9 ACCIDENTS OR MALFUNCTIONS

The LNG industry has an exceptional safety record. This is partially attributable to the relatively low risk associated with the production, handling and transportation of LNG. Liquefied natural gas as a liquid is not flammable or explosive, and it is stored in non-pressurized conditions at sub-zero temperatures. The production of LNG for transport requires that impurities be removed. Therefore, LNG that is released into the environment will rapidly vaporize into natural gas, leaving no residue or contamination to the surrounding land, water or biota. When LNG vapourizes into natural gas (i.e., methane), the gas has a narrow flammable range of 5% to 15% by volume in air. However, natural gas has a lower density than air and rapidly dissipates in the air to concentrations that are below the lower flammable limit. Nonetheless, there is potential for accidents or malfunctions to occur during the course of Project activities.

This section evaluates the potential effects of a Project-related accident (unexpected occurrence or unintended action) or malfunction as required in Section 19(1) (a) of the CEAA 2012 (Government of Canada 2012). An accident is defined as an unexpected occurrence or unintended action that can result in an adverse environmental, social, economic, heritage or human health effect. A malfunction is defined as the failure of a piece of equipment, a device, or a system to function normally that can result in an adverse environmental or human health effect. Potential causes of accidents or malfunctions include human error, abnormal operating conditions, aging equipment, acts of nature, and extreme weather events. Many accidents or malfunctions can be addressed or avoided by proper training, planning, design, equipment selection and maintenance, risk assessment, corrective actions, emergency response planning, emergency preparedness, and mitigation. Aurora LNG's Environmental Management Plan (EMP) and the Emergency Response Plan (ERP) (see Section 14.0) will include potential accident or malfunction scenarios that apply to the operations phase of the proposed Project. In the event of an accident or malfunction that requires the implementation of the ERP, notification of the event will be provided to residents, landowners, members of the public, local municipalities, regulators, and Aboriginal Groups.

Effects of the environment on the Project (e.g., severe weather, seismic events, climate change) are addressed in Effects of the Environment on the Proposed Project (see Section 10.0). The potential environmental effects and their significance resulting from the accident or malfunction scenarios identified in the Application Information Requirements (AIR) are addressed in this section.

9.1 Nexen's Safety First Culture

Nexen's Safety First culture emphasizes safety and environmental responsibility. Safety is a core value at Nexen, and it is integrated into the planning, design, construction, operations and emergency response capabilities for the Project. Safety leadership involves building a strong Safety First culture among Nexen's employees through workshops intended to enhance their understanding of their roles and accountability as safety leaders in the organization. Process safety management is integrated into the design and operations of the facility to reduce the potential risk to people, the environment and to Project facilities and associated corporate assets. The ultimate goal is to reduce the potential for an accident or malfunction through the implementation of preventative safeguards and mitigation measures so that the risks are as low as reasonably practical.

Nexen will initiate a proactive response when early signs indicate a potential emergency condition may be developing. Nexen's Health Safety and Environment (HSE) Emergency Response Plan philosophy is to initiate an early and rapid response to a safety issue and to scale down resources and response efforts as needed, rather than attempting to scale up response efforts when faced with an actively changing, deteriorating or misunderstood situation.

Nexen's North American Gas and Tight Oil emergency management plan defines the framework and the tools that will facilitate the ability of Nexen to respond to emergency incidents in order to protect human life and mitigate adverse effects to the environment.

In the event of an accident or malfunction scenario, Nexen will give prompt and appropriate notification of an emergency condition to government agencies, local Aboriginal Groups, area residents, stakeholders and authorities. Nexen will maintain lines of communication that provides accurate, consistent and timely information to employees, regulators, local Aboriginal Groups, governments, local stakeholders, the general public and the mass media.

Nexen's Corporate HSE Management System is not designed to assess cumulative risk to the environment. The HSE Management System describes how to use the Nexen Risk Matrix to consistently identify the associated risk of a given activity or process qualitatively. The Nexen Risk Matrix assesses the HSE risk of single scenarios qualitatively such that appropriate levels of controls can be identified to manage the risk to tolerable levels.

The risk matrix applied in this document characterizes the residual effects to the environment as they pertain to each Valued Component (VC). The methods used to define likelihood, consequence and risk are summarized below.

9.2 Methods

Accident or malfunction scenarios were identified based on experience with similar projects, input from regulators and the Working Group, and professional judgment. This assessment considers the following accident or malfunction scenarios, consistent with the scenarios described in the AIR:

- Motor vehicle collision
- Facility impact from aircraft
- On-shore fires or explosions
- LNG Plant malfunctions (emergency LNG facility shutdown including emergency flaring)
- On-shore hazardous spills
  - Stationary and mobile equipment (fuelling, fluid leaks)
  - On-shore hazardous material storage (fuels, waste, reagents)
  - On-shore releases of LNG (loss of containment of LNG or other hydrocarbons in the plant process area or storage tanks)
  - Process water and surface/storm water containment areas.
- Vessel grounding or collision

- Releases from LNG carriers (cryogenic releases at loading facility)
- Outflow of non-pressurized LNG (above and below waterline)
  - Liquid pool formation resulting in a pool fire.

The AIR lists fires, explosions and hazardous spills as "onsite" scenarios within the Project development area (PDA). For clarification, this chapter describes fire, explosion and hazardous spill events as originating "on-shore" with the potential to spread off-shore within the PDA.

The AIR also listed power generation malfunction as a scenario requiring consideration. Power generation is the most likely cause of an LNG plant malfunction and therefore is being assessed as part of this scenario.

Hypothetical events or interactions were identified for each scenario and were selected if they were recognized as a likely accident and had a potential consequence of concern.

The method used for the assessment of accidents or malfunctions consists of the following:

- **Description of event or interaction** – Characterization of the accident or malfunction scenarios that were identified as likely with a potential consequence of concern, including secondary events that could occur following the initial accident or malfunction.
- **Preventative and response measures** - Identification of the proposed Project design, preventative, mitigation and emergency response measures that will be implemented to manage or mitigate the likelihood of the event and resulting environmental effects.
- **Potential residual effects -** Identification of potential interactions between the potential event and the Project VCs. Interactions between a potential accident and malfunction event and a Project VC are carried forward in the assessment.
- **Characterization of the potential effects** - Description of the potential effects, including a consideration of environmental effects as they are identified in Section 5 of CEAA 2012 (Government of Canada 2012), the probability of an accident or malfunction occurring, the mitigation measures to reduce the potential effect, and the likelihood and consequence that may result should mitigation measures and contingency plans not be fully effective.
- **Residual Effects Conclusions** - Determination of the potential risk, including a significance determination as required in Section 19(1)(a) and (b) of CEAA 2012 (Government of Canada 2012), in the context of the overall likelihood and consequence of the event and with reference to significance thresholds for individual VCs.
- **Potential cumulative effects -** Identification of Project accidents or malfunctions that are likely to result from the designed Project in combination with other physical activities that have been or will be carried out within the assessment area as required in Section 19 (1)(a) of CEAA 2012 and consistent with CEAA's Operational Policy Statement titled "Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012" (Government of Canada 2012).

9.2.1 Definition of Likelihood and Consequence

The likelihood of events is discussed quantitatively where data are available (e.g., historic statistics); otherwise, a qualitative approach is taken based on professional judgment. The categories of likelihood and consequence used to determine risk and to describe each event are defined as:

- **Likelihood (post-mitigation**)—the likelihood of a residual effect to the VC after mitigation measures and response measures have been applied following an accident or malfunction event:
  - Very low
  - Low
  - Medium
  - High
  - Very high.
- **Consequence (post-mitigation)**—measure of the severity or magnitude of the residual effect to the VC after mitigation measures and response measures have been applied generally following an accident or malfunction event:
  - Very low (negligible to low magnitude, localized, generally short-term)
  - Low (negligible to low magnitude, localized, generally short-term)
  - Moderate (low to moderate magnitude, localized, generally short-term to long-term)
  - High (moderate to high magnitude, local or regional, generally short-term or long-term)
  - Very high (high magnitude, local or regional, generally short-term to long-term or permanent).

The assessment of accidents or malfunctions applies the same spatial boundaries, measurable parameters for environmental effects, residual effects characterization criteria and thresholds for residual effect significance as those used in the description of Project effects to each VC as described in Sections 4.0 through 8.0.

9.2.2 Risk Matrix

The assessment of the potential risk of effects resulting from accidents or malfunctions includes the use of a risk matrix, where the combination of likelihood (post-mitigation) and consequence (post-mitigation) identifies the level of potential risk (see Table 9.2-1). Risk levels (post-mitigation) are colour-coded to provide a visual means of expressing risk as:

- Remote (green colour shows risk is acceptable; no additional risk mitigation required)
- Low (yellow colour shows risk is tolerable; continue to monitor risk; no additional risk mitigation required)
- Moderate (orange colour shows risk may be tolerable; more detailed review required; if warranted, additional risk mitigation may be required)
- High (light red colour shows risk is unacceptable; additional risk mitigation needs to be applied)
- Very High (dark red colour shows risk is imminent; additional risk mitigation needs to be applied; long-term risk reduction plan needs to be developed and implemented).

Table 9.2-1 Risk Matrix

Consequence	Likelihood (post-mitigation)				
Severity	**Very Low**	**Low**	**Moderate**	**High**	**Very High**
Very High	Low	Moderate	High	Very High	Very High
High	Low	Moderate	Moderate	High	Very High
Moderate	Remote	Low	Moderate	Moderate	High
Low	Remote	Low	Low	Moderate	Moderate
Very Low	Remote	Remote	Remote	Low	Low

9.2.3 Significance Determination

As noted in Section 3.6.6, threshold criteria were developed for each potential effect, beyond which a residual effect would be assessed as significant. The thresholds present the limits of an acceptable change in a measurable parameter or state of the VC or CEAA 5(1)(c), based on resource management objectives, community standards, scientific literature or ecological processes (e.g., desired states for fish or wildlife habitats or populations). Residual effects significance thresholds have been developed for each VC (see Sections 4.0 through 8.0) and have been used to determine the significance of residual effects resulting from key accident or malfunction events.

9.3 Identification of Potential Interactions with VCs

For each accidents or malfunctions scenario, consideration was given to whether the scenario could have an interaction of concern with each VC. Potential interactions between each accident and malfunction event and the VCs are indicated in Table 9.3-1. A check mark indicates that an interaction of concern could occur. Subsequent sections discuss the associated probability of the event occurring and the likelihood and consequence of post-mitigation residual effects following such an event.

During certain accident or malfunction scenarios, events may occur which could influence a VC in principle, but do not constitute an interaction of concern (i.e., there are no residual effects to the VC). For example, scenarios such as a motor vehicle collision, facility impact from an aircraft or on-shore fires or explosions will produce audible noise. However, the types of noise associated with these scenarios (e.g., a single isolated noise event and short-term or instantaneous in duration) is not expected to influence the acoustic environment in a manner considered to be an interaction of concern, since the acoustic environment VC is assessed based on measurable parameters such as long-term daytime and nighttime sound levels and the percent of highly annoyed individuals resulting from the noise.

Similarly with the visual quality VC, accident or malfunction scenarios such as a facility impact from an aircraft, on-shore fires or explosions, or LNG plant malfunctions may have visible effects. Visible effects may include fires, smoke or a natural gas vapour cloud, but these visual effects would be single isolated events of short-term duration and have limited visual prominence. Therefore, these influencing factors do not constitute an interaction of concern.

Table 9.3-1 Potential Interactions of Project Accident or Malfunction Events with VCs

Accident or Malfunction Event	Air Quality	Greenhouse Gases	Acoustic Environment	Water Quality	Vegetation and Wetland Resources	Wildlife Resources (Terrestrial)	Freshwater Fish and Fish Habitat	Marine Fish and Fish Habitat	Marine Mammals	Marine Birds	Economic Environment	Visual Quality	Infrastructure and Services	Land and Resource Use	Marine Use and Navigable Waters	Community Health	Archaeological and Heritage Resources	Human Health
Motor vehicle collision	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Facility impact from aircraft	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	✓	-	-
On-shore fires or explosions	✓	✓	-	-	✓	✓	✓	-	-	✓	✓	-	✓	✓	✓	✓	✓	✓
LNG plant malfunctions (includes power generation malfunction)	✓	✓	-	-	-	✓	-	-	-	✓	-	-	✓	-	-	-	-	✓
On-shore hazardous spills	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓	-	-	✓	✓
Vessel grounding or collision	✓	✓	-	✓	-	-	-	✓	✓	✓	-	-	✓	-	✓	✓	-	✓
Releases from LNG carriers (while loading)	✓	✓	-	✓	-	-	-	✓	✓	✓	-	-	-	-	✓	✓	-	✓

NOTES:

A check mark ("✓") indicates a potential interaction of concern between a potential accident or malfunction effect and a specific VC may occur, and is moved forward into the assessment.

- Not applicable

9.4 Motor Vehicle Collisions

9.4.1 Description of Event or Interactions

Motor vehicle collisions include single and multiple vehicle accidents along the roadways in the PDA. Motor vehicles within the PDA will be used primarily during the construction phase, with a reduced fleet during the operations phase. Motor vehicle collisions are more probable during periods of low visibility (e.g., nighttime hours or foggy conditions) and may result in injury to vehicle occupants and wildlife or cause damage to property and infrastructure.

Aurora LNG is committed to the development of the Transportation Management Plan to include procedures that will mitigate the potential for serious injuries or fatalities to motor vehicle occupants and wildlife in the event of a collision. These procedures include the management of Project-related traffic during all phases of the Project, reducing the number of motor vehicles on the road by carpooling or using multi-passenger vehicles (e.g., bus) to transport workers, and complying with applicable traffic, road-use, and safety laws. Workers will be expected to follow the applicable road safety procedures as described in the Transportation Management Plan, while contractors will be required to specify, implement and check the required safety measures while working on the Project.

The potential for serious injuries or fatalities will be further mitigated by the application of a maximum speed limit of 30 kilometers per hour (km/hr) for motor vehicles travelling in the PDA. At speeds of 30 km/hr or less, the probability of a motor vehicle collision declines substantially compared to the standard speed limits applicable to urban and rural roads in British Columbia. Aurora LNG will have the resource capacity (e.g., medical services, tow truck, fire and clean-up crews) to address most low-speed motor vehicle collisions within the PDA. The use of external resources such as hospitals, emergency medical helicopters, or fire and cleanup crews is not anticipated.

Based on these factors, there are no interactions associated with any VCs from motor vehicle collisions within the PDA. Accident scenarios involving motor vehicles and pedestrian workers at the site (e.g., an accident while backing up a motor vehicle) falls within occupational health and safety guidelines under the jurisdiction of WorkSafe BC and are not included in this scenario.

9.4.2 Conclusions

There are no interactions between motor vehicle collisions within the PDA with any VCs. The application of the Transportation Management Plan will mitigate the probability of motor vehicle collisions through the management of all Project-related traffic in the PDA and through the reduction of motor vehicles on the road. A maximum speed limit of 30 km/hr will apply to all motor vehicles operating in the PDA, which will mitigate the potential for serious injury to vehicle occupants and wildlife, and the potential for serious damage to property and infrastructure. Aurora LNG will have the resource capacity to address the types of injury to vehicle occupants and wildlife associated with low-speed motor vehicle collisions. The use of external resources to address motor vehicle collisions within the PDA is not anticipated, resulting in no interactions with any VCs.

9.5 Facility Impact from Aircraft

9.5.1 Description of Event or Interactions

There is a potential for an aircraft to directly impact the LNG facility considering that the Project is located within an existing aerodrome, namely the Prince Rupert airport on Digby Island. The types of aircrafts that could be involved in a direct impact to the LNG facility includes airplanes, float planes and helicopters from Project-related, commercial, private and personal/recreational applications.

