SECTION 3.0 PROJECT DESCRIPTION





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3.0 **PROJECT DESCRIPTION**

3.1 **Project Components, Structures, and Site Layout**

The Project description presented in this section is based on a preliminary and conceptual design (CB&I, 2013a). It will be further developed through a FEED process which will commence immediately upon receipt of EA approval.

The Project comprises an onshore gas processing plant, a marine terminal for loading carriers with LNG product and a wharf for mooring associated support vessels and unloading materials during construction. The key components of the proposed facility are listed in Table 3.1-1.

Components	Description
Natural Gas Liquefaction Plant	 A facility for converting 10 Mtpa of natural gas from the M&NP pipeline into LNG at atmospheric pressures and approximately -162 Degrees Celsius (°C) for export to overseas markets. Refer to Section 3.1.2, below.
LNG Storage Tanks	 Full containment LNG cryogenic storage tanks shall be utilised each with a net storage capacity of 210,000 m³ which equates to a gross capacity of around 230,000 m³. Two LNG tanks are considered for Phase 1, with potential for an additional one depending on storage required during Phase 2 determined by results of studies.
Marine Facilities	 A jetty trestle for the LNG transfer lines and access road, and two LNG ship loading berths (the second berth for future development). A marine wharf for the unloading of construction equipment and materials and for mooring of the tug and pilot vessels.
180 MW Power Plant	 On-site (gas turbine) power generation to support the LNG facility and support services. Emergency diesel generator sets provided for essential loads.
Feed Gas Pipeline and Inlet Facilities	 Supply pipeline from the M&NP pipeline including pigging and metering.
Potable Water Pipeline and Intake Structure	• Supply pipeline from a new intake structure at Meadow Lake to Facility for necessary treatment.
Buildings and Utilities	 Various administrative, control and maintenance buildings. Utilities units to support the liquefaction and export facilities. On-site power generation suitable for 114 kiloVolt-amps (kVA).
Temporary Work Camp	 For the duration of the construction phase, the Project will include a work camp situated along the northern site boundary.
Information Centre	 With the start of the construction activities Pieridae is planning on operating an information centre at the Project site.

 Table 3.1-1
 Key Components - Goldboro LNG Project



A non-technical overview of the layout of the plant and the marine terminal is included in Figures 3.1-1 to 3.1-2. For technical reviewers, engineering drawings are located in Appendix B (Appendix B-1). The following sections describe the conceptual designs of the various Project components, highlight the design approaches, and indicate key design considerations.

3.1.1 Technical Requirements and Standards

The design of the LNG terminal will at a minimum meet the current requirements of the principle North American standards including: Canadian Standards Association (CSA) Z276-11 *"Liquefied Natural Gas (LNG) – Production, Storage, and Handling"* and National Fire Protection Association (NFPA) 59A *"Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)"*. The provisions for seismic design will be adopted from the National Building Code of Canada (NBCC) for the Safe Shutdown Earthquake.

Given that CSA Z276-11 does not explicitly address full containment storage tanks, the provisions of the US Standard NFPA 59A will be adopted. Both CSA Z276-11 and NFPA 59A provide a comprehensive list of standards that are to be met for the design and operation of LNG facilities and storage/containment tanks. Environmental loads will be based on NBCC, with the provisions of CSA Z276-11 prevailing where conflict exists.

The marine facilities will be designed and operated in general accordance with key guidelines from the following organizations:

- Transport Canada (TC) (Technical Review Process of Marine Terminal Systems in Transhipment Sites (TERMPOL) process);
- International Maritime Organization (IMO);
- Oil Companies International Marine Forum; and
- Society of International Gas Tanker & Terminal Operators.

3.1.2 LNG Liquefaction Plant

The Goldboro LNG onshore facility will comprise the following major components:

- inlet facilities and feed gas compression;
- gas treatment facilities;
- two natural gas liquefaction trains;
- near Atmospheric LNG storage and Boil-off Gas (BOG) compression;
- refrigerant storage;
- on-plot power generation;
- flare stacks;
- raw water extraction and storage;
- plant utilities;
- wastewater and stormwater management;
- administration and control buildings; and
- truck loading facility.



The general LNG plant layout is shown in Figure 3.1-2. Technical reviewers should refer to Appendix B-1. Further details of each component and its operation are provided in Sections 3.2.5 and 3.3 below.

