase

MT = Medium-term—effect extends through operations phase

LT = Long-term—effect extends beyond closure

P = Permanent—measurable parameter unlikely to recover to baseline

FREQUENCY:

S = Single event—occurs once

MI = Multiple irregular event—occurs sporadically at irregular intervals throughout construction, operation and/or decommissioning

MR = Multiple regular event—occurs on a regular basis and at regular intervals throughout construction, operation, or decommissioning phases

C = Continuous—occurs continuously throughout the life of the Project

REVERSIBILITY:

R = Reversible—potential human health risks will return to existing baseline levels after decommissioning

I = Irreversible—effect is permanent

CONTEXT:

L = Low resilience—low capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

M = Moderate resilience—moderate capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

H = High resilience—high capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

SIGNIFICANCE:

S = Significant

N = Not Significant

PREDICTION CONFIDENCE:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation, and assumptions made.

L = Low level of confidence

M = Moderate level of confidence

H = High level of confidence

LIKELIHOOD OF RESIDUAL EFFECT OCCURRING:

Based on professional judgment

L = Low likelihood that there will be a residual effect

M = Moderate likelihood that there will be a residual effect

H = High likelihood that there will be a residual effect

9.2.10 Follow-up Program and Compliance Monitoring

Project activities will not have a measurable or significant effect on human health. Although the maximum modelled SO_2 concentrations will exceed the human health-based air quality criteria for 1-hour and 24-hour exposures for the base case, these exceedances are rare, and SO_2 does not represent a potential concern for human health. The incremental increase in SO_2 concentrations that is attributed to the Project and activities of other projects in the area will not alter this overall conclusion. As a result, neither a follow-up program nor compliance monitoring is required for human health.

9.2.11 Summary of Mitigation Measures

The assessment of residual human health effects is based on CAC concentrations in air predicted by the air quality assessment (Section 5.2). The air quality assessment defines a number of mitigation measures to reduce the predicted CAC concentrations in air. These measures will therefore also mitigate residual human health effects. Mitigation measures specific to the protection of human health are not required and have not been incorporated in the assessment of residual effects associated with inhalation exposures to Project-related chemicals. A follow-up program and compliance monitoring are not required. Consequently, no commitments specific to human health are required.

9.2.12 Conclusion

Residual effects from the Project are assessed to be not significant. Project activities are likely to result in small changes in SO_2 concentrations in the Kitimat region. However, any change in human health beyond what already exists under the base case will be negligible. Further, these health effects will be reversible should SO_2 emissions for the cumulative industrial operations decline, either through the closure of facilities or through the application of more stringent SO_2 emission regulations. In addition, any changes in human health associated with combined SO_2 and NO_2 exposures, beyond what already exists under the base case, will be negligible. Therefore, the changes in human health resulting from Project-specific changes in air quality are assessed as not significant. The prediction confidence is considered high for all Project residual effects.

9.3 Summary of Potential Health Effects

9.3.1 Summary of Project Residual Health Effects

Project residual effects are not predicted to result in a change in human health as a result of changes in air quality related to SO_2 emissions or changes in air quality related to combined SO_2 and NO_2 emissions. Residual effects from the facility will be negligible, of long-term duration, limited to the LSA, and reversible. Table 9.3-1 summarizes Project residual effects on human health.

Table 9.3-1: Summary of Project Residual Effects on Human Health

Valued Component [1]	Potential Effects	Key Mitigation Measures[2]	Significance Analysis of Residual Effects
Human health (O)	Change in human health risk from degraded air quality	▪ No mitigation measures specific to human health are required.	Not significant. Project residual effects are not predicted to result in a change in human health as a result of changes in air quality related to SO_2 emissions or changes in air quality related to combined SO_2 and NO_2 emissions. Residual effects from the facility will be negligible, of long-term duration, limited to the LSA, and reversible and are assessed as not significant.

NOTES:
[1] Operation Phase = O
[2] See Section 20 for a full list of mitigation measures.

9.3.2 Summary of Cumulative Health Effects

Changes in CAC concentrations in the Kitimat region that occur between the base and cumulative cases do not present potential human health concerns from human exposure to PM, CO, and NO_2. Cumulative effects from existing projects, including the expected increases from the RTA facility and modernization project, will cause an incremental increase in SO_2 concentrations from the base case to the cumulative case. The increase in potential respiratory events from the base case to the cumulative case is anticipated to be less than 0.01%. Therefore, changes in human health associated with changes in SO_2 exposures are negligible, and the effects will be reversible. Therefore, the Project's contribution to cumulative effects on human health resulting from changes in air quality is assessed as not significant.