Aviation safety data are tracked, investigated and documented by the Transportation Safety Board of Canada to analyze safety deficiencies and identify safety risks in the Canadian transportation system. From 2005 to 2014, the number of aircraft accidents per year ranged from 30 to 70 in British Columbia (BC) (TSBC 2014). In 2014, 12% (30) of Canadian-registered aircraft accidents occurred in BC, two of which resulted in a total of three fatalities. That compares with a ten-year annual average of 51 accidents and 17 fatalities. This decreasing trend is attributed to an increase in professionalism (particularly in small and mid-sized commercial operations), high fuel prices resulting in less flying by private enthusiasts, and implementation of safety management systems for larger management systems for larger operations.

Although the probability of facility impact from aircraft is very low, there is potential interaction with the Infrastructure and Services, and Community Health VCs (see Table 9.3-1). The potential consequences of concern from an aircraft directly impacting the LNG facility includes serious injury to people, loss of human life and damage to property and infrastructure. Events that could occur subsequent to an aircraft directly impacting the LNG facility include on-shore fires or explosions, which are assessed in Section 9.6; and on-shore hazardous spills, which are assessed in Section 9.8.

9.5.2 Preventative and Response Measures

Preventative measures to reduce the probability of an aircraft from directly impacting the LNG facility include the compliance with applicable safety laws and the application of Project design standards developed in collaboration with Canadian aviation regulators to reduce the potential for Project aviation activities from overlapping with the southern approach / take-off vector for the Prince Rupert Airport.

Examples of Project design standards considered in the context of commercial aviation safety at the Prince Rupert airport include design parameters to reduce the geographical extent and vertical velocity of gas plumes from the Project. Gas plumes could influence air turbulence along the southern take-off and landing approach and increase the probability of loss of aircraft control if left unmitigated. Examples of other considerations include physical zoning areas that limiting obstacles around protected airspaces along the southern take-off and landing approach, electronic zoning areas to protect the integrity of the electronics systems at the airport from interference and the application of additional airspace and flight procedures specific to the conditions applicable to the Project.

For aircraft such as helicopters associated with Project activities, Aurora LNG prescreens potential helicopter service providers to assess the rigor and adequacy of their management systems. Helicopter service providers must meet or exceed the applicable requirements to qualify for contract opportunities. Helicopters used for the Project will be regularly inspected and flown by experienced pilots.

Project aircraft traffic information will be provided to applicable municipal and provincial authorities prior to the start of construction activities. In particular, close collaborative planning will take place with the Prince Rupert airport authority. Aurora LNG will also notify potentially affected members of the public regarding Project initiation, and the location and schedule of Project activities requiring use of airspace.

In the unlikely event of an aircraft collision with the facility, Aurora LNG will implement the ERP (see Section 14.0). This includes contacting appropriate authorities and engaging emergency medical services.

Aurora LNG will use the Incident Command System (ICS) to develop and deploy emergency response plans. ICS is widely recognized for emergency response by industry, government, and emergency service agencies to provide the decision-making framework and action plans to respond and manage sudden emergencies and incidents. Training and emergency response exercises are conducted on a continual basis for Project personnel to remain cognizant of their training and skills and maintain an awareness of their roles and responsibilities

9.5.3 Potential Residual Effects

The potential residual effects to each VC from interactions with a facility impact from an aircraft are:

- **Infrastructure and Services**—Transportation may be temporarily limited or rerouted due to an aircraft collision. An aircraft collision with the facility would likely result in the implementation of the ERP and the use of emergency response services. This may result in a large-scale response that is likely within the operational capacity of local and regional emergency response services, including airport response services. The magnitude of residual effects to infrastructure and services would be moderate and within the geographical extent of the local assessment area (LAA). The frequency would be a single event of medium-term duration during the operations phase and reversible. The context of residual effects is resilient (moderate) because infrastructure and services can accommodate moderate levels of increased demand.

  After mitigation and response measures have been implemented following an aircraft collision with the facility, the likelihood of residual effects to infrastructure and services would be low, with a moderate consequence. Based on these factors, the risk characterization for residual effects to infrastructure and services is low. Potential residual effects on infrastructure and services are predicted to be not significant.

- **Community Health** – Injury or mortality to people from an aircraft collision is expected to have residual effects to community health in those communities in which aircraft passengers and crew and their families live. Counselling and trauma support services may be required depending on the severity of the event.

  In general, the severity of an aircraft collision to the facility and resulting injuries will determine the risk and significance of residual effects to community health. If the severity of the aircraft collision with the facility and resulting injuries are minor, the magnitude of residual effects would be low and within the geographical extent of the LAA. The residual effects would be characterized as a continuous effect with a medium-term duration that is irreversible. The context of residual effects to community health is resilient (moderate) because community health is moderate and slightly vulnerable to social, economic and environmental change.

If a facility impact from an aircraft resulted in the loss of human life, the magnitude of residual effects to community health would be high and within the geographical extent of the LAA. The residual effects would be characterized as a continuous effect that is irreversible with a long-term duration potentially lasting through the life of the Project. The context of residual effects to community health is resilient (moderate) because community health is moderate and slightly vulnerable to social, economic and environmental change.

The likelihood and consequence of residual effects to community health from a facility impact from an aircraft without the loss of human life are low. In this scenario, the risk matrix ranking would be low and the potential residual effects to community health are predicted to be not significant.

The likelihood and consequence to community health from a facility impact from an aircraft resulting in the loss of human life are very high. In this scenario, the risk matrix ranking would be very high and the potential residual effects to community health would be significant.

9.5.4 Conclusions

With the implementation of best practices, regulatory requirements and company standards, an accident or malfunction scenario involving a facility impact from an aircraft may have significant residual effects to community health if the event results in a loss of human life. Aurora LNG is committed to working collaboratively with the Canadian aviation regulators to reduce the potential for Project activities from overlapping with the southern approach / take-off vector for the Prince Rupert Airport.

The residual effects to other VCs that have the potential for interaction with facility impacts from an aircraft (i.e., infrastructure and services) are not significant. A summary of the residual effects and significance from a facility impact from an aircraft explosions is in Table 9.5-1.

Table 9.5-1 Summary of Residual Effects – Facility Impact from Aircraft

Valued Component	Residual Effects Characterization						Likelihood	Consequence	Risk Matrix Ranking	Significance
	Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Context				
Infrastructure and Services	M	LAA	S	MT	R	R	Low	Moderate	Low	Not significant
Community Health	L[1] H[2]	LAA	C	MT[1] LT[2]	I	R	Low[1] Very High[2]	Low[1] Very High[2]	Low[1] Very High[2]	Not significant[1] Significant[2]

NOTES

[1] Characterization for facility impacts from aircraft without loss of human life.

[2] Characterization for facility impacts from aircraft with the loss of human life.

KEY

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PDA: Project development area
LAA: Local assessment area
RAA: Regional assessment area
G: Global

Frequency:
S: Single event
MI: Multiple irregular events
MR: Multiple regular events
C: Continuous

Duration:
ST: Short-term
MT: Medium-term
LT: Long-term
P: Permanent

Reversibility:
R: Reversible
I: Irreversible

Context:
D: Disturbed
U: Undisturbed
R: Resilient
N: Not resilient

9.6 On-shore Fires or Explosions

9.6.1 Description of Event or Interactions

The LNG facility will have large volumes of flammable liquids and gases stored onsite during the operations phase of the Project. Flammable liquids stored onsite may include fuels for vehicles and emergency generators (e.g., gasoline and diesel), refrigerants and compressed hydrocarbon gases (e.g., propane), and LNG. Fires or explosions may occur if these liquids or their vapours are ignited, or if a leak of natural gas upstream of the liquefaction process is ignited. A credible scenario with a potential consequence of concern would be a fire or explosion from the ignition of an uncontrolled release of flammable liquids, vapours or natural gas. The scenario includes potential releases of flammable material associated with the scenario of a facility impact from an aircraft (see Section 9.5). Flammable liquids and gases may also be used or stored in areas that extend beyond the LNG facility, and the possibility of a fire or explosion extends to these areas. A fire involving gasoline or diesel would generally be limited to the area of the fuel spill. Gasoline or diesel fires could lead to an explosion if the fire occurs at a fuel storage tank. Hydrocarbon liquid fires involving propane could lead to an explosion if the scenario involves a fuel storage tank. The probability of a fire or explosion is very low.

LNG is produced and handled under low pressure conditions at sub-zero temperatures and it is not flammable in liquid form when directly exposed to an ignition source. Natural gas, which is present onsite before liquefaction and potentially generated from spilled LNG transitioning to a gas phase, has a narrow flammable range as a vapour (5 to 15% by volume in air). Natural gas is lighter than air and rapidly dissipates in the air to concentrations that are below the lower flammable limit. If a natural gas plume were to ignite, the resulting fire would scale back quickly to the point of release and continue to burn until either the source is cut off or the fire is extinguished. In general, released LNG will not result in potentially explosive conditions unless the release is in a confined space, which would allow concentrations of natural gas to increase to the flammable range. A release of LNG in a confined space could also result in vapourization to natural gas that could increase the concentration rapidly beyond the flammable range, displacing oxygen which is required for ignition.

Although it is unlikely that a fire would extend beyond the boundaries of the PDA, the event used for this assessment is an accidental ignition of any flammable substance (e.g., natural gas, engine fuel, or natural fuel sources such as vegetation or slash piles) with the potential to spread beyond the PDA but remaining on Digby Island.

The LNG industry applies a broad set of stringent regulations, standards and codes that are continuously updated to reflect industry design improvements and to maintain its high safety record. In particular, Canadian Standards Association code Z276-15 and associated codes of practice apply to a broad range of safety and performance design criteria in Canada including required setbacks from occupied areas. Associated design technologies and controls are applied to reduce potential hazards during operations of an LNG facility.

Although the probability of an on-shore fire or explosion (including during loading and unloading at the terminal) is very low, should one occur there is potential interaction with the following VCs: Air Quality, Greenhouse Gases (GHGs), Vegetation and Wetland Resources, Wildlife Resources (Terrestrial), Freshwater Fish and Fish Habitat, Marine Birds, Economic Environment, Infrastructure and Services, Land and Resource Use, Marine Use and Navigable Waters, Community Health, Archaeological and Heritage Resources, and Human Health VCs (see Table 9.3-1).

9.6.2 Preventative and Response Measures

To mitigate the effects of an on-shore fire or an explosion, the Project will be designed to prevent, control and suppress LNG, natural gas and hydrocarbon releases. According to Aurora LNG's corporate safety philosophy, the siting and design of the LNG facility is intended to mitigate the potential effect from fires and explosions when selecting the relative placement of fuel storage facilities, critical infrastructure and buildings where workers are commonly located. The LNG plant will meet stringent regulations, standards and codes and implement controlled ignition, gas leak detection, fire control and fire suppression technologies. Aurora LNG will perform fire and explosion analyses as per company requirements and produce a quantitative risk analysis for the facility. The Project will comply with the Canadian Standards Association Z276-15 code, as per the LNG Facility Regulation, which describes a number of specific requirements including emergency shutdown systems, fire and leak control, fire protection systems, emergency equipment, security and personnel safety codes specific to the LNG production, storage and handling industry.The Canadian Standards Association code Z276-15 requires the Project to achieve prescribed setbacks from occupied areas to protect the public based on modelled heat transfer from a Project-induced fire and dispersion of an unignited vapor cloud. As per Section 5.2.3.3, the distance

between the LNG tank impounding area and the nearest property line will be established such that, in the event of a design spill, the average concentration of methane in the air would be less than half the lower flammability limit at the property line. Distance will be defined based on vapour dispersion modelling that accounts for LNG vapour dispersion, heat transfer, wind speed, and other physical parameters. Calculated distances will be validated by experimental test data, and will account for design mitigations. As per Section 5.2.5.3, integral heated vaporizers will be located at least 30 m from a property line that can be built upon and at least 15 m from other structures such as flammable liquids and refrigerants, any impounded LNG and control buildings. As per Section 5.2.6.1, process equipment containing LNG, refrigerants, flammable liquids and gasses shall be located at least 15 m from ignition sources, property lines that can be built upon and other structures occupied structures.

Project personnel will complete fire prevention and management training and have equipment readily available for risk related activities. Emergency response equipment will meet applicable codes and standards designed to respond to fires or explosions. All emergency response equipment will be located at pre-determined, strategic locations in the process, storage and loading areas to provide access to necessary equipment in the potential event of a fire or explosions. All personnel will monitor the area for potential fire hazards including maintaining the PDA to avoid the accumulation of flammable materials. Smoking will be prohibited in the operating areas and near flammable storage areas.

The EMP (see Section 14.0) will include measures to reduce the likelihood and consequence of fires, including waste management practices, equipment inspection, maintenance programs, and emergency response planning. Aurora LNG will use the ICS to develop and deploy emergency response plans including coordination and joint planning exercises with other local responders.

9.6.3 Potential Residual Effects

The potential residual effects to each VC from interactions with on-shore fires or explosions are:

- **Air Quality**— A fire will release gas and particulate matter that would affect air quality. The effects would be low in magnitude and localized within the LAA. The effects to air quality would be a single event of short-term duration and the effects would be reversible within days after the fire has been extinguished. The context is characterized as disturbed because air quality is already influenced by other emission sources in the area.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, the likelihood of residual effects to air quality is low, while the consequence is very low. Based on these factors, the risk matrix ranking is remote. The potential residual effects to air quality are predicted to be not significant.

- **GHGs**— GHG emissions resulting from a fire or an explosion would contribute to the levels in the atmosphere. The magnitude of the volume released would be negligible in the context of the overall provincial and national GHG emissions totals, and the geographical extent of effects are global. The effects to GHGs would be a single event of short-term duration, and the contribution of GHGs to the atmosphere is irreversible. The context is characterized as disturbed because there are other sources of GHGs in the area. The emissions would disperse and the environmental effect would not substantially change local or regional GHG inventories.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, the likelihood of residual effects to GHGs is low, while the consequence is very low. Based

on these factors, the risk matrix ranking for GHGs is remote. Residual effects on GHG inventories are predicted to be not significant.

- **Vegetation and Wetland Resources**— Fires have the potential to cause harm or loss of vegetation and wetland functions in the area directly affected by an on-shore fire or explosion. Fires that consume understory vegetation could result in delays before the vegetation community can regenerate. Herbaceous and shrub-dominated vegetation communities could feasibly recover within 10 years. While mature or old forest communities could eventually recover, their full recovery would require 100-250 years to develop (longer than the operational timeframe of the proposed Project). The magnitude of effect is moderate, while the spatial extent of vegetation loss would occur primarily within the PDA and could extend into the LAA if flammable liquids or gases migrate beyond the PDA. Given the high average annual rainfall in the region, the environmental conditions are not conducive to widespread forest fires. Therefore, fires would be largely sustained by the availability of hydrocarbon fuels (e.g., LNG, natural gas, gasoline, diesel or propane) at the location of the leak or spill, and not sustained by the availability of vegetation. The effects to vegetation and wetland resources would be a single event, and could be long-term based on the type of vegetation or wetland resource affected, but reversible. The context is described as resilient because there is capacity for vegetation and wetland resources to recover from perturbations caused by a fire or explosion.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, there is a medium likelihood of residual effects to vegetation and wetland, while the consequence is high. Based on these factors, the risk matrix ranking for residual effects to vegetation and wetland resources is moderate. In the case of a small-scale fire limited to the PDA, residual effects on vegetation and wetlands are predicted to be not significant. Large-scale fires or explosions affecting unique or sensitive habitats and vegetation communities could cause significant residual effects on vegetation and wetlands.