The layout of the plant is designed in such a manner so as to be cognisant of safe separation requirement for areas and equipment during simultaneous operations of Phase 1 and Phase 2. In addition, due to the phased nature of the Project providing appropriate spacing to allow for uninterrupted safe operational activities of Phase 1 whilst allowing expansion construction activities to be carried out in parallel is a key design consideration. The relative positions of buildings, equipment and process units are in accordance with the distances indicated in appropriate codes and standards. This is supported by best engineering practices, which due to the early nature of the design include benchmarking against similar projects and preliminary safety studies. During the FEED and detailed design the proposed plot plan will be subject to detail model reviews at pre-defined stages. These shall cover conformity of design to scope of work, applicable company and regulatory design codes and guidelines, constructability, safety and operations. In addition to this, the layout will be subject to further constructability, safety and environmental reviews. The layout ensures that each LNG train shall be accessible from two sides to allow for escape routes and access for maintenance vehicles, escape routes and muster stations will be further defined during the FEED.

Sensible design approaches with regards to spacing, for example, positioning power generation and utilities to the northeast of the plant to allow for ease of alignment with the gas inlet facilities have also been adopted in developing the layout.

The site allows direct access for the construction of the LNG train areas via a Haul road from the Marine Offloading Facility (MOF) which can be fenced off from the operating process plant and controlled. This allows Phase 2 to be constructed while Phase 1 is operating. The Haul road facilitates module delivery to the plant during the construction phases. Site roads have been located for ease of access for construction and operation phases.

3.1.3 Marine Facilities

The marine portion of the works includes the following elements: jetty trestle and roadway; jetty heads and loading berths; and marginal wharf for tug boat protection and unloading during construction.

The marine terminal will be designed to accommodate LNG carriers ranging in capacity from 125,000 m³ to 266,000 m³.

The layout of the marine terminal has been arranged so as to avoid the need for dredging whilst retaining access into the channel leading to Isaac's and Country Harbours. The proposed layout of the marine facilities is included in Figure 3.1-1. A technical drawing which includes the vessel turning radius is included in Appendix B-1 (Overall Plot Plan – Jetty & Berthing). Marine studies are on-going, however, and the final alignment and length of the jetty is subject to their completion.



During pre-FEED development an assessment of the final approach routes to the LNG jetty was carried out, including a review of tug berthing requirements. This review focused on the crossing of the subsea pipelines, and the location of a turning circle (with respect to Jetty Head). A detailed shipping study, specifically with respect to the approach, turning and mooring analysis of the inner berth will be required during FEED, or prior to FEED when final bathymetry and met-ocean data is available. There is potential that the presence of the sub-sea pipelines may cause restrictions on tankers dropping anchor in emergency scenarios, this study shall also investigate. This study shall also investigate this and, if required, provide for jetty specific design adjustments and/or specific navigational and berthing related operating procedures. It is envisaged that vessel approach, turning and mooring will also be a key component in the TERMPOL review and planning process and associated agency consultations in particular with TC, Canadian Pilotage Authority, and Canada Coast Guard.

3.1.3.1 LNG Jetty Trestle, Transfer Lines and Access Road

The proposed 1.8 km long mono-piled jetty trestle carries both the 5 m wide access road, and pipe racks supporting the main loading lines. The trestle runs directly from the shore in front of the LNG tanks, minimizing the loading line length and avoiding Red Head. The jetty runs parallel to the MOF, before turning 90 degrees out to the jetty. Further detailed assessments are required to finalize the design and will include the occurrence of sea ice in the region as well as an inner berth access study.

The jetty trestle will accommodate piping, cabling, and the access road between the main plant and the loading berths. The trestle will be approximately 6 m wide and will include loop structures approximately every 200 m along its length; although loop spacing must be finalized in FEED once detailed piping and surge analysis is completed. A 5 m wide access road will also be carried by the common supporting structure. A preliminary drawing with some detail of the proposed jetty structure is provided in Appendix B-1 (LNG jetty – Approach Trestle Details).

The trestle will be a steel truss structure and will be mounted on 3.5 m diameter monopiles sunk into the sea bed. Monopiles have been selected at this stage with the objective of minimizing the marine piling as far as practicable, and to minimize potential ice loads on the structure. The jetty will also include a maintenance access road leading to the jetty heads that will be supported on the same piles as the trestle. At this stage of the Project it has been assumed that the piles will be spaced at 45 m intervals along the jetty length. This will need to be confirmed in the FEED phase once detailed structural design is completed.