- **Wildlife Resources (Terrestrial)**—Fires have the potential to cause loss or alteration of wildlife habitat. A small or large-scale fire at the facility would modify foraging, breeding, nesting, rearing, or staging habitat. There is also potential for direct mortality of individuals that are unable to leave the area (i.e., have limited dispersal ability, have limited mobility, or are of a life stage that inhibits movements). The magnitude of effect is moderate although the viability of the local or regional population of wildlife resources will not be affected. Effects are localized to the PDA and potentially extend into the LAA. Fires or explosions would be sustained by the availability of hydrocarbon fuels at the location of the leak or spill and these fuels could migrate into the LAA. Effects to wildlife resources would be a single event, and could be long-term up to 10 years, but reversible. The context is described as resilient because terrestrial wildlife species or species groups are able to tolerate change from existing conditions, and the viability of the population is not expected to be affected.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, there is a medium likelihood of residual effects to terrestrial wildlife resources, while the consequence is high for habitats most likely to support wildlife species at risk (e.g., old growth forest). Based on these factors, the risk matrix ranking is moderate. In the case of a small-scale fires limited to the PDA, residual effects on wildlife resources are predicted to be not significant. A large-scale fires or explosions affecting habitats that support species at risk has potential to result in significant residual effects on wildlife resources.

- **Freshwater Fish and Fish Habitat**—Damage to riparian habitat by an on-shore fire or explosion could cause effects to freshwater fish habitat through loss of timber for shading, increases in water temperature due to loss of shading, reduction of litterfall and nutrient input to streams, and reduced bank stability if the fire is intense in riparian forest. The magnitude of potential effects would be low and localized within the PDA and possibly into the LAA if hydrocarbon fuels migrate beyond the PDA during a fire or explosion. Effects to freshwater fish and fish habitat would be a single event, and could be short-term up to one month, and reversible. The context for changes in fish habitat is disturbed because the area would have been previously disturbed by human development, namely the Project. The context for changes in fish mortality or health, and change in fish abundance or relative abundance is resilient because the VC is able to assimilate the additional change.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, the likelihood and consequence of residual effects to freshwater fish and fish habitat is low. Based on these factors, the risk matrix ranking is low. Residual effects on freshwater fish and fish habitat are predicted to be not significant.

- **Marine Birds**—Marine bird species associated with shoreline or intertidal habitats (e.g., shorebirds, waders, or dabbling ducks) may experience direct habitat loss associated with a fire and explosion at the LNG plant. Given the localized nature of this event that will be largely within the PDA and possibly the LAA, the magnitude of potential effect to marine birds is low. The effect to marine birds would be a single event that is short-term and reversible within one month. The context for changes to marine birds is resilient, because marine bird species or species groups are able to tolerate changes relative to existing conditions and the viability of the population is not expected to be affected.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, the likelihood and consequence of residual effects to marine birds are low. Based on these factors, the risk matrix ranking is low. Residual effects on marine birds from an on-shore fire or explosion are predicted to be not significant.

- **Economic Environment**—An on-shore fire or explosion at the LNG facility or off-site would require an investigation that could affect the economic environment. In the case where Project operations are temporarily suspended economic losses would have a low magnitude of adverse effects on both local and regional economies within the regional assessment area (RAA) by affecting wages, government revenues and, depending on the length of suspended operations, regional and provincial gross domestic product. In addition, increased economic costs to non-Project related activities (e.g., any disruption of services to the Digby Island airport) could have an adverse effect on local businesses, residents of Dodge Cove and persons accessing services. Localized spending within Prince Rupert and nearby communities could have a short-term beneficial effect on select businesses supplying goods and services in support of the emergency responses including maintenance and overhaul. The residual effect to the economic environment would be a single event with a short-term duration that is reversible within one month or less. The context for residual effects to the economic environment is resilient because the local and regional economy is diverse and dynamic, and able to accommodate an economic shock.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, the likelihood and consequence of residual effects to the economic environment is low. Based on these factors, the risk matrix ranking is low. Residual effects on the economic environment predicted to be not significant.

- **Infrastructure and Services**— In the event of an on-shore fire or explosion, Aurora LNG's emergency response services would constitute the primary response team. Municipal and regional emergency services from Prince Rupert (e.g., police and fire department) are not expected to respond to an on-shore fire or explosion because the area falls outside of the municipal jurisdiction. If requested by Aurora LNG, municipal and regional emergency response services may offer assistance, however, these services would be required to travel to Digby Island by ferry, which has a limited capacity to accommodate emergency service vehicles. Consequently, a scenario involving an on-shore fire or explosion has limited interactions with local and regional infrastructure and services. For smaller scale fires or explosion, Aurora LNG will use its resources and implement the ERP with limited external aid. However, in the event of a large fire or explosion, limited additional external aid may be requested which may include emergency medical helicopters for hospital transportation. In the event of an on-shore fire or explosion scenario, Aurora LNG will give prompt and appropriate notification of an emergency condition to government agencies, local Aboriginal Groups, area residents, stakeholders and authorities.

  The magnitude of residual effect to infrastructure and services is low and within the geographical extent of the LAA. The frequency of the residual effect is a single event that would be short-term in duration and reversible within one month. The context of residual effects is resilient (moderate) because infrastructure and services can accommodate moderate levels of increased demand.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, the likelihood and consequence of residual effects to infrastructure and services are low. Based on these factors, the risk matrix ranking is low. Residual effects on infrastructure and services are predicted to be not significant.

- **Land and Resource Use**—Use of land for non-Project-related activities (e.g., fishing, hunting, trapping and gathering activities) could be affected if access is compromised (e.g., any disruption of services to the airport or safety buffer zones implemented following a fire or explosion) or a property or tenure is damaged by an on-shore fire or explosion. The effects to other VCs (e.g., freshwater fish and fish habitat, wildlife resources, and vegetation and wetland resources), as described above, may have subsequent effects to the viability of the resource for land users. The magnitude of effects would be low, and localized within the LAA. The residual effects to land and resource use would be a single event, short-term lasting up to one year and reversible. The context for residual effects to land and resource use is resilient (high) because the VC is able to accommodate substantial changes.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, there is a medium likelihood of residual effects to land and resource use, while the consequence is low. Based on these factors, the risk matrix ranking is low. Residual effects on land and resource use are predicted to be not significant.

- **Marine Use and Navigable Waters**—Project-related fire or explosion may temporarily delay marine traffic in the immediate vicinity but the residual effects are expected to be negligible in magnitude and localized within the LAA. The effect would be a single event of short-term duration lasting several days and reversible. The context for residual effects to marine use and navigable waters is resilient (high) because this VC can incur a high level of disturbance without adverse effects.

  After mitigation and response measures have been implemented following an on-shore fire or explosion, the likelihood and consequence of residual effects to marine use and navigable waters is

very low. Based on these factors, the risk matrix ranking is remote. Residual effects on marine use and navigable waters are predicted to be not significant.

- **Community Health**—Although worker safety is beyond the scope of this assessment, death or serious injury to workers from an on-shore fire or explosion will affect community health and well-being in those communities in which the workers and their families live. Counselling and trauma support services for those affected may be required and may exceed existing local and regional capacity in the short-term.

  For fire and explosion scenarios that do not involve the loss of human life, the magnitude of residual effects are low. The geographic extent would be within the LAA with a medium-term duration lasting for a substantial part of the operations phase. The residual effects to community health would be continuous following the event and irreversible. The context of residual effects to community health is resilient (moderate) because community health is moderate and slightly vulnerable to social, economic and environmental change.

  For fire and explosion scenarios that involve the loss of human life, the magnitude of residual effects are high. The geographic extent would be within the LAA with a long-term and continuous duration for the life of the Project, which would be irreversible. The context of residual effects to community health is resilient (moderate) because community health is moderate and slightly vulnerable to social, economic and environmental change.

  After mitigation and response measures have been implemented following an on-shore fire or explosion resulting in a loss of life, the likelihood of residual effects to community health is high, while the consequence is very high. Based on these factors, the risk matrix ranking is very high. The residual effects to community health in the case of an on-shore fire or explosion are predicted to be significant with and without the loss of human life.

- **Archaeological and Heritage Resources**—If undocumented or unmitigated archaeological and heritage resources are present in the vicinity of an on-shore fire or explosion, damage or destruction of these archaeological heritage sites within the LAA would be permanent and irreversible, resulting in a high magnitude of residual effect. The frequency would be a single event. The context of residual effects to archaeological and heritage resources disturbed because the area would have been substantially disturbed by previous human development or current human development.

  The likelihood of residual effects to archaeological and heritage resources is low since the area of the PDA and surround LAA has been previously investigated for archaeological and heritage resources. If undocumented or unmitigated archaeological and heritage resources (e.g., culturally modified trees) are affected, the consequence would be very high in the context of archaeological and heritage resources. Based on these factors, the risk matrix ranking is moderate. Unmitigated damage or destruction of archaeological or heritage resources due to an on-shore fire or explosion would be predicted to result in significant residual effects.

- **Human Health**—The severity of an on-shore fire or explosion would determine the extent of changes to air quality and subsequent effects to the population from inhalation exposure to gases and particulates released in the atmosphere. People may avoid exposure to smoke and particulates by remaining indoors and closing their windows to reduce inhalation exposure during the event. The magnitude of effects to human health would be low since smoke and particulates from a fire or explosion would be localized to the LAA. The residual effects to human health are short-term lasting several days after the event as the smoke and particulates disperse and dissipate in the atmosphere.

The frequency of residual effects is based on a single event, and the types of health risk would be reversible once the air quality in the area returns to existing conditions before the event. The context of residual effects to human health is resilient, indicating that there is a high capacity for human health to recover from a perturbation.

After mitigation and response measures have been implemented following an on-shore fire or explosion, the likelihood and consequence of residual effects to human health is very low. Based on these factors, the risk matrix ranking is remote. Residual effects on human health are predicted to be not significant.

Physical injury and mortality to workers during an accident or malfunction involving fire and explosions falls under WorkSafeBC and Occupational Health and Safety regulations, and is not included in the scope of this assessment. Human health is evaluated using the methods described in Health Canada's Detailed Quantitative Risk Assessment framework. This method quantifies health risk from exposure to chemicals in the environment and is not designed to predict physical injury or mortality from accidents or malfunctions involving fire. Death or serious injury to workers from an on-shore fire or explosion will affect community health and well-being in those communities in which the workers and their families live, and are therefore addressed in the context of community health above.

9.6.4 Conclusions

With the implementation of best practices, regulatory requirements and company standards, an accident or malfunction scenario involving small-scale on-shore fires and explosions may have significant residual effects to community health, and archaeological and heritage resources. Large-scale on-shore fires and explosions may result in significant residual effects to vegetation and wetland resources, wildlife resources, community health and archaeological and heritage resources.

The residual effects to other VCs that have the potential for interaction with on-shore fires and explosions (i.e., air quality, GHGs, freshwater fish and fish habitat, marine birds, economic environment, infrastructure and services, land and resource use, marine use and navigable waters, and human health) are not significant. A summary of the residual effects and significance from an accidents and malfunctions scenario involving on-shore fires or explosions is in Table 9.6-1.

Table 9.6-1 Summary of Residual Effects – On-shore Fires and Explosions

Valued Component	Residual Effects Characterization						Likelihood	Consequence	Risk Matrix Ranking	Significance
	Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Context				
Air Quality	L	LAA	S	ST	R	D	Low	Very Low	Remote	Not significant
Greenhouse Gases	N	G	S	ST	I	D	Low	Very Low	Remote	Not significant
Vegetation and Wetland Resources	M	LAA	S	LT	R	R	Medium	High	Moderate	Not significant[1] Significant[2]
Wildlife Resources (Terrestrial)	M	LAA	S	LT	R	R	Medium	High	Moderate	Not significant[1] Significant[2]
Freshwater Fish and Fish Habitat	L	LAA	S	ST	R	R, D	Low	Low	Low	Not significant
Marine Birds	L	LAA	S	ST	R	R	Low	Low	Low	Not significant
Economic Environment	L	RAA	S	ST	R	R	Low	Low	Low	Not significant
Infrastructure and Services	L	LAA	S	ST	R	R	Low	Low	Low	Not significant
Land and Resource Use	L	LAA	S	ST	R	R	Medium	Low	Low	Not significant
Marine Use and Navigable Waters	N	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant
Community Health	L[3] H[4]	LAA	C	MT[3] LT[4]	I	R	High	Very High	Very High	Significant
Archaeological and Heritage Resources	H	LAA	S	P	I	D	Low	Very High	Moderate	Significant
Human Health	L	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not Significant

NOTES:

1 Characterization for small scale fires or explosions.
2 Characterization for large scale fires or explosions.
3 Characterization for fires or explosions without loss of human life.
4 Characterization for fires or explosions with the loss of human life.

KEY

Magnitude:	**Geographic Extent:**	**Frequency:**	**Duration:**	**Reversibility:**	**Context:**
N: Negligible	PDA: Project development area	S: Single event	ST: Short-term	R: Reversible	D: Disturbed
L: Low	LAA: Local assessment area	MI: Multiple irregular events	MT: Medium-term	I: Irreversible	U: Undisturbed
M: Moderate	RAA: Regional assessment area	MR: Multiple regular events	LT: Long-term		R: Resilient
H: High	G: Global	C: Continuous	P: Permanent		N: Not resilient

9.7 LNG Plant Malfunctions

9.7.1 Description of Event or Interactions

A credible accidents and malfunctions scenario with a potential consequence of concern at the LNG facility includes the partial or full emergency shutdown of a maximum of one production train with associated flaring. Power generation is the most likely cause of an LNG plant malfunction. The LNG facility is designed with automated shutdown systems in the event of an emergency. The automated shutdown will transition all systems to a safe controlled standby mode to reduce the loss of train inventory. During upset conditions, natural gas vapours will be safely redirected to associated flares for incineration and controlled discharge to the atmosphere.

Fluctuations in normal operations (i.e., an upset) or the failure of localized equipment may cause short periods of flaring. This flaring will be short-term and will have a substantially smaller emission load relative a complete shutdown.

The probability of an emergency shutdown of one train is low but more likely than an emergency shutdown of all four trains. Potential effects of an emergency shutdown of one train are therefore assessed for Wildlife Resources (Terrestrial), Marine Birds, Infrastructure and Services (see Table 9.3-1). Potential effects of a four train shutdown are assessed for Air Quality, GHGs, , and Human Health VCs as a result of air emission and dispersion modelling assumptions (see Table 9.3-1).

9.7.2 Preventative and Response Measures

The LNG plant will be designed to shut down in a safe and controlled manner in response to upset conditions (i.e., protecting against high pressure, high and low temperatures, and low flow conditions), or in the event of an emergency. The plant design will comply with the codes and standards from the Canadian Standards Association, National Building Code of America, American Society of Mechanical Engineers, American Concrete Institute, and American Petroleum Institute.

To reduce the probability of an emergency shutdown of an LNG train or to mitigate the effects of a shutdown, preventative and mitigation and response measures are currently anticipated to include:

- Central control and emergency shutdown systems that engage protection barriers such as safeguard trips
- Detectors for combustible gas, fire, smoke heat and manual call points
- Flare design systems with a maximum incineration efficiency of 99.5%
- Continuously lit pilot light options on all flares
- Use of skilled personnel competent in LNG plant operations
- Safe work procedures, work permits and emergency response system administrative controls.

During a flaring event, observed bird mortalities by staff will be reported to Environment and Climate Change Canada, Ministry of Forests, Lands and Natural Resource Operations and the onsite environmental monitor. The report will include information on species (if available), location and time of the event, and weather conditions at the time of the event.

9.7.3 Potential Residual Effects

The potential residual effects to each VC from interactions with LNG plant malfunctions are:

- **Air Quality**—The potential residual effects to air quality from a full facility emergency shutdown (i.e., four LNG trains) with subsequent flaring were modelled as a worst case scenario and summarized in the Air Quality Technical Data Report (TDR) (see Appendix A). The dispersion modelling indicated that predicted concentrations of all criteria air contaminants would be less than the applicable ambient air quality objectives. Therefore, the credible scenario of a single train emergency shutdown would also result in predicted concentrations of criteria air contaminants below the ambient air quality objectives.