The jetty trestle will be designed to accommodate the piping for Phase 1 (5 Mtpa) and Phase 2 (10 Mtpa) of the Project in order to minimize near shore work in the expansion phase, and has been routed so as to avoid the sensitive Red Head area.

The piping will carry LNG liquid and BOG, utilities such as air, nitrogen and water and possibly diesel for refueling of tug boats. The need for the latter will be determined in the FEED phase of the Project.



3.1.3.2 LNG Jetty Head and Loading Berths

The Project will eventually encompass a total of two LNG loading berths located on a common jetty head. Although only one berth will be developed in the first phase, disruptive work such as piling will be completed for both berths in Phase 1. The piping design has been developed to take account for maximum plant throughput of 10 Mtpa.

The jetty head will comprise a concrete deck structure and structural steel loading platform. The whole structure will be mounted on monopiles. The concrete sub-structure will be designed to be trafficable for maintenance access and to support jetty equipment. Normally rainwater is not collected on jetty heads unless there are heavy hydrocarbons present. Further work will be undertaken in FEED to determine the drainage on the marine structure.

The jetty head area will also include berthing and mooring dolphins used to fix the LNG carriers in position during loading. Each of the dolphins will comprise a monopile and concrete deck structure.

The basis of the marine terminal design is that only one berth will actually be loading at a time in Phase 2, although a second carrier can be manoeuvred in preparation for loading.

Each loading berth will contain four LNG loading arms (two liquid, one hybrid and one vapour arm), that carry LNG and LNG vapour between the carrier and the LNG storage facility, the intent being to minimize any emissions (i.e., vapour is captured as opposed to being vented as it would normally be on a condensate vessel, for example).

The LNG carriers will be loaded with LNG at a rate of 12,000 cubic metres per hour (m^3/h) using three of the loading arms attached to the carrier whilst the remaining loading arm will be used to transfer displaced vapour back to the plant.

BOG is generated on-shore by flashing the run down in the tanks, heat leak into both the storage tanks and LNG lines and displacement of vapour in storage tanks from LNG rundown. BOG is also generated at the Jetty Head due to heat input from the loading pumps, heat leak into the loading system and displacement of vapour from the ships tanks. BOG from onshore is combined with vapour returned from the jetty head during loading and compressed in the BOG compressors. The compressed gas is transferred into the fuel gas system which is required to fuel normal LNG facility operation.

The carriers are manoeuvred to and from the jetty berths by tug boats in order to ensure the loading operation is completed safely. It typically takes up to 24 hours to load a vessel depending on the size of the carrier.

Initial assessments indicate that the approach to the berths from offshore requires the vessels to take a route over the Sable and Deep Panuke pipelines, as was found to be the case for the MapleLNG Project (MapleLNG, 2008). Final jetty layout, turning circles, and approach requirements will be confirmed in further studies in FEED.



Further, during FEED studies will also be conducted to establish wave conditions, bathymetry, and the location of a nearby shipwreck to confirm suitability of the proposed marine layout. In addition, a detailed study will be undertaken to determine the need for ice breaking capability and/or equipment for the tug boats or the jetty.

The jetty will also include a building for housing the electrical power and control panels for the equipment mounted on the jetty. Further work must be undertaken to confirm that one building is sufficient for both phases of the Project.

An additional building will be required to house the sea water pumps which (with the exception of a one hour weekly test) will be used only as a backup in the event of a significant fire when the fresh fire water has been exhausted.

3.1.3.3 Marginal Wharf and Causeway

A marginal wharf and causeway of combined length totalling 480 m will be constructed parallel to the jetty approach trestle and on the southerly end of Red Head, that will initially accommodate barges and cargo vessels for the transfer of modules used in the construction of the LNG plant and associated infrastructure. Following the construction phase of the LNG plant, the marginal wharf will be used to accommodate tug, line, and pilot boats.

The marginal wharf is envisaged to be 220 m in length and 44 m wide in order to allow the safe unloading of modules weighing up to 1000 tonnes (t).

The marginal wharf location has been selected to permit sufficient draught for the vessels used in transporting and unloading modules in the construction phase. During the permanent use for the LNG facility, it is proposed that the tug, line and pilot boats are doubled-berthed alongside the wharf.