  The magnitude of residual effects to air quality would be negligible and within the geographical extent of the LAA. The frequency of the effect would be a single event, with a short-term duration up to 24 hours after the event. The residual effects would be reversible as the emissions disperse in the atmosphere and the conditions for air quality return to those before the event. The context is characterized as disturbed because air quality is already influenced by other emission sources in the area.

  After mitigation and response measures have been implemented following an LNG plant malfunction, the likelihood and consequence of residual effects to air quality is very low. Based on these factors, the risk matrix ranking is remote. Residual effects on air quality are predicted to be not significant.

- **GHGs**— The potential residual effects to GHGs from a full facility emergency shutdown (i.e., four LNG trains) with subsequent flaring were modelled as a worst case scenario and summarized in the GHG TDR (see Appendix B). The emission totals associated with a full facility shutdown demonstrated that GHG contributions were negligible in the context of the overall provincial and national GHG emission totals. Therefore, the credible scenario of a single train emergency shutdown would also result in a negligible magnitude of residual effects to GHGs that are global in geographical extent. The effects to GHGs would be a single event of short-term duration, and the contribution of GHGs to the atmosphere is irreversible. The context is characterized as disturbed because there are other sources of GHGs in the area. The emissions would disperse and the environmental effect would not substantially change local or regional GHG inventories.

  After mitigation and response measures have been implemented following an LNG plant malfunction scenario, the likelihood of residual effects to GHGs is low, while the consequence is very low. Based on these factors, the risk matrix ranking for GHGs is remote. Residual effects on GHG inventories are predicted to be not significant.

- **Wildlife Resources (Terrestrial)**—An LNG plant malfunction scenario that involves flaring would produce light that could attract terrestrial birds, causing grounding of animals from exhaustion. Injury or mortality may also result from direct collision with facility infrastructure or from contact with the flare. The magnitude of residual effects to wildlife resources is low because the effect will not affect the viability of the population. The geographical extent of residual effects is within the LAA. The frequency of the residual effect is a single event that is short-term in duration that lasts only for the duration that the flare is active. The residual effects are reversible within one month or less, and the bird population is unlikely to sustain long-term effects. The context is described as resilient because terrestrial wildlife species or species groups are able to tolerate change from existing conditions, and the viability of the population is not expected to be affected.

After mitigation and response measures have been implemented following an LNG plant malfunction and subsequent flaring, the likelihood and consequence of residual effects to wildlife resources are low. Based on these factors, the risk matrix ranking is low. Residual effects from an LNG plant malfunction on terrestrial wildlife resources are predicted to be not significant.

- **Marine Birds**— An LNG plant malfunction scenario that involves flaring would produce light that could attract marine birds, causing grounding of animals from exhaustion. Injury or mortality may also result from direct collision with facility infrastructure or from contact with the flare. The magnitude of residual effects to marine birds is low because the effect will not affect the viability of the marine bird population. The geographical extent of residual effects is within the LAA. The frequency of the residual effect is a single event that is short-term in duration that lasts only for the duration that the flare is active. The residual effects are reversible within one month or less, and the marine bird population is unlikely to sustain long-term effects. The context for changes to marine birds is resilient, because marine bird species or species groups are able to tolerate changes relative to existing conditions and the viability of the population is not expected to be affected.

  After mitigation and response measures have been implemented following an LNG plant malfunction and subsequent flaring, the likelihood and consequence of residual effects to marine birds are low. Based on these factors, the risk matrix ranking is low. Residual effects from an LNG plant malfunction on marine birds are predicted to be not significant.

- **Infrastructure and Services**— Flaring activities could temporarily interfere with civil aviation. Gas plumes and heat radiation from the flare stack could influence air turbulence along the southern take-off and landing approach and increase the probability of loss of aircraft control. The Project design currently includes mitigation measures to reduce the geographical extent and vertical velocity of gas plumes from the Project during the operations phase, which will also apply during flaring from an LNG plant malfunction scenario. Close collaborative planning will also take place with the Prince Rupert Airport Authority to identify the affected airspace during these flaring events (i.e., flaring from both the operations phase and an LNG plant malfunction scenario requiring flaring). The magnitude of residual effects to infrastructure and services (i.e., airport traffic and safety) is low, and the geographical extent will be within the LAA. The frequency of the residual effect would be a single event with a short-term duration lasting the duration that the flare is active and reversible. The context of residual effects is resilient (moderate) because infrastructure and services can accommodate moderate levels of increased demand.

  After mitigation and response measures have been implemented following an LNG plant malfunction with associated flaring events, the likelihood of residual effects to infrastructure and services is low, while the consequence is very low. Based on these factors, the risk matrix ranking is remote. Residual effects from an LNG plant malfunction on infrastructure and services are predicted to be not significant.

- **Human Health**—Flaring activities associated with an LNG plant malfunction and shutdown will release emissions of sulphur dioxide, nitrogen dioxide and particulate matter to the atmosphere. Dispersion modelling for flaring scenarios in the Air Quality TDR (see Appendix A) indicates that the predicted concentrations of sulphur dioxide, nitrogen dioxide and particulate matter would be less than the applicable health-based BC ambient air quality objectives. The magnitude of residual effects to human health would be negligible and localized to the LAA. The frequency of residual effects would be a single event of short-term duration that would be reversible after emissions have dispersed and

the conditions for air quality return to those before the flaring event. The context of residual effects to human health is resilient, indicating that there is a high capacity for human health to recover from a perturbation.

After mitigation and response measures have been implemented following an LNG plant malfunction with subsequent flaring and release of emissions to the air, the likelihood and consequence of residual effects to human is very low. Based on these factors, the risk matrix ranking is remote. Residual effects from an LNG plant malfunction on human health are predicted to be not significant.

9.7.4 Conclusions

With the implementation of best practices, regulatory requirements and company standards, an accidents and malfunctions scenario involving an LNG plant malfunction will result in no significant effect to the VCs (i.e., air quality, GHGs, wildlife resources (terrestrial), marine birds, infrastructure and services, and human health). A summary of the residual effects and significance from an accidents and malfunctions scenario involving an LNG plant malfunction is in Table 9.7-1.

Table 9.7-1 Summary of Residual Effects – LNG Plant Malfunctions

Valued Component	Residual Effects Characterization						Likelihood	Consequence	Risk Matrix Ranking	Significance
	Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Context				
Air Quality	N	LAA	S	ST	R	D	Very Low	Very Low	Remote	Not significant
Greenhouse Gases	N	G	S	ST	I	D	Low	Very Low	Remote	Not significant
Wildlife Resources (Terrestrial)	L	LAA	S	ST	R	R	Low	Low	Low	Not significant
Marine Birds	L	LAA	S	ST	R	R	Low	Low	Low	Not significant
Infrastructure and Services	L	LAA	S	ST	R	R	Low	Very Low	Remote	Not significant
Human Health	N	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant

KEY

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PDA: Project development area
LAA: Local assessment area
RAA: Regional assessment area
G: Global

Frequency:
S: Single event
MI: Multiple irregular events
MR: Multiple regular events
C: Continuous

Duration:
ST: Short-term
MT: Medium-term
LT: Long-term
P: Permanent

Reversibility:
R: Reversible
I: Irreversible

Context:
D: Disturbed
U: Undisturbed
R: Resilient
N: Not resilient

9.8 On-shore Hazardous Spills

9.8.1 Description of Event or Interactions

A spill is any release or discharge of a substance into the environment not authorized under the provincial *Environmental Management Act* or in an amount equal to or greater than the amounts or volumes established in the Schedule specified by the provincial Spill Reporting Regulation (BC 2008). This section considers small-scale spills (i.e., hazardous spills in amounts or volumes less than those stated in the Spill Reporting Regulation) and large-scale on-shore spills (i.e., hazardous spills in amounts or volumes greater than those stated in the Spill Reporting Regulation). Releases from LNG carriers (loss of LNG and loading arm failure) over marine environments are discussed separately in Section 9.10.

Spills of hazardous material could occur during any phase of the Project. During the construction phase, potential spill hazards include equipment fuels and lubricants (e.g., fuels, motor oil, lubricants, or hydraulic fluids) used in vehicles or stationary equipment (e.g., diesel power generators) and mobile equipment (e.g., on-shore construction mobile fleet). Construction of the materials offloading facility (MOF) and marine terminal may also require some mobile equipment to operate near the marine shoreline. During the commissioning and operations phases, potential spill hazards include on-shore hazardous material storage (e.g., fuels, waste and reagents), on-shore containment of LNG, process water, and surface/storm water.

Once final engineering details are confirmed, a detailed list of products classified as dangerous goods under the federal *Transportation of Dangerous Goods Act* and/or those defined as controlled products under the provincial and federal Workplace Hazardous Materials Information System (WHMIS) legislation will be produced along with the associated Safety Data Sheets. In the event of an on-shore accidental spill, the ERP (see Section 14.0) will be implemented, if necessary.

The magnitude of an environmental effect associated with on-shore hazardous spills depends on a number of factors including the chemical composition of the spilled product, the volume that is released, the location of the release (e.g., proximity to shoreline or a sensitive habitat), the timing of the spill (e.g., meteorological conditions contributing to evaporation of spilled hydrocarbons, seasonality of sensitive receptors such as marine birds), and the success of response operations.

The most likely scenario of a small-scale hazardous material spill is an accidental release while refueling or leaks from stationary or mobile equipment. Such small-scale hazardous material spills are typically several litres or less in volume, localized to the immediate area of the spill, and can be promptly cleaned up by site personnel using standard procedures, equipment and materials. Mitigation and response measures and standard practices to reduce the probability and impact of a small-scale spill include, in general:

- Locating refuelling and maintenance areas away from water bodies to reduce the spatial area and spread of the release
- Regular maintenance and inspection of all equipment to reduce potential for spill of hazardous materials.

Further details on preventative and response measures are described in Section 9.8.2. With mitigation (including prevention and clean-up measures), small-scale spills are not likely to result in residual environmental effects, and are not assessed further.

A likely worst case scenario would include loss of on-shore containment of materials in storage tanks (e.g., LNG, gasoline, diesel or propane), or a natural gas pipeline rupture onsite upstream of the liquefaction process. This scenario may result in a large-scale release of hazardous materials in amounts or volumes greater than those described in the Spill Reporting Regulation (BC 2008).

The probability of a large-scale spill is very low due to the design of the Project, which includes spill prevention measures and controls specifically intended to reduce the probability of such an event (e.g., secondary containment). The implementation of spill response plans further mitigates the potential residual effects that could occur in the event of a large-scale hazardous spill. Fires or explosions that may result from a hazardous spill of flammable or explosive substances are addressed in Section 9.6.

On-shore hazardous spills have the potential to interact with the following VCs: Air Quality, GHGs, Water Quality, Vegetation and Wetland Resources, Wildlife Resources (Terrestrial), Freshwater Fish and Fish Habitat, Marine Fish and Fish Habitat, Marine Mammals, Marine Birds, Infrastructure and Services, Land and Resource Use, Archaeological and Heritage Resources, and Human Health (see Table 9.3-1).

9.8.2 Preventative and Response Measures

The Project will be designed, operated, and managed to reduce the potential for hazardous spills of any size. Hazardous materials will be transported, handled, and stored in accordance with the *Transportation of Dangerous Goods Act*, WHMIS, and other applicable regulations.

The proposed facility will meet strict design codes and standards and will be designed to avoid confined spaces where spills of LNG could vaporize into natural gas and accumulate. Canadian Standards Association code Z276-2011 requires that LNG storage systems be located far enough from the facility boundary to mitigate the levels of radiant heat flux from fires and to mitigate the potential for spills to generate vapour concentrations beyond acceptable limits at the facility boundary. While these events could still have effects to staff onsite, these personnel will be appropriately trained to react and respond to any such event.

The Project will implement a series of preventative measures to reduce the probability of hazardous material spills of any size during all phases of the Project. Design controls and preventative measures according to applicable regulatory requirements will include:

- Fuel and hazardous materials storage tanks will be designed and operated as per the specifications of the BC *Environmental Management Act* (2003), the recommendations included in the *Field Guide to Fuel Handling, Transportation and Storage* (BC MOE 2002), the *National Fire Code of Canada* (2010), the *BC Fire Code* (2006), and the *Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products* (Canadian Council of Ministers of the Environment 2003).
- Secondary containment design will comply with applicable federal, provincial, and municipal regulations for an aboveground single storage tank system (CCME 2003).

Design controls and preventative measures that are part of Aurora LNG's best practices will include:

- Hazardous materials will be stored 250 metres (m) or more from water bodies and other sensitive habitats unless secondary containment is provided.
- Drainage systems will be in place to collect contaminated water and process effluents.
- Refuelling and maintenance areas for heavy equipment will be 30 m or more from water bodies and sensitive habitats unless secondary containment is provided.
- Mobile equipment operating near the marine shoreline will be monitored by qualified personnel to manage the potential for small-scale leaks into the marine environment.
- Equipment will be kept in good working condition and will be inspected regularly by qualified personnel. Equipment used in or adjacent to the freshwater or marine environment will be clean and free of external grease, oil, or other fluids of a hazardous nature.
- Personnel working with hazardous materials will receive training in the proper handling, identification, documentation, and storage of wastes and hazardous materials (e.g., WHMIS training and Transportation of Dangerous Goods certification).
- Equipment operators will follow recommended operational practices for fuelling and other tasks that have the potential to cause a spill.

The EMP will include measures to reduce the chance of spills of hazardous materials, including equipment inspection and maintenance programs. In the event of a hazardous material spill, the ERP will be initiated, if necessary. The ERP describes provisions for spill response to limit adverse effects to sensitive environmental receptors, personnel, and the public. The response to a hazardous materials spill will vary depending on several factors including the physical and chemical characteristics of the product spilled, the nature of the receiving environment, and the volume of the released product. Response strategies described in the ERP may include:

- The source of the spill will be secured (i.e., valves closed, patching tanks) to reduce, stop or mitigate the ongoing spill of hazardous materials.
- Spill containment kits (with contents such as absorbent pads and socks, specialized personal protective equipment, and disposal bags or bins) will be located at strategic locations throughout the PDA to facilitate immediate response to a spill.
- Response to the release of a hazardous product will be carried out by trained and properly equipped personnel.
- Personnel responding to the spill will review Safety Data Sheets for properties of the spilled material. If the identity of the substance cannot be confirmed, the spill will be treated as hazardous material until the spilled material is identified.
- Notification of relevant regulatory agencies, potentially affected Aboriginal Groups, stakeholders, and the public.
- If a hazardous spill has the potential to enter the drinking water source used by Dodge Cove residents located adjacent to the Dodge Cove community, residents may be supplemented with trucked or bottled water.

Response measures for fires or explosions that may occur subsequent to an on-shore hazardous spill are addressed in Section 9.6.

9.8.3 Potential Residual Effects

The potential residual effects to each VC from interactions with small and large-scale spills of hazardous materials on-shore are:

- **Air Quality**—Small and large spills of a hazardous material will release vapours into the air. With the implementation of mitigation and response measures described above, the magnitude of potential residual effects to air quality are negligible and localized within the LAA. The frequency of the residual effect to air quality will be a single event with a short-term duration that may last from hours to days, depending on the spilled material and the volume. The residual effects to air quality are reversible as the vapours dissipate and disperse into the atmosphere and the conditions for air quality will return to those before the event. The context is characterized as disturbed because air quality is already influenced by other emission sources in the area.

  After mitigation and response measures have been implemented following an on-shore hazardous spill, the likelihood and consequence of residual effects to air quality is very low. Based on these factors, the risk matrix ranking is remote. Residual effects to air quality from spills of hazardous materials on-shore are predicted to be not significant.