The wharf quay will be constructed from combi-walls which comprise large diameter steel piles with sheet piles between them to form the perimeter, on top of which is mounted a concrete cope. Following completion of the combi-walls, the wharf is then filled with suitable (clean) material and topped with an asphalt layer.

To allow passage of modules to the onshore plant area, a 260 m long causeway will be constructed to join the marginal wharf to the land. The causeway will connect to the south eastern end of Red Head to utilize the easement leading to the LNG plant and is required to avoid near shore dredging and so provide adequate draft for ships unloading at the wharf.

The causeway is linked to the plant perimeter road via a haulage road around Red Head, then following the perimeter of the onshore facility. The haulage road utilizes an existing easement around Red Head. This will need further evaluation owing to the fill needed to create the road, specifically any potential sensitivity of the existing lakes. It is emphasized that the results of this section are based on theoretical design guidelines and on a limited amount of site data. In the following design stages additional studies will be carried out based on geotechnical information to determine the optimum location and layout.



The causeway will be a composite structure comprising revetments and asphalt topped suitable fill material. The revetments are constructed by suitable fill material protected by concrete and rock armoury all placed upon a geotextile membrane. Further work must be completed in FEED to confirm the construction methodology.

Services are required at the marginal wharf during the permanent stage of its life when it will accommodate the tugs, line and pilot boats to include provisions such as electrical power and potable water, as well as diesel for re-fuelling purposes.

3.1.3.4 Access to Red Head Peninsula

An all new road and causeway will be constructed to access the marginal wharf, and there is no plan to use the existing road on Red Head Peninsula. The new road and causeway will run across the barrier beach that separates Dung Cove Pond from the bay. The detailed causeway design will be developed during the FEED and will consider the need for special protection or drainage features due to high water conditions. The road will be used to move the LNG plant modules from the marginal wharf to the main plant area. Modules will weigh up to 1000 t and will require a road width in the order of 44 m. Some allowance will also be required to build the road up to the correct elevation. The final width will be dependent on the stability of the material used to construct. This will be determined using detailed geotechnical surveys to be completed in the next phase of work.

3.1.4 Power Plant

The facility will require up to 180 MW of electrical power for the 10 Mtpa plant. The final power requirement will be dependent on the final process configuration and feed gas composition, both to be finalized in the next phase of the Project. Power will be supplied by industrial gas turbines driven generator sets in an open cycle configuration.

Emergency back-up power supply will also be required to ensure the safe start-up and/or operation of the plant in the event of a failure of the normal supply. The emergency power supply will be a diesel driven genset coupled with Uninterruptible Power Supply (batteries) for the essential power loads.

3.1.5 **Project Related Water Requirements**

There will be a considerable raw water requirement during both construction and operation. Water is one of the most valued natural resources and is both ecologically and socially sensitive. Therefore, the Project design has aimed to minimize water requirements to the extent feasible, mainly through selection of processes with lower water requirements. Based on preliminary design estimates, the raw water requirement during construction will peak around 560 cubic metres per day (m³/d), and the operational requirement will be around 500 m³/d. For the purpose of this EA report, a conservative value of 600 m³/d has been used. The precise water requirement will be further explored during FEED. The breakdown of water uses are detailed below for the construction phase (Section 3.2.6) and the operation phase (Section 3.3.12).



3.1.6 Meadow Lake Water Intake Structure and Pipeline

During construction and operation, the Project water requirement will be approximately 500 to 600 m^3 /d. To satisfy this requirement, a freshwater supply system will be constructed that involves the following components:

- freshwater reservoir (Meadow Lake);
- raw water intake structure;
- pump house;
- all season access road for construction and maintenance of the intake and pump house facility including overhead power line; and
- pipeline infrastructure from Meadow Lake to the LNG facility.

The water intake facility is proposed to be located at the southern end of Meadow Lake to supply raw water from Meadow Lake to the service water system located at the proposed Goldboro LNG Facility (see Appendix B-2; Figure 1). The water supply pipeline will be designed for a 1200 m³/d peak flowrate; however, with an expected average daily consumption of 500 to 600 m³/d. Details on construction water usage and operation water usage are presented in Sections 3.2.6 and 3.3.12, respectively. The assessment of water supply options leading to the selection of Meadow Lake is presented in Section 9.2.2. The proposed withdrawal rate is approximately 1.2 percent (%) of the baseflow during the period of lowest average monthly flow in the year, and only 0.23% of annual baseflow; therefore, no special water usage restrictions are anticipated during construction or operation. The following sections describe the components of the water supply pipeline system.

3.1.6.1 Intake Structure

The approximate water surface elevation of Meadow Lake is 34.0 m. This lake is very shallow, with a maximum depth of approximately 2 m (see Appendix B; Figure 2). The proposed location of the intake structure is at the 2 m maximum depth location, which is approximately 140 m from the shoreline. The area of lake impacted by this installation is the 6 square metres (m^2) at the intake structure, and approximately 540 m^2 for the intake pipe trenching (see Appendix B; Figure 3).

This concept includes a precast concrete intake structure located at the 2 m depth complete with fiberglass screens and stainless steel mesh. This intake would be approximately 1.5 m by 1.5 m by 1 m high and would be installed on a rock mattress after completing a small amount of dredging to prepare the subgrade. Two 300 millimetre (mm) diameter HDPE intake pipes would be installed in a trench approximately 180 m long to the pump house wet well. One of these 300 mm diameter pipes would have sufficient capacity to carry the peak design flow of 50 m³/h, therefore, one pipe could remain in service, while the other pipe is shut down for maintenance or cleaning.

The design of the water intake facility includes low flow velocities at the intake structure to avoid entrainment/impingement of the different fish species that may be present in the lake. The screen design will comply with the Department of Fisheries and Oceans (DFO) "Freshwater



Intake End of Pipe Fish Screen Guidelines", based on meeting the requirements for the anguilliform group of fish, such as eels.

3.1.6.2 Pump House and Wet Well

The pump house facility will include a fenced yard around a small structure to enclose the intake screens, pump and appurtenances and emergency generator as shown in Figures 4 and 5 located in Appendix B-2. Vehicle parking, with turning, emergency generator fuel storage and an electrical substation are located within the fenced area at the facility.

Access to the facility will be obtained via an all-weather access road 6 m wide to accommodate trucks for construction and maintenance. The access road will be approximately 1000 m in length extending from the Isaac's Harbour River Road. It will utilize the existing forest road and include a short (approximately 200 m) link to the new pump house.

The pump house facility would be located on shore with a floor slab elevation of approximately 36.0 m, which is 2 m above the normal lake elevation. The footprint of the building will be approximately 100 m². This building has been sized to house two vertical turbine pumps and a back-up power emergency generator. Removable sky lights will be installed directly over each pump, which will allow removal of the vertical turbine pumps during maintenance. A concept floor plan for the Pump House building is shown in Figure 4 located in Appendix B-2.

The raw lake water will be screened as it enters the wet well. A structural steel lifting frame and hoisting system will be installed over these screens, to enable lifting the screens for cleaning and maintenance. The wet well is used to provide water to the two vertical raw water turbine pumps. The wet well is approximately 5 m wide, 6 m long and 4.5 m deep.

The vertical raw water pumps consist of one duty and one standby pump, capable of supplying peak hourly flow of 833 litres per minute (Lpm) (50 m³/h). The pumps will discharge to a common header that connects to the proposed 150 mm nominal diameter raw water transmission main leading to the Goldboro LNG Facility. Each pump will be equipped with surge-anticipating valves to direct water to the wet well if the system is over pressurized. System hydraulics were evaluated to overcome the line losses and discharge water into the Goldboro LNG Facility. Indicative pumping design parameters are provided below:

- Number of pumps: two (one duty, one standby);
- Type: vertical turbine, variable speed;
- Model: Flowserve;
- Drive: 15 kW, 600 Volts (V), 1775 Revolutions Per Minute (RPM) (maximum);
- Capacity: 833 Lpm; and
- Total dynamic head: 8 bar.

The precise details of the water intake design and pump system will be reviewed during FEED.



3.1.6.3 Pump House Power Supply

There are a number of options to supply electrical power to the pump house including a power line constructed from the Isaac's Harbour road following the access road to the pump house as well as power being provided from the LNG terminal along the water pipeline alignment. The power source will be refined as part of the FEED. For the purposes of this document it is assumed that an overhead power line will be constructed along the access road to the pump house, connecting to existing three phase power lines at Isaac's Harbour River road.