- **GHGs**—With the implementation of the mitigation and response measures, GHG emissions (including methane and carbon dioxide) resulting from small and large spills would be negligible in the context of the overall provincial and national GHG emissions totals. The emissions would disperse and the environmental effect would not contribute substantially to local or regional GHG inventories. The magnitude of residual effect would be negligible within a global geographical extent. The frequency of the residual effect to GHGs would be a single event with a short-term duration lasting days to months, and irreversible. These emissions would have a negligible magnitude of residual effect nominal contribution to the global concentration of GHGs and will be irreversible within the life of the Project. The context is characterized as disturbed because there are other sources of GHGs in the area. The emissions would disperse and the environmental effect would not substantially change local or regional GHG inventories.

  After mitigation and response measures have been implemented following an on-shore hazardous material spill, the likelihood and consequence of residual effects for GHGs are very low. Based on these factors, the risk matrix ranking is remote. Residual effects from spills of hazardous materials on-shore on overall provincial and national GHG emission totals are predicted to be not significant.

- **Water Quality**—A spill of hazardous material may lead to surface water contamination (either or both freshwater and marine). In general, small-scale spills can be rapidly contained and effectively cleaned within a short period of time, reducing the potential for hazardous spills to reach surface or marine waters. Large-scale spills, particularly if the event occurs near a waterbody, may enter the aquatic environment. The residual effects of a hazardous spill to water quality would be low in magnitude and within the geographic extent of the LAA. The frequency of the residual effect would be a single event with a short-term duration lasting up to several months, and reversible following the implementation of preventative and response measures. The context of the residual effects to water quality is disturbed, because the area will have been disturbed by human development, namely, the Project.

  After mitigation and response measures have been implemented following an on-shore hazardous spill, the likelihood and consequence of residual effects to water quality from both small-scale and large-scale spills are very low. Based on these factors, the risk matrix ranking is remote and the residual effects are not significant.

- **Vegetation and Wetland Resources**—A spill of hazardous material on terrestrial vegetation would be limited to the immediate area of the spill and the effects would be effectively mitigated with the implementation of spill response procedures. The magnitude of residual effect to terrestrial vegetation would be negligible and within the geographical extent of the LAA. The frequency of the residual effect would be a single event that is short-term in duration that lasts up to several months and reversible. The context is described as resilient because there is capacity for vegetation to recover from perturbations caused by a hazardous spill.

  After mitigation and response measures have been implemented following a small or large- scale on-shore hazardous material spill, the likelihood and consequence of residual effects to vegetation resources are very low. Based on these factors, the risk matrix ranking is remote. The residual effect to vegetation resources from an on-shore spill of hazardous materials is predicted to be not significant.

  The magnitude of residual effects to wetland function would depend on several factors including the material spilled, volume of material spilled, type of wetland affected, surface and subsurface water flow, speed of natural removal, species sensitivity and time of year. Spills of hazardous materials that are generally harmful to life (e.g., toxic, corrosive and/or persistent in the environment) may result in a moderate magnitude of residual effects within the geographical extent of the LAA, while some substances such as LNG would a lower magnitude of residual effect because they are not particularly toxic. The frequency of the residual effect would be a single event, that is likely to be short-term and reversible within one to several years. The context is described as resilient because there is capacity for wetland resources to recover from perturbations caused by a hazardous spill.

  After mitigation and response measures have been implemented following an on-shore hazardous material spill, there is a medium likelihood of residual effects to wetland function, while the consequence is high. Based on these factors, the risk matrix ranking is moderate. The residual effects to wetland function from an on-shore spill of hazardous materials are predicted to be significant.
- **Wildlife Resources (Terrestrial)**—Potential residual effects on terrestrial wildlife depend on the volume of the spill, the toxicity of the hazardous substance, and the speed of the response and containment. Exposure to hazardous materials could result in acute toxic effects to wildlife, but these effects are unlikely to affect wildlife species at the population level. Wildlife would be deterred from the area due to heavy human traffic and activity once response crews arrive to clean the spill. Therefore, the magnitude of residual effects to wildlife resources is negligible and within the geographical extent of the LAA. The frequency of the residual effect is a single event of short-term duration lasting up to several months, and the effect is reversible. The context is described as resilient because terrestrial wildlife species or species groups are able to tolerate change from existing conditions, and the viability of the population is not expected to be affected.

  After mitigation and response measures have been implemented following either a small or large-scale on-shore spill of hazardous material, the likelihood of residual effects to terrestrial wildlife is low, while the consequence is very low. Based on these factors, the risk matrix ranking is remote. Residual effects to terrestrial wildlife from a spill are predicted to be not significant.
- **Freshwater Fish and Fish Habitat**—A spill of hazardous material that could affect freshwater fish and fish habitat would likely come from trucks, machinery, or any vehicle transporting fuel or hazardous material that is considered a deleterious substance under the *Fisheries Act*. If a spill of hazardous material reaches riparian habitat, recovery is expected to occur over a period of a year,

particularly if the response and clean-up efforts result in the removal of the affected riparian habitat. Habitat offsetting programs will be implemented if it is determined that there is a residual "serious harm" to fish habitat that supports commercial, recreational or Aboriginal (CRA) species.

The range of residual effects to freshwater fish and fish habitat would depend on the volume of the spill, the size of the stream, the speed of response and containment, and the inherent toxicity of the hazardous material. Mitigation measures to contain a spill of hazardous materials would reduce the amount or volume entering nearby watercourses and the magnitude of residual effect would be low. The geographical extent of a spill would be within the LAA and could vary between a localized event within the PDA with very little material entering a channel to one that is of greater volume entering multiple channels. The frequency of the residual effect is a single event with a short-term duration that would be reversible within a few days. The context for residual effects to freshwater fish and fish habitat is resilient because the VC is able to assimilate the additional change.

After mitigation and response measures have been implemented following a small or large-scale spill of hazardous material, the likelihood and consequence of residual effects to freshwater fish and fish habitat are very low. Based on these factors, the risk matrix ranking is remote. Residual effects from a small-scale spill affecting freshwater fish and fish habitat are predicted to be not significant.

- **Marine Fish and Fish Habitat**—An on-shore spill of hazardous materials that potentially enters the marine environment has the potential to affect marine fish and fish habitat. Exposure to hazardous or toxic substances such as oil could result in sub-lethal and lethal effects through uptake by the gills, physical contact, or ingestion of oil or oiled prey. Spilled oil can also degrade habitat and adversely affect algae and plant growth with the potential to cause die-off (US FWS 2004).

  The sensitivity of marine fish to a hazardous substance varies among taxa (e.g., fish versus invertebrates) and may depend on the life history stage (e.g., larvae versus adult), habitat preferences (e.g., distribution within the water column), and the ability of the organism to physically move to avoid the affected area (e.g., sessile versus highly mobile species), among other factors. The physical nature of the shoreline (e.g., steep, rocky habitat versus gently sloping soft substrate) also influences the degree to which intertidal communities are affected (NOAA 2014).

  Depending on the volume of the released product, the speed and effectiveness of the response and clean-up efforts, the proximity to the marine environment, and oceanographic conditions (e.g., currents, waves, and weather), most spills would be localized with very little material entering the marine environment. It is assumed that small-scale spills will be contained onsite and would not enter the marine environment. In the event of a large-scale on-shore spill reaching the marine environment, the magnitude of residual effects on marine fish and fish habitat would be moderate and within the geographical extent of the LAA. The frequency of residual effects would be a single event that is moderate-term in duration and reversible within months to years depending on the conditions of the spill (e.g., spill material, spill amount or volume, location). The context for changes to marine fish and fish habitat is resilient, because the VC is able to tolerate changes relative to existing conditions and the viability of the marine fish population is not expected to be affected. Although some marine organisms would likely be killed, this would not affect the overall viability of any marine fish populations.

  After mitigation and response measures have been implemented following a large-scale spill of hazardous materials, there is a medium likelihood of residual effects to marine fish and fish habitat. The consequence of residual effects is moderate. Based on these factors, the risk matrix ranking is moderate. It is expected that the effects of a large-scale on-shore spill entering marine fish habitat

causing serious harm to CRA species would be sufficiently counterbalanced by Aurora LNG through clean-up, remediation and habitat offsetting so that residual effects would ultimately be not significant.

- **Marine Mammals**—Potential residual effects on marine mammals would depend on the volume of the spill, the toxicity of the hazardous substance, and the speed of response and containment. Exposure to hazardous materials could result in acute toxic effects to marine mammals; but these effects are unlikely to affect wildlife species at the population level. Given proposed mitigation and response measures, small-scale on-shore spills are expected to be localized to the immediate area around the spill, and are assumed to be effectively mitigated within days of the event with no residual effects to marine mammals.

  In the event of a large-scale spill reaching the marine environment, the magnitude of residual effects to marine mammals is moderate and within the geographical extent of the LAA. The frequency of residual effects to marine mammals is a single event over the short-term that is reversible within days. However, should a large-scale spill result in acute effects on marine mammal species at risk, or should the effects to marine fish adversely affect foraging opportunities for marine mammal species at risk, recovery may be further delayed due to the increased sensitivity of these species from disturbances at the population level. The context of residual effects to marine mammals is disturbed because the event would take place in an area that has been substantially disturbed by human development.

  After mitigation and response measures have been implemented following a large-scale on-shore spill of hazardous materials entering the marine environment, there is a medium likelihood of residual effects to marine mammals, while the consequence is high. Based on these factors, the risk matrix ranking is moderate. Should a large-scale on-shore spill entering the marine environment result in acute effects on marine mammal species at risk, or should the effects to marine fish adversely affect foraging opportunities for marine mammal species at risk, population-level effects on marine mammals could occur and residual effects could be significant.

- **Marine Birds**—Potential residual effects on marine birds from an on-shore spill entering the marine environment would depend on the volume of the spill, the toxicity of the hazardous substance, the speed of response and containment, and the seasonal presence of marine birds. Exposure to hazardous materials could result in acute toxic effects to marine birds. Some species may experience sub-lethal effects through indirect exposure to residual hazardous materials in sediment and prey; but these effects are unlikely to affect marine bird species at the population level. Small-scale spills will be localized to the immediate area around the spill, and are assumed to be effectively mitigated within days of the event with no residual effects to marine birds. For large-scale spills, the magnitude of residual effects to marine birds would be moderate and within the geographical extent of the LAA. The frequency of the residual effect would be a single event that is short-term in duration and reversible within several months to several years depending on the spill conditions. The context for changes to marine birds is resilient, because marine bird species or species groups are able to tolerate changes relative to existing conditions and the viability of the population is not expected to be affected.

  After mitigation and response measures have been implemented following a large-scale spill of hazardous material, there is a medium likelihood of residual effects to marine birds, while the consequence is high, particularly for marine bird species at risk, due to their greater sensitivity to disturbances at the population level. Based on these factors, the risk matrix ranking is moderate.

Should a large-scale on-shore spill entering the marine environment result in population-level effects on marine birds, residual effect would be significant.

- **Infrastructure and Services**—Aurora LNG will use its onsite resources and apply the ERP to address on-shore spills to limit the need for use of public emergency services. Therefore, the magnitude of residual effect to local infrastructure and services would be negligible and within the geographic extent of the LAA. The frequency of the residual effect would be a single event that is short-term in duration and reversible within a few days to weeks. The context of residual effects is resilient (moderate) because infrastructure and services can accommodate moderate levels of increased demand.

  After mitigation and response measures have been implemented following a spill of hazardous material, the likelihood and consequence of residual effects to infrastructure and services are very low. Based on these factors, the risk matrix ranking is remote. Residual effects on infrastructure and services are predicted to be not significant.

- **Land and Resource Use**—The effects of hazardous material spills on land and resource use would depend on the location of the spill and the type of land use that occurs there. If the spill affects fish or wildlife, then fishing and hunting would be affected. Agricultural land uses will not be affected as there are no agricultural land reserves within the PDA or the LAA. Prevention and response measures noted above would mitigate effects of on-shore spills from lands outside of the PDA. For example, Canadian Standards Association code Z276-2011 requires that LNG storage systems be located far enough from the facility boundary to mitigate the potential for spills to generate vapour concentrations beyond acceptable limits in surrounding areas. Therefore, the magnitude of residual effects to land and resource use would be low and within the geographical extent of the LAA. The frequency of residual effects would be a single event that is short-term in duration and reversible within one month after a clean-up is completed. The context for residual effects to land and resource use is resilient (high) because the VC is able to accommodate substantial changes.

  After mitigation and response measures have been implemented following a spill of hazardous materials, the likelihood and consequence of residual effects to land and resource use are low. Based on these factors, the risk matrix ranking is low. Residual effects from an on-shore spill on land and resource use are predicted to be not significant.

- **Archaeology and Heritage Resources**— An on-shore hazardous spill may have residual effects to archaeology and heritage resources if the spill occurs in the immediate vicinity of an undocumented or unmitigated resource. If undocumented or unmitigated archaeological and heritage resources are in the immediate vicinity of a hazardous spill, the magnitude of residual effects would be high and within the geographical extent of the LAA. The frequency of the residual effect would be a single event that is permanent and irreversible. The context of residual effects to archaeological and heritage resources disturbed because the area would have been substantially disturbed by previous human development or current human development.

  After mitigation and response measures have been implemented following a spill of hazardous materials, the likelihood of residual effects to archaeology and heritage resources is very low since the PDA and surrounding LAA have been previously investigated for archaeological and heritage resources, and most spills would occur in high activity areas (e.g., PDA, roads) that would already subject to disturbance. If all conditions are met and a hazardous spill has residual effects to

archaeological and heritage resources, the consequence would be very high. Based on these factors, the risk matrix ranking is moderate and the residual effects would be not significant.

- **Human Health**—A large spill of a hazardous substance into a watercourse could impact drinking water quality, which could affect human health. Local residents of Dodge Cove obtain some of their drinking water from a small reservoir created from damming a small stream adjacent to the Dodge Cove community. This untreated water has been under a boil water advisory since 1988 due to the risk of exposure to microbiological parameters. Residents may also obtain drinking water from municipal water sources on the mainland, which is brought back to Dodge Cove by boat. Among these sources of drinking water, a spill of hazardous materials is most likely to affect the small reservoir adjacent to Dodge Cove because the proposed access road may overlap the area for which surface water drains into the reservoir. Municipal tap water from Prince Rupert or Port Edward is unlikely to be affected by a spill of hazardous materials. Effects to human health may be mitigated in the event of a spill near the local drinking water reservoir by supplementing residents with trucked or bottled water. This will mitigate the potential for exposure to hazardous substances for Dodge Cove residents who utilize the drinking water reservoir. Therefore, the magnitude of residual effects to human health would be negligible and within the geographic extent of the LAA. The frequency of the residual effect would be a single event of short-term duration that is reversible within one year. The potential residual effect to human health from a spill of hazardous materials into a drinking water source would be local and reversible within one year or less. The context of residual effects to human health is resilient, indicating that there is a high capacity for human health to recover from a perturbation.

  After mitigation and response measures have been implemented following a spill of hazardous material, the likelihood and consequence of residual effects to human health are very low. Based on these factors, the risk matrix ranking is remote. In the case of a spill affecting the water supply of Dodge Cove residents, it is understood that alternative water supplies will be provided to prevent exposure to hazardous spill materials from consuming locally sourced drinking water. Therefore, the residual effects on human health would be not significant.

9.8.4 Conclusions

With the implementation of best practices, regulatory requirements and company standards, an accident or malfunction scenario involving small-scale or large-scale on-shore hazardous spills may have significant residual effects to vegetation and wetland resources (specifically, wetland resources), marine mammals, and marine birds.

The residual effects to other VCs that have the potential for interaction with on-shore hazardous spills (i.e., air quality, GHGs, water quality, vegetation and wetland resources (specifically, vegetation resources), wildlife resources, freshwater fish and fish habitat, marine fish and fish habitat, infrastructure and services, land and resource use, archaeological and heritage resources, and human health) are not significant. A summary of the residual effects and significance from an accidents and malfunctions scenario involving on-shore hazardous spills is in Table 9.8-1.