A 60 kVA generator may be located at the pump station to provide emergency back-up power; however this will be subject to review during FEED based on availability and storage capacity on site.

3.1.6.4 Raw Water Transmission Main

The preliminary location of the water supply pipeline and its major components are shown in Figure 1.7-3. Raw water shall be pumped to the Goldboro LNG Facility through an approximately 7 km long HDPE pipe with a 200 mm diameter and designed to the required pressure ratings (pipe diameter and pressure to be refined as part of FEED). The buried pipeline will be constructed from the pumping station to the LNG facility. Pipeline alignment will be adjacent to the M&NP natural gas pipeline easement and will likely cross the M&NP pipeline at two locations. It is assumed that the pipeline could require up to a 15 m wide cleared right-of-way (ROW) for construction. The ROW would be allowed to revegetate to 10 m wide during operation and would be kept clear of woody vegetation during the Project lifetime. The precise details of the raw water transmission main design will be reviewed during FEED.

It is anticipated that the pipeline route will not require blasting, based on a concept level review of available mapping. In places with shallow soils, the pipeline will be insulated and/or the local ground surface will be built up to cover the pipe with sufficient cover. The preliminary route is detailed in Figure 1.7-3.

The water supply pipeline will cross two known freshwater watercourses and numerous (10 to 15) wetlands.

3.1.7 On-site Wastewater Treatment System

The LNG facility will include an on-site wastewater treatment plant, intended to receive the majority of potentially contaminated discharges and will be sized to accommodate the peak design flow of 600 m³/d. The water management systems will comprise a number of streams including; potentially contaminated, oily water, and domestic water. The plant will discharge treated water into the sea at the south eastern corner of the plot. The final location of the discharge point will be selected in FEED subject to dispersion analysis and to meeting any environmental requirements. Management of wastewater streams during construction and operation is detailed in Sections 3.2.6 and 3.3.14 respectively.



3.1.8 Natural Gas Pipeline Tie-in

A short natural gas pipeline will be required to tie-in to the existing M&NP pipeline to supply feed-stock for the LNG facility. This "take-off" pipeline will be constructed by M&NP, including a custody transfer station, and is not considered part of the Project for the purpose of this EA. The location of the tie-in pipeline is assumed to be in the same easement as the water supply pipeline as shown on Figure 3.1-2; which enters the LNG facility near the northeast corner of the site.

3.1.9 Route 316 Realignment

For reasons of safety, Highway 316 (Figure 1.7-2) will be rerouted around the LNG facility. The Nova Scotia Department of Transportation and Infrastructure Renewal (NSTIR) is the proponent for the road realignment and responsible for route delineation, design, construction, and permitting. Therefore, this highway realignment is not part of the Project. It is considered though in the context of potentials for cumulative effects (Section 10.19).

3.1.10 Watercourse Diversions

The unnamed small watercourse that originates in the western part of the LNG facility and flows into Dung Cove Pond will need to be diverted along the western perimeter of the site. The proposed relocated watercourse is shown in Figure 3.1-2.

3.1.11 Information Centre

With the start of the construction activities Pieridae is planning on operating an information centre at the Project site. The centre is envisaged to be expanded as the Project evolves and to be maintained throughout Project operation. Exhibits and information material will inform about the Project and such topics as LNG, liquefaction technology, LNG tanker technology, and energy markets. Some cultural history will also be included, such as the Black Loyalist community and former Red Head Cemetery associated with the Project area.

3.1.12 Approach to Detailed Design

3.1.12.1 Electrical Design

For the safe operation of the facility, a secure and reliable power supply is crucial. Normal power supply shall be obtained via gas turbine driven generators in a "N+1" sparing configuration such that there is always a spare generator and that N number of generators meets the highest expected power demand of the facility. Power for essential services shall be provided by back-up diesel generator sets. Essential loads will be identified during FEED development.

Emergency power to allow safe shutdown of the facility and personnel safe evacuation shall be provided by the Uninterruptible Power Supply and other battery back-up systems. Local substations will be provided for various process areas, each substation shall be supplied via redundant feeders and the preliminary approach is that upon completion of the Phase 2 works full redundancy remains available.



3.1.12.2 Instrumentation

The design approach for instrumentation shall be to utilize an Integrated Control and Safety System (ICSS) that shall be designed to provide safe, reliable and continuous monitoring and control of the facility.