Table 9.8-1 Summary of Residual Effects – On-shore Hazardous Spills

Valued Component	Residual Effects Characterization						Likelihood	Consequence	Risk Matrix Ranking	Significance
	Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Context				
Air Quality	N	LAA	S	ST	R	D	Very Low	Very Low	Remote	Not significant
Greenhouse Gases	N	G	S	ST	I	D	Very Low	Very Low	Remote	Not significant
Water Quality	L	LAA	S	ST	R	D	Very Low	Very Low	Remote	Not significant
Vegetation and Wetland Resources	N[1] M[2]	LAA	S	ST	R	R	Very Low[1] Medium[2]	Very Low[1] High[2]	Remote[1] Moderate[2]	Not significant[1] Significant[2]
Wildlife Resources (Terrestrial)	N	LAA	S	ST	R	R	Low	Very Low	Remote	Not significant
Freshwater Fish and Fish Habitat	L	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant
Marine Fish and Fish Habitat	M	LAA	S	MT	R	R	Medium	Moderate	Moderate	Not significant
Marine Mammals	M	LAA	S	ST	R	D	Medium	High	Moderate	Significant
Marine Birds	M	LAA	S	ST	R	R	Medium	High	Moderate	Significant
Infrastructure and Services	N	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant
Land and Resource Use	L	LAA	S	ST	R	R	Low	Low	Low	Not significant
Archaeological and Heritage Resources	H	LAA	S	P	I	D	Very Low	Very High	Moderate	Not significant
Human Health	N	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant

NOTES:

[1] Characterization for Vegetation.
[2] Characterization for Wetland Resources.

KEY

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PDA: Project development area
LAA: Local assessment area
RAA: Regional assessment area
G: Global

Frequency:
S: Single event
MI: Multiple irregular events
MR: Multiple regular events
C: Continuous

Duration:
ST: Short-term
MT: Medium-term
LT: Long-term
P: Permanent

Reversibility:
R: Reversible
I: Irreversible

Context:
D: Disturbed
U: Undisturbed
R: Resilient
N: Not resilient

9.9 Vessel Grounding or Collision

9.9.1 Description of Event or Interactions

At full build-out, the marine terminal will have the capacity to accommodate two Q-Flex LNG carriers (i.e., 315 m long, 50 m beam, 109,500 dead weight tonnes) and vessels at the MOF. The marine terminal is expected to be a port-of-call for between 160 and 320 LNG carriers each year. Each LNG carrier will use the proposed shipping route between the Digby Island marine terminal and the Triple Island pilot boarding station. Safe passage of the LNG carriers will be supported by escort and berthing tugs as well as an onboard BC Coast Pilot.

Although very unlikely, LNG carriers and MOF-bound vessels servicing the marine terminal have the potential to become grounded in shallow waters, collide with another vessel along its shipping route, or collide with marine terminal infrastructure. Potential effects associated with such occurrences vary with the magnitude of the event and the type of hazardous materials released into the marine environment (e.g., marine fuel or LNG).

The magnitude of potential effects depends on the chemical composition of the product, the volume of the release, location relative to sensitive environments, and the efficiency of emergency response measures (e.g., deployment of containment and recovery equipment). A credible worst case scenario with a potential consequence of concern is a hull breach and containment failure of one LNG membrane tank (up to 48,000 cubic metres (m^3) in volume) and one marine fuel tank (up to 2,500 m^3 in volume).

In the event of a vessel grounding or collision resulting in a hull breach and containment failure of an LNG membrane tank, up to 48,000m^3 of LNG may be released into the marine environment. Released LNG would vaporize quickly by absorbing heat from contact with warm water surfaces and the atmosphere. The resulting natural gas is only flammable if it occupies a relatively small range of 5 to 15% by volume of air. Water and other surfaces in the immediate vicinity of the spill would freeze. Upon cessation of the spill, the ice created by the spill would warm and melt rapidly back to ambient conditions.

If the LNG is released into the water and vaporizes quickly (i.e., rapid phase transition), a large amount of energy is released from the LNG transition from a liquid to gas. An explosion from pressurized gas in the immediate vicinity where LNG contacts water may occur. This explosion does not involve fire, but it can cause underwater blasts of pressure that could damage structures or injure marine life. Over the history of commercial LNG shipping, there have been no fires or explosions concerning an LNG ship's containment system in port or at sea (GIIGNL 2012).

Released marine fuel (i.e., bunker fuel oil or diesel) is expected to spread quickly on the water surface following release into the marine environment. Diesel is composed of light hydrocarbons and typically disperses and evaporates rapidly into the water column (NOAA 2014). The rapid dispersion and evaporation assists with effective containment and remediation efforts. Dispersed droplets may adsorb or adhere to fine grained shoreline or estuarine sediment. However, due to the expected small volume released, this process rarely results in measurable sediment contamination (NOAA 2014). Diesel degrades quickly within one to two months through naturally occurring processes.

Bunker fuel has a low evaporation rate with a low volatility. It is also persistent in the environment and may take longer to degrade naturally. Bunker fuel could spread on the water surface and form patches or tarballs. Rapid emergency response through the containment and mechanical recovery is effective at limiting the adverse effects from a spill and preventing the material from reaching the shoreline.

Although the probability of LNG carrier grounding or collision is very low, there is potential interaction with the following VCs: Air Quality, GHGs, Water Quality, Marine Fish and Fish Habitat, Marine Mammals, Marine Birds, Infrastructure and Services, Marine Use and Navigable Waters, Community Health, Archaeological and Heritage Resources and Human Health (see Table 9.3-1). Releases from an LNG carrier at berth are addressed in Section 9.10.

9.9.2 Preventative and Response Measures

The LNG carrier industry has a well-documented safety record, with no collisions, explosions, or fires reported since the first LNG carrier sailed in 1964 (GIIGNL 2012). Factors contributing to this long-standing safety record include engineering design and construction of the LNG carrier cargo containment systems, equipment maintenance planning, industry standards, regulatory oversight, and personnel training in the context of applicable operational procedures. LNG carriers are double-hulled; therefore, a hull breach resulting in the release of LNG would require a high-intensity impact penetrating the outer hull, ballast tanks/void spaces, inner hull, and the cargo containment system itself. Within one tanker, there are multiple storage tanks. As such, even if LNG containment is compromised, it is unlikely that more than one LNG tank would be compromised at the same time.

The Project will implement a series of design controls and preventative measures to reduce the probability of grounding or collision of marine vessels including:

- Vessels will be subject to mandatory pilotage while in Canadian waters in compliance with the *Pilotage Act* (2011), Pacific Pilotage Regulations (Government of Canada 2009).
- Vessel crews and operators will have a high standard of training including vessel-specific emergency response protocols.
- Vessels will be operated by experienced master mariners and supported by the BC Coast Pilots for the entire duration of passage within the marine access route.
- Vessels will comply with the speed limits established by the Prince Rupert Port Authority. Vessel movement will rely on the judgement of an experienced ship captain, the local advice from the BC Coast Pilots, and existing environmental conditions.
- Vessels will be equipped with automatic identification systems in compliance with Marine Communications and Traffic System call-in procedures in Prince Rupert.
- Vessels will be equipped with standard navigational safety aids such as emergency steering, radars, electronic charts, navigation lights, sound-signalling devices, and marine VHF radios.
- LNG vessels will be escorted in and out of port by assist tugs while in transit within Prince Rupert Port Authority boundaries or berthing at the marine terminal.
- LNG carriers will be equipped with double-hulled cargo containment systems supported by containment breach sensors to reduce the probability of LNG leakage or rupture.
- Vessels will comply with the *Canada Shipping Act*, 2001, Vessel Pollution and Dangerous Chemicals Regulations.
- Vessels will be certified under the International Association of Classification Societies, which supports maritime safety through international standard training, emergency response protocols, technical support, compliance verification, research, and development.

- LNG carriers built after July 1, 1986 must comply with the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IMO 1993).

Emergency response specific to a vessel grounding or colliding with another vessel away from the marine terminal is within the jurisdiction of the Canadian Coast Guard and Transport Canada. If the vessel collides with the marine terminal, response will be managed through the ERP. LNG carriers using the marine terminal will be required to implement their own emergency response plans, which will meet or exceed Project safety standards. If required, the Project will initiate its ERP to limit adverse effects to the environment, personnel, and the public. The response to grounding of a marine vessel will vary with the extent of the damage to the LNG carrier and the nature of the affected environment. In the event of a Q-Flex LNG carrier hull break of one LNG storage tank or one marine fuel tank, Aurora LNG will support response efforts and may implement the following response measures to mitigate or reduce potential effects:

- Response to hazardous material spills including containment of the spill and clean-up will be carried out by trained, competent, and properly equipped personnel.
- Vessel-specific emergency procedures will comply with the requirements of the Canadian Coast Guard, Transport Canada, and the Marine Mammal Response Program under Fisheries and Oceans Canada.
- Response deployment will be supported by a Transport Canada certified Response Organization (e.g., Western Canada Marine Response Corporation) located in Prince Rupert to foster immediate response to a spill.
- Spill response procedures may include monitoring natural attenuation of released product and/or mechanical containment (e.g., booms) and recovery (e.g., removal using skimmers, sorbents, shoreline clean-up techniques).
- Personnel will notify relevant regulatory agencies, local Aboriginal Groups, stakeholders and authorities.

Clean up, remediation and habitat off-setting will be undertaken, where required, for fish habitat a degraded by a spill of hazardous material into the marine environment causing serious harm to CRA fish species to counterbalance loss of habitat function. Further information on requirements for off-setting programs for serious harm to marine fish and fish habitat is provided in Section 4.9.

9.9.3 Potential Residual Effects

The potential residual effects to each VC from interactions with a vessel grounding or collision event are:

- **Air Quality**—A vessel grounding or collision resulting in a spill of diesel fuel will result in the volatilization of light hydrocarbons. Bunker oil will not volatilize because it is composed of heavy hydrocarbons which have very low volatility. If ignited, the combustion of diesel and bunker oil will emit gases and particulate matter. A spill of LNG will result in the outflow of non-pressurized LNG which will vaporize into natural gas and disperse into the atmosphere. If LNG pooling on the surface of the water ignites from a nearby heat source, incomplete combustion of natural gas will release gases and particulate matter that would affect air quality. Overall, the magnitude of residual effects to air quality would be low and within the geographical extent of the LAA. The emissions associated with a short-term fire from spilled fuel, would not substantially influence the air quality in the region. The frequency would be a single event that is short-term and reversible within a few days as the

emissions dissipate and air quality conditions return to those before the event. The context is characterized as disturbed because air quality is already influenced by other emission sources in the area.

After mitigation and response measures have been implemented following a vessel grounding or collision, the likelihood and consequence of residual effects to air quality are very low. Based on these factors, the risk matrix ranking is remote. Residual effects on air quality from a release related to a vessel grounding or collision are predicted to be not significant.

- **GHGs**— A vessel grounding or collision resulting in a spill of diesel or bunker oil with subsequent ignition of the fuel will emit carbon dioxide into the air. A spill of LNG into the marine environment will result in the outflow of non-pressurized LNG which will vaporize into natural gas and disperse into the atmosphere. The resulting vapour cloud will be mostly facility-processed methane. If liquid pooling on the surface of the water leads to a fire, incomplete combustion of methane will emit carbon dioxide into the air. GHG emissions associated with this scenario involving the release and/or ignition of diesel, bunker oil or natural gas would be negligible in the context of the overall provincial and national GHG emissions totals with a global geographical extent. The emissions would disperse and the environmental effect would not contribute substantially to local or regional GHG emission inventories. The frequency of would be a single event and the contribution of GHGs to the atmosphere is permanent and irreversible within the life of the Project. The context is characterized as disturbed because there are other sources of GHGs in the area.

  After mitigation and response measures have been implemented following a vessel grounding or collision event resulting in a fire or release of LNG, the likelihood and consequence of residual effects to GHG are very low. Based on these factors, the risk matrix ranking is remote. The residual effects on GHG emissions inventories from a release related to a vessel grounding or collision are predicted to be not significant.

  Water Quality—A vessel grounding or collision that results in the release of diesel or bunker oil could affect marine water quality. A vessel grounding or collision resulting in the release of LNG is not expected to substantially change water quality. LNG would volatilize into natural gas quickly upon contact with marine water and disperse in the atmosphere while leaving no residue.

  Depending on the volume of the fuel spilled, the speed of containment response, climate and oceanic conditions at the time of the incident, the geographic extent of the spill could vary but likely to remain within the LAA. Both diesel and bunker oil will float on the water surface; however, diesel will evaporate over time or dissolve into the water column, while bunker oil will not evaporate and remain in the marine environment for months to years. Bunker oil will move along the water surface based on the currents and becoming stranded on the shoreline (Lee et al. 2015).

  Both diesel and bunker oil have the potential to contaminate marine water. There is potential for acute toxicity from the quickly evaporating low molecular weight hydrocarbons (e.g., benzene, toluene, ethylbenzene and xylenes, or other hydrocarbons) which may result in concentrations higher than the applicable marine water quality guidelines for the protection of aquatic life. There is also potential for chronic toxicity from the more persistent higher molecular weight hydrocarbons (e.g., polycyclic aromatic hydrocarbons), which tend to accumulate in sediment, and may have concentrations higher than sediment quality guidelines for the protection of aquatic life.

The magnitude of residual effect to water quality from a vessel grounding or collision resulting in a spill of diesel or LNG is low and within the geographical extent of the LAA. The frequency would be a single event that is short-term and reversible within months. The context of the residual effects to water quality is disturbed, because the area will have been disturbed by human development, namely, the Project.

After mitigation and response measures have been implemented following a vessel grounding or collision event with a spill of diesel or LNG, the likelihood and consequence of residual effects to water quality is low. Based on these factors, the risk matrix ranking is low. Residual effects on marine water quality from a release of diesel or LNG due to a vessel grounding or collision event are predicted to be not significant.

For a vessel grounding or collision resulting in a spill of bunker oil, the magnitude of residual effect to water quality is moderate and within the geographical extent of the LAA. The frequency would be a single event that is medium-term and reversible within months to years. The context of the residual effects to water quality is disturbed, because the area will have been disturbed by human development, namely, the Project.

After mitigation and response measures have been implemented following a vessel grounding or collision event with a spill of bunker oil, the likelihood of residual effects to water quality is low, while the consequence is moderate. Based on these factors, the risk matrix ranking is low. Residual effects on marine water quality from a release bunker oil due to a vessel grounding or collision event are predicted to be not significant.

- **Marine Fish and Fish Habitat**— A vessel grounding or collision may affect marine fish and fish habitat if the event results in the release of LNG, diesel or bunker oil into the marine environment. LNG spilled into the marine environment may freeze the water and cause temporary but rapid changes in water temperature. Fish are considered to be less vulnerable to thermal stress than sessile species because of their ability to physically move away from the affected area. If the LNG spill reaches the shoreline, it could affect intertidal habitats and species.

  Diesel is a volatile light hydrocarbon and typically creates a thin layer of film on the surface of the water. Diesel can be acutely toxic to fish, especially to fish species that live in the upper portions of the water column (US FWS 2004). Bunker oil is composed of heavy hydrocarbons and does not evaporate in appreciable amounts. Bunker oil is persistent in the environment and has a greater potential to mix with shoreline sediments and contaminate intertidal habitats (US FWS 2004). The residual effect is also influenced by the temporal and spatial overlap of any spill with sensitive life stages of fish (e.g., the outmigration of juvenile salmon).

  Depending on the volume spilled, the response mobilization time, the effectiveness of containment response measures, ecological conditions (e.g. presence of sensitive life stages), and environmental and oceanographic conditions (e.g., exposure to sunlight, wave action, and currents), the magnitude of residual effect of a diesel spill or LNG on marine fish and fish habitat would be low and within the geographical extent of the LAA. The frequency of residual effects would be a single event that is short-term and reversible within one to two months (e.g., diesel can be broken down by naturally occurring microbes within one to two months (NOAA 2014), while LNG would evaporate within hours). The context for changes to marine fish and fish habitat is resilient, because the VC is able to tolerate changes relative to existing conditions and the viability of the marine fish population is not expected to be affected.

Any subsequent ignition of the spilled LNG has the potential to cause injury or mortality of marine fish that come in direct contact with the fire. Rapid phase transition associated with the release of LNG into the water could create underwater shock waves and potentially cause injury or mortality of marine fish in the immediate area.

After mitigation and response measures have been implemented following a vessel grounding or collision event resulting in a spill of diesel, the likelihood and consequence of residual effects to marine fish and fish habitat are low. Based on these factors, the risk matrix ranking is low. Residual effects on marine water quality from diesel or bunker fuel due to a vessel grounding or collision event are predicted to be not significant.

For vessel grounding or collision events resulting in a spill of bunker oil, the magnitude of residual effects to marine fish and fish habitat is moderate and within the geographical extent of the LAA. The frequency of residual effects is a single event that could be long-term but reversible within months to years (e.g., bunker fuel can persist in the marine environment and if left to weather, clean-up efforts can be difficult and continue over the long-term (US FWS 2004)). The context for changes to marine fish and fish habitat is resilient, because the VC is able to tolerate changes relative to existing conditions and the viability of the marine fish population is not expected to be affected.

After mitigation and response measures have been implemented following a vessel grounding or collision event resulting in a spill of bunker oil, there is a medium likelihood of residual effects to marine fish and fish habitat. The consequence of residual effects is moderate. Based on these factors, the risk matrix ranking is moderate. Residual effects on marine water quality from diesel or bunker fuel due to a vessel grounding or collision event are predicted to be not significant.

- **Marine Mammals**— A vessel grounding or collision may affect marine mammals if the event results in the release of LNG, diesel or bunker oil into the marine environment. The scale of potential residual effects on marine mammals will depend on the material released (e.g., bunker oil is likely to be of greater concern to marine mammals than LNG or diesel), the volume of the spill, the speed of containment response, climate and oceanic conditions at the time of the incident, and the seasonal timing and area of occurrence (i.e., relative to important marine mammal areas). Following a spill, exposure to concentrations of vapours above the spill (e.g., volatile hydrocarbons or a methane vapour cloud) is the most immediate threat to marine mammal health, and could lead to lethargy and intoxication, asphyxiation, lung damage, or freezing. Contact with oil or vapours may also damage soft tissues and act as an irritant to mucous membranes of the eyes and airways; this may also lead to secondary sources of infection.

  The magnitude of residual effects from a vessel grounding or collision resulting in a spill of LNG or diesel would be low and within the geographical extent of the LAA. The frequency of the residual effect would be a single event that is short-term and reversible within days to months. The context of residual effects to marine mammals is disturbed because the event would take place in an area that has been substantially disturbed by human development.

  After mitigation and response measures have been implemented following a vessel grounding or collision event resulting in a spill of LNG or diesel, the likelihood and consequence of residual effects to marine mammals are low. Based on these factors, the risk matrix ranking is low and the residual effects to marine mammals are predicted to be not significant.

Bunker fuel can contaminate fur and baleen, and may diminish capacity to feed, swim, or thermoregulate, or lead to toxicity through ingestion. Bunker oil bioaccumulates in zooplankton, entering the marine food web. Its ingestion by marine mammals can affect physiology, reproductive performance and the immune response systems.

In the event of a vessel grounding or collision resulting in a spill of bunker oil, the magnitude of residual effects on marine mammals would be moderate and within the geographic extent of the LAA. The frequency of the residual effect is a single event that is long-term and reversible within one year. The context of residual effects to marine mammals is disturbed because the event would take place in an area that has been substantially disturbed by human development.

After mitigation and response measures have been implemented following a vessel grounding or collision event resulting in a large-scale release of bunker oil, there is a medium likelihood of residual effects to marine mammals. The consequence of residual effects is moderate. Based on these factors, the risk matrix ranking is moderate. This scenario could result in acute effects on marine mammal species at risk or forage fish with potential population-level effects on marine mammals. Should this occur, residual effects on marine mammals could be significant.

In the event of a large-scale bunker oil or diesel spill reaching the marine environment, the magnitude of residual effect on marine mammals may be greater than predicted. If a large-scale spill result in acute effects (e.g., mortality) on marine mammal species at risk, or adversely affect breeding habitat or foraging opportunities for marine mammal species at risk, recovery may be further delayed. Likewise, should the spill occur near important areas for marine mammals, there may be population-level effects.

- **Marine Birds**— Marine birds may experience direct habitat loss and suffer acute or chronic effects from direct contact with released diesel or bunker oil or from feeding on contaminated invertebrate or fish prey in affected areas. Long-term physiological changes may result in lower reproductive success or other sub-lethal effects. In the unlikely event of a large-scale bunker oil or diesel spill in the marine environment, the magnitude of residual effect on marine birds is moderate and within the geographical extent of the LAA. The frequency of residual effects is a single event that is short-term and reversible within one year or less. The context for changes to marine birds is resilient, because marine bird species or species groups are able to tolerate changes relative to existing conditions and the viability of the population is not expected to be affected. A spill of LNG is not expected to have any lasting effect on marine birds because they are expected to immediately leave the area of an LNG spill due to the vapour cloud formation. LNG would not leave a residue in the marine environment that could accumulate in the food chain.

  After mitigation and response measures have been implemented following a vessel grounding or collision event resulting in the release of diesel or bunker oil, there is a medium likelihood of residual effects to marine birds. The consequence of residual effects is moderate. Based on these factors, the risk matrix ranking is moderate. Residual effects from a small-scale spill entering the marine environment and affecting marine birds are predicted to be not significant. Small-scale spills would be dispersed through wave action and may affect individual animals but have a limited effect at the population-level. Should a large-scale on-shore spill entering the marine environment result in population-level effects on marine birds, the residual effect would be significant.
- **Infrastructure and Services**—The terminal operator will work in collaboration with vessel operators, regulatory agencies and the Prince Rupert Port Authority to address spills resulting from vessel

grounding or collision with another vessel. For example, response deployment will be supported by a Transport Canada certified Response Organization (e.g., Western Canada Marine Response Corporation) located in Prince Rupert to foster immediate response to a spill. The residual effect may include delays in availability of local infrastructure and services. The magnitude of the residual effect is low, and within the geographical extent of the LAA. The frequency of residual effects would be a single event that is short-term and reversible within one month. The context of residual effects is resilient (moderate) because infrastructure and services can accommodate moderate levels of increased demand.

After mitigation and response measures have been implemented following a vessel grounding or collision event, the likelihood of residual effects to infrastructure and services is low, while the consequence is very low. Based on these factors, the risk matrix ranking is remote. Residual effects on infrastructure and services related to a spill resulting from a vessel grounding or collision are predicted to be not significant.

- **Marine Use and Navigable Waters**—A spill of diesel, bunker oil or LNG may temporarily delay marine traffic and fishing activity in the immediate vicinity of a vessel accident, but is expected to be localized and reversible within one month or less. In the event of a spill of marine fuel it is expected that a localized ban on fishing would occur within the area affected by the spill, imposed by regulatory authorities and harvested foods from the area could be perceived as less desirable thus affecting marketability of the fish. The magnitude of the residual effect would be low and within the geographical extent of the LAA. The frequency of the residual effect is a single event that is short-term and reversible within one year or less, assuming the release does not result in a population level effect on CRA fish. The context for residual effects to marine use and navigable waters is resilient (high) because this VC can incur a high level of disturbance without adverse effects.

  After mitigation and response measures have been implemented following a vessel grounding or collision event, the likelihood and consequence of residual effects to marine use and navigable waters are very low. Based on these factors, the risk matrix ranking is remote and the residual effects are not significant.

- **Community Health -** In the event of a spill of diesel or bunker oil, a localized ban on fishing within the area affected by the spill may be imposed by regulatory authorities. Harvested foods from the affected area could be perceived as less desirable thus affecting the consumption of marine resources (e.g., fish, seaweed etc.). The magnitude of the residual effect to community health would be low and within the geographical extent of the LAA. The frequency of the residual would be a single event that is short-term in duration and reversible within one year, assuming the release does not result in a population level effect on marine resources. The context of residual effects to community health is resilient (moderate) because community health is moderate and slightly vulnerable to social, economic and environmental change.

  After mitigation and response measures have been implemented following a vessel grounding or collision event, the likelihood and consequence of residual effects are very low. Based on these factors, the risk matrix ranking is remote and the residual effects are not significant.

Although worker safety is beyond the scope of this assessment, death or serious injury to workers from a Project-related vessel grounding or collision could affect community health and well-being in those communities in which local workers and their families live. Counselling and trauma support services may be required and may exceed existing local and regional capacity in the short-term. The residual effects could be greater than those predicted.

- **Human Health**— A spill of diesel or bunker oil could impact water and sediment quality as discussed above, which in turn could affect the quality of marine country foods. Consumption of affected marine country foods could affect human health. In the event of a spill of diesel or bunker oil it is expected that a localized ban on harvesting marine foods would occur within the area affected by the spill, imposed by regulatory authorities. Such a ban would limit human exposures to marine foods containing contaminants. People may continue to harvest outside of the ban area and consume those foods safely. As a result, the magnitude of residual effect to human health is negligible and within the geographical extent of the LAA. The frequency of the residual effect is a single event that is short-term and reversible within one year or less. The context of residual effects to human health is resilient, indicating that there is a high capacity for human health to recover from a perturbation.

  After mitigation and response measures have been implemented following a vessel grounding or collision event resulting in a release of diesel or bunker oil, the likelihood and consequence of residual effects to human health are very low. Based on these factors, the risk matrix ranking is remote. Residual effects on human health are not significant.

9.9.4 Conclusions

With the implementation of best practices, regulatory requirements and company standards, an accident scenario involving a vessel grounding or collision may have significant residual effects to marine mammals (for events involving a spill of bunker oil) and marine birds.

The residual effects to other VCs that have the potential for interaction with a vessel grounding or collision (i.e., air quality, GHGs, water quality, marine fish and fish habitat, marine mammals (for events involving a spill of LNG or diesel), infrastructure and services, marine use and navigable waters, community health and human health) are not significant. A summary of the residual effects and significance from an accidents and malfunctions scenario involving on-shore hazardous spills is in Table 9.9-1.

Table 9.9-1 Summary of Residual Effects – Vessel Grounding or Collision

Valued Component	Residual Effects Characterization						Likelihood	Consequence	Risk Matrix Ranking	Significance
	Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Context				
Air Quality	L	LAA	S	ST	R	D	Very Low	Very Low	Remote	Not significant
Greenhouse Gases	N	G	S	P	I	D	Very Low	Very Low	Remote	Not significant
Water Quality	L[1] M[2]	LAA	S	ST[1] MT[2]	R	D	Low	Low[1] Moderate[2]	Low	Not significant
Marine Fish and Fish Habitat	L[1] M[2]	LAA	S	ST[1] LT[2]	R	R	Low[1] Medium[2]	Low[1] Moderate[2]	Low[1] Moderate[2]	Not significant
Marine Mammals	L[1] M[2]	LAA	S	ST[1] LT[2]	R	D	Low[1] Medium[2]	Low[1] Moderate[2]	Low[1] Moderate[2]	Not significant[1] Significant[2]
Marine Birds	M	LAA	S	ST	R	R	Medium	Moderate	Moderate	Significant
Infrastructure and Services	L	LAA	S	ST	R	R	Low	Very Low	Remote	Not significant
Marine Use and Navigable Waters	L	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant
Community Health	L	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant
Human Health	N	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant

NOTES:

[1] Characterization for vessel grounding or collision event with a spill of LNG or diesel.

[2] Characterization for vessel grounding or collision event with a spill of bunker oil.

KEY

Magnitude:	**Geographic Extent:**	**Frequency:**	**Duration:**	**Reversibility:**	**Context:**
N: Negligible	PDA: Project development area	S: Single event	ST: Short-term	R: Reversible	D: Disturbed
L: Low	LAA: Local assessment area	MI: Multiple irregular events	MT: Medium-term	I: Irreversible	U: Undisturbed
M: Moderate	RAA: Regional assessment area	MR: Multiple regular events	LT: Long-term		R: Resilient
H: High	G: Global	C: Continuous	P: Permanent		N: Not resilient

9.10 LNG Releases at the Loading Facility

9.10.1 Description of Event or Interactions

This accident or malfunction scenario includes the potential for cryogenic releases of LNG at the loading facility. The likely worst case scenario for an LNG carrier while loading would be a separation of the LNG loading arm or loading line from the carrier resulting in the release of non-pressurized LNG and liquid pool formation on water with a subsequent vapour cloud of natural gas. Released LNG is expected to spread across the water surface, possibly freezing the water in the immediate vicinity. If spilled on a metal surface, contact with LNG may make the metal brittle. The vaporization of LNG to natural gas would create a dense fog in the immediate vicinity and reduce visibility of the affected area.

The natural gas vapour cloud will disperse into the atmosphere as natural gas is lighter than air, and the vapour cloud is only flammable if it occupies a range of 5 to 15% by volume of air. The probability of ignition of the vapour cloud is low. Ignition of the vapour cloud would result in a fire that would burn back to the source or to the LNG pool and continue as a pool fire over water. Natural gas vapours generated from the LNG pool will continue to burn until the LNG has evaporated. An explosion is not a likely scenario because LNG is not pressurized.

If the LNG is released into the water and vaporizes quickly (i.e., rapid phase transition), a large amount of energy may be released from the rapid transition of LNG from a liquid to gas. An explosion from pressurized gas in the immediate vicinity where LNG contacts water may occur. This explosion does not involve fire, but it can cause underwater blasts of pressure that could damage structures or injure marine life.

Although the probability of cryogenic releases of LNG at the loading facility is very low, there is potential interaction with Air Quality, GHGs, Water Quality, Marine Fish and Fish Habitat, Marine Mammals, Marine Birds, Marine Use and Navigable Waters, Community Health, and Human Health VCs (see Table 9.3-1).

Releases of other types of hazardous substances originating from on-shore spills and vessel collisions and groundings are addressed in Section 9.8 and Section 9.9, respectively.

9.10.2 Preventative and Response Measures

The Project will implement a series of preventative measures to reduce the probability of a cryogenic release of LNG during loading and/or reduce the volume that could be released. Design controls and preventative measures will include:

- Aurora LNG will consider Society of International Gas Tanker and Terminal Operators and Oil Companies International Marine Forum guidelines in its siting, design and operations
- The marine terminal will be equipped with safe-guarding instruments including process alarms, gas detection and fire detection systems
- The consideration of a spill basin designed into the jetty along with emergency shutdown systems that will be engaged to stop the flow of LNG from the loading arm which would limit the volume of LNG released
- Standard terminal procedures will be used to enhance safety and reduce the probability of a cryogenic spill.

In the event of a cryogenic spill of LNG at the loading facility, the ERP will be initiated. The ERP describes provisions for spill response to limit adverse effects to sensitive environmental receptors, personnel, and the public. The response to the spill will vary depending on several factors including the volume of the released product. Response strategies will include standard operating procedures to response to specific emergencies situations, and will include:

- Securing of the source of the release (i.e., valves closed, patching tanks) to stop the ongoing spill
- Response by trained, competent and properly equipped personnel
- Notification of relevant regulatory agencies, potentially affected Aboriginal Groups, and stakeholders .

Since LNG evaporates quickly and does not leave a residue, a spill clean-up is not anticipated. If water freezes and results in damage to the environment, appropriate restoration programs will be deployed.

9.10.3 Potential Residual Effects

The potential residual effects to each VC from interactions with an LNG release at the loading facility are:

- **Air Quality**— A release of LNG will result in the outflow of non-pressurized LNG which will vaporize and quickly disperse into the atmosphere as methane gas. If natural gas generated from vaporizing LNG ignites and/or leads to an explosion, incomplete combustion of methane will release criteria air contaminants that would affect air quality. The magnitude of residual effects to air quality would be low and within the geographical extent of the LAA. The frequency of the residual effect to air quality would be a single event with a short-term duration that is reversible within a few days as the emissions dissipate and disperse in the atmosphere. The context is characterized as disturbed because air quality is already influenced by other emission sources in the area.

  After mitigation and response measures have been implemented following a release of LNG at the loading facility, the likelihood of residual effects to air quality is low, while the consequence is very low. Based on these factors, the risk matrix ranking is remote. Residual effects on air quality are predicted to be not significant.

- **GHGs**— A release of LNG at the loading facility will result in the outflow of non-pressurized LNG which will vaporize and quickly disperse into the atmosphere. The resulting vapour cloud will be mostly facility-processed methane and some nitrogen. If natural gas generated from vaporizing LNG ignites and/or leads to an explosion, some of the methane will be converted to carbon dioxide during the combustion process. The emissions of methane and carbon dioxide would disperse and the environmental effect would not contribute substantially to local or regional GHG inventories. Therefore, the magnitude of residual effects to GHGs would be negligible with a global geographical extent. The frequency of the residual effect would be a single event that is permanent in duration and irreversible. The context is characterized as disturbed because there are other sources of GHGs in the area. The emissions would disperse and the environmental effect would not substantially change local or regional GHG inventories.

  After mitigation and response measures have been implemented following an LNG release at the loading facility, the likelihood of residual effects for GHGs is low and the consequence is very low. Based on these factors, the risk matrix ranking is remote. Residual effects from a release from an LNG carrier during loading on overall provincial and national GHG emission totals are predicted to be not significant.

- **Water Quality**— A release of LNG at the loading facility that enters the marine environment would have limited effects to water quality. The LNG would quickly absorb heat energy upon contact with water and vaporize into natural gas. Contact with LNG may temporarily freeze the surface of the marine water for the duration that LNG remains in direct contact with the water surface. LNG does not leave a chemical trace in the water after it has evaporated. Consequently, the magnitude of residual effect to air quality is negligible and within the geographic extent of the LAA. The frequency of the residual effect is a single even that is short-term in duration and reversible within hours or days of the event. The context of the residual effects to water quality is disturbed, because the area will have been disturbed by human development, namely, the Project.

  After mitigation and response measures have been implemented following an LNG release, the likelihood and consequence of residual effects to water quality are very low. Based on these factors, the risk matrix ranking is remote. Residual effects to water quality from a release of LNG at the loading facility are predicted to be not significant.

- **Marine Fish and Fish Habitat**—A release of LNG at the loading facility could enter the marine environment and result in sudden temperature changes that could have lethal or sublethal effects on marine organisms present at the air/water interface. Fish are considered to be less vulnerable to thermal stress than sessile species because of their ability to physically move away from the affected area. If the LNG release reaches the shoreline, it could affect intertidal habitats and species.

  Any subsequent ignition of natural gas vapours generated from a release of LNG at the loading facility has the potential to cause injury or mortality of marine fish that come in direct contact with the fire. The release of large volumes of LNG into marine water may result in rapid phase transition where large volumes of natural gas are produced rapidly, leading to an explosion of gas pressure that does not involve fire or ignition. The explosion of pressure could create underwater shock waves and potentially cause injury or mortality of marine fish in the immediate area. However, these effects are not expected to affect the viability of the fish population. The magnitude of residual effects to marine fish and fish habitat would be low and within the geographic extent of the LAA. The frequency of residual effects is a single event that is short-term in duration and reversible within days to months. The context for residual effects to freshwater fish and fish habitat is resilient because the VC is able to assimilate the additional change.

  After mitigation and response measures have been implemented following an LNG release at the loading facility, the likelihood of residual effects to marine fish and fish habitat is low, while the consequence is very low. Based on these factors, the risk matrix ranking is remote. Residual effects on marine fish during loading of LNG vessels are predicted to be not significant.

- **Marine Mammals**— Marine mammals may suffer acute effects from a release of LNG at the loading facility if they are located in the immediate vicinity of the release when it occurs. The residual effects may result from a sudden change in temperature when LNG contacts water, or from a non-fire pressure explosion resulting from rapid phase transition when large volumes of natural gas are produced when LNG contacts water. In the event of an LNG release at the loading facility that reaches the water, magnitude of potential effects on marine mammals are likely localized and reversible within one year or less. If the release of LNG results in acute effects (e.g., mortality) on marine mammal species at risk either from direct exposure or injury from a pressure explosion, recovery may be further delayed. The context of residual effects to marine mammals is disturbed

because the event would take place in an area that has been substantially disturbed by human development.

After mitigation and response measures have been implemented following an LNG release from the loading facility, the likelihood of residual effects to marine mammals is high, while the consequence is moderate. Based on these factors, the risk matrix ranking is moderate. If the release of LNG results in acute effects (e.g., mortality) on marine mammal species at risk the residual effects may be significant.

- **Marine Birds**— Marine birds may experience direct habitat loss, reduced foraging opportunities resulting from direct mortality of prey that is exposed to the released LNG and its subsequent effects (e.g., freezing of water and rapid phase transition pressure explosions). Since the effects of an LNG release is limited to the immediate area, the magnitude of the residual effect is low and within the geographic extent of the LAA. Individual marine birds may be affected, but the effects are unlikely to affect the short-term and long-term viability of the population of marine birds. The frequency of the effect would be a single event that is short-term in duration and reversible within one month or less. The context for changes to marine birds is resilient, because marine bird species or species groups are able to tolerate changes relative to existing conditions and the viability of the population is not expected to be affected.

  After mitigation and response measures have been implemented following a release from an LNG carrier, the likelihood and consequence of residual effects to marine birds are low. Based on these factors, the risk matrix ranking is low. Residual on marine birds are predicted to be not significant.

- **Marine Use and Navigable Waters**—A release of LNG may temporarily delay marine traffic for safety purposes in the immediate vicinity, and would be dependent on the volume of LNG released. The magnitude of residual effects to marine use and navigable waters is negligible and within the geographical extent of the LAA. The frequency of the effect is a single event that is short-term in duration and reversible within days. The residual effect to marine use and navigable waters is not likely to substantially restrict commercial, traditional or recreational fishing activity. The context for residual effects to marine use and navigable waters is resilient (high) because this VC can incur a high level of disturbance without adverse effects.

  After mitigation measures have been implemented following an LNG release at the loading facility, the likelihood and consequence of residual effects to marine use and navigable waters are very low. Based on these factors, the risk matrix ranking is remote. Residual effects on marine use and navigable waters are predicted to be not significant.

- **Community Health**—Although worker safety is beyond the scope of this assessment, death or serious injury to workers from a release of LNG at the loading facility could affect community health and well-being in those communities in which local workers and their families live. Counselling and trauma support services may be required and may exceed existing local and regional capacity in the short-term. The magnitude of residual effects to community health in the event of a serious injury or loss of human life would be high and within the geographical extent of the LAA. The frequency of the residual effect to community health would be continuous with and long-term in duration that is irreversible. The context of residual effects to community health is resilient (moderate) because community health is moderate and slightly vulnerable to social, economic and environmental change.

After mitigation measures have been implemented following an LNG release at the loading facility that results in serious injury or loss of human life, the likelihood of residual effects to community health is high and the consequence is very high. Based on these rankings, the risk matrix ranking is very high and the residual effects to community health are significant.

If an LNG release at the loading facility does not result in serious injury or loss of human life, the magnitude of residual effects to community health would be low and within the geographical extent of the LAA. The frequency of the residual effect would be a single event that is short-term and reversible within one year. The context of residual effects to community health is resilient (moderate) because community health is moderate and slightly vulnerable to social, economic and environmental change.

After mitigation measures have been implemented following an LNG release at the loading facility that does not result in serious injury or loss of human life, the likelihood of residual effects to community health are very low. Based on these rankings, the risk matrix ranking is remote and the residual effects to community health are not significant.

- **Human Health**—In the event of an LNG release at the loading facility, the immediate safety concern would be the potential for physical contact with LNG due to its sub-zero storage temperature and freezing properties. Inhalation of natural gas vapours is not a health concern because natural gas is not toxic when inhaled. Inhalation exposure to a natural gas vapour cloud is also not expected to displace oxygen in an outdoor environment to the extent that it poses a risk of asphyxiation to people.

  If the natural gas vapour cloud ignites, a fire could affect air quality with subsequent effects to human health. Inhaled smoke particulates and other emissions could affect health sensitive individuals with pre-existing respiratory problems. The magnitude of the residual effect would be negligible and localized within the LAA in the immediate vicinity of the fire. Smoke and particulates are not expected to travel to populated areas in Dodge Cove, Prince Rupert or Port Edward in concentrations that would have effects to human health. People may also avoid inhalation exposure by remaining indoors and closing windows. The frequency of residual effects to human health would be a single event that is short-term and reversible within days because any smoke and particulates would disperse after the fire has been extinguished. The context of residual effects to human health is resilient, indicating that there is a high capacity for human health to recover from a perturbation.

  After mitigation and response measures have been implemented following a release from an LNG carrier during loading the likelihood and consequence of residual effects to human health are very low. Based on these factors, the risk matrix ranking is remote. Residual effects on human health from an LNG release during vessel loading are predicted to be not significant.

9.10.4 Conclusions

With the implementation of best practices, regulatory requirements and company standards, an accident or malfunction scenario involving an LNG release at the loading facility may have significant residual effects to marine mammals and community health (if the event results in a serious injury or loss of human life).

The residual effects to other VCs that have the potential for interaction with an LNG release at the loading facility (i.e., air quality, GHGs, water quality, marine fish and fish habitat, marine birds, marine use and navigable waters, community health and human health) are not significant. A summary of the residual effects and significance from an accidents and malfunctions scenario involving on-shore hazardous spills is in Table 9.10-1.

Table 9.10-1 Summary of Residual Effects – LNG Release at the Loading Facility

Valued Component	Residual Effects Characterization						Likelihood	Consequence	Risk Matrix Ranking	Significance
	Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Context				
Air Quality	L	LAA	S	ST	R	D	Low	Very Low	Remote	Not significant
Greenhouse Gases	N	G	S	P	I	D	Low	Very Low	Remote	Not significant
Water Quality	N	LAA	S	ST	R	D	Very Low	Very Low	Remote	Not significant
Marine Fish and Fish Habitat	L	LAA	S	ST	R	R	Low	Very Low	Remote	Not significant
Marine Mammals	M	LAA	S	ST	R	D	High	Moderate	Moderate	Significant
Marine Birds	L	LAA	S	ST	R	R	Low	Low	Low	Not significant
Marine Use and Navigable Waters	N	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant
Community Health[1]	L[1] H[2]	LAA	S[1] C[2]	ST[1] LT[2]	R[1] I[2]	R	Very Low[1] High[2]	Very Low[1] Very High[2]	Remote[1] Very High[2]	Not significant[1] Significant[2]
Human Health	N	LAA	S	ST	R	R	Very Low	Very Low	Remote	Not significant

NOTES:

[1] Characterization for LNG releases at the loading facility that does not result in serious injury or the loss of human life.

[2] Characterization for LNG releases at the loading facility that results in serious injury or the loss of human life.

KEY

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PDA: Project development area
LAA: Local assessment area
RAA: Regional assessment area
G: Global

Frequency:
S: Single event
MI: Multiple irregular events
MR: Multiple regular events
C: Continuous

Duration:
ST: Short-term
MT: Medium-term
LT: Long-term
P: Permanent

Reversibility:
R: Reversible
I: Irreversible

Context:
D: Disturbed
U: Undisturbed
R: Resilient
N: Not resilient

9.11 Potential Cumulative Effects

CEAA's Operational Policy Statement titled "Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act*, 2012" (Government of Canada 2012) requires that "the environmental effects of accidents or malfunctions must be considered in the assessment of cumulative environmental effects if they are likely to result from the designated project in combination with other physical activities that have been or will be carried out."

Project accidents or malfunctions that are likely to result from the Project in combination with other physical activities that have been or will be carried out within the RAA are associated with vessel-to-vessel collisions. Cumulative effects associated with other accidents and malfunctions are considered to be highly unlikely given the low probability of these scenarios occurring, and the low probability of temporal or spatial overlap with other projects and activities. Project-bound vessel traffic (both LNG carriers and MOF-bound vessels) will increase the number of vessels along the shipping route. Daily shipping traffic in Prince Rupert Harbour is managed by the Prince Rupert Port Authority Harbour Master in coordination with the Canadian Coast Guard, Pacific Pilotage Authority, Transport Canada, and the Royal Canadian Mounted Police (see Section 6.5). In 2014, shipping traffic peaked with about 650 vessels using the Port of Prince Rupert. The majority of piloted shipping traffic was from bulk and container carriers. Introduction of Project-bound LNG carriers and MOF-bound vessels will increase the probability of a vessel-to-vessel collision along the shipping route. However, the probability of a vessel-to-vessel collision is very low given that vessel traffic management is designed to mitigate the probability for such events along with the use of escort tugs and on-board pilots. Section 6.5 notes that potential residual effects of Project-bound vessels are likely to act cumulatively with other large ship traffic (i.e., over 300 gross tonnages). By implementing mitigation and response measures outlined in Section 6.5 (e.g., port traffic management, land-based radar and real-time tidal current sensors, and operating at safe speeds for the given marine area and marine conditions), the probability of a vessel-to-vessel collision is effectively reduced. However, if a vessel-to-vessel collision were to occur, the potential cumulative effects are expected to be significant for marine mammals and marine birds if the event results in a release of diesel and/or bunker oil, similar to the scenario described in Section 9.9.

9.12 Summary of Effects of Accidents or Malfunctions

This assessment of accidents and malfunction focused on scenarios identified in the AIR that were identified based on experience with similar projects, input from regulators and the Working Group and professional judgment. Each scenario considered in the assessment was deemed to be likely with a potential consequence of concern for various VCs.

The proposed Project will be designed, constructed and operated with full regard to environmental protection and human health and safety. To manage or mitigate the risk associated with each accident and malfunction scenario, suitable Project design, preventative, mitigation and emergency response measures were proposed. If an accident and malfunction scenario had the potential to interact with a VC, potential residual effects after the application of mitigation and response measures were characterized as a function of likelihood, consequence, and risk, followed by a significance determination.

Potential adverse residual effects were assessed as significant for the following VCs:

- **Motor vehicle collisions** – No significant residual effects to any VC.
- **Facility impact from aircraft** – Community Health (if the scenario involves the loss of human life).
- **On-shore fires or explosions** – Vegetation and Wetland Resources (for large scale fires or explosions), Wildlife Resources (Terrestrial) (for large scale fires or explosions), Community Health, and Archaeological and Heritage Resources.
- **LNG plant malfunctions** – No significant residual effects to any VC.
- **On-shore hazardous spills**– Vegetation and Wetland Resources, Marine Mammals and Marine Birds.
- **Vessel grounding or collision** – Marine Mammals (if bunker oil is spilled) and Marine Birds.
- **LNG release at the loading facility**- Marine Mammals and Community Health (if the scenario involves the loss of human life).

Regarding potential residual cumulative effects, after mitigation, which includes adherence to the EMP and the ERP (see Section 14.0), the cumulative residual effects from spills of diesel and/or bunker oil from a vessel-to-vessel collision are assessed as significant for marine mammals and marine birds similar to the conditions described in Section 9.9.

9.13 References

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