The ICSS comprises three main sub-systems:

- Process Control System;
- Emergency Shutdown (ESD) System; and
- Fire and Gas System.

The Main Control Room shall be the centralized location for the control of the facility, details and layout of the Main Control Room shall be subject to development during the next phases of design. In addition the berthing and loading shall be controlled from a single Jetty Control Room located within proximity of the jetty with appropriate safety distance considerations.

Local equipment rooms utilized to install ICSS hardware shall be strategically located throughout the Facility, the current approach is that these shall be unmanned during normal operations and as such no permanent workstations are to be installed. A redundant fiber optic network and hard wiring (system dependent) shall be used to connect ICSS equipment located in various locations; said fiber optic networks shall carry both the ICSS and telecommunications data.

Electronic field instrumentation shall be used throughout, except for the final control elements, which shall be pneumatic or hydraulic and shall be designed for fail-safe operation, positioning dependent upon the design requirement. All safety and shutdown signals shall be hardwired. Consideration of intrinsically safe instrumentation has been allowed, however, the use of intrinsic safe instrumentation shall be evaluated in further design phases.

Fire and gas detection shall be provided for the facility integrated within the Fire and Gas System. The buildings shall be provided with separate fire alarm panels interfacing with the ICSS for common alarms.

3.1.12.3 Telecommunications Philosophical Approach

The telecommunications systems will be designed and implemented to provide an integrated telecommunications infrastructure which will support all operations, safety, maintenance, and administration.



Telecommunications systems central equipment shall be located within the Telecom Equipment Room in the control building and Local Equipment Rooms located on site and Jetty Control Room. Field equipment shall be distributed throughout the facility. A diversely routed fibre optic network shall be designed to enable transmission of communication and control data between telecommunications systems and relevant field equipment. The telecommunications system shall consist of the following:

- Structured Cabling and Local Area Network (LAN);
- Wide Area Network;
- Telephone System;
- Hotline Telephone Systems;
- Public Address and General Alarm System;
- Trunked Radio System;
- VHF (very high frequency) (FM) Marine Band Radio Facilities;
- Ship-to-Shore Communications;
- Marine Radar;
- VHF (AM) Air Band Radio Facilities;
- Meteorological Monitoring Package;
- Closed Circuit Television Facilities;
- Perimeter Intruder Detection; and
- Access Control.

A master clock system shall be included to provide an accurate and common time source for those components of the telecommunications systems that require time stamping for logging and a network management system shall be provided for fault finding and diagnostic aids along with performance, alarm monitoring and traffic history reports of all the system.

3.1.12.4 Civil and Structural Design

Soil and ground conditions information is currently available from a limited number of site investigations carried out in 2007. Additional geotechnical surveys will be carried out to establish a clear basis for all civil and structural design prior to commencement of FEED stage development (Section 3.2.2). These original site investigations revealed the presence of pits, shafts, trenches and waste dumps within the LNG facility footprint; the additional surveys to be carried out shall ascertain their exact locations and the required design considerations that they pose. Review of geological, tectonic and seismic data indicates that there is no evidence of the existence of "active faulting" at or within the vicinity of the facility. The site is situated within a low seismic hazard area.

Results from the future surveys shall also be pertinent in the development plan for site preparation. The suspected presence of abandoned mine workings means area geophysics will be done in advance of the main borehole investigation.

After the investigation work is completed, mitigations for any problematic foundations will be evaluated. Each foundation will be considered on a case by case basis, in terms of cost



efficiency, durability and risk; possible solutions to encountering inadequate ground conditions would include:

- filling the voids with mass concrete or gravel;
- filling the voids with sand integrated within the rock mass to eradicate possible differential settlement issues;
- piling type to be determined; and
- relocation of equipment.

In addition to the ground structural investigation as described above there is also the issue of ground contamination to consider. Soil samples in the location of suspected mine workings will be sampled and analyzed for contaminants. Contaminated soil depending on the environmental regulatory requirements will either be safely disposed of or treated and used as fill material where possible on site. This is addressed in further detail in Section 10.1.

The current design approach indicates the expectation that the LNG tanks will be founded on the bedrock; therefore the investigations will determine possible means of ripping ability through the rock (e.g., by excavating, ripping, blasting etc.) in addition to general evaluation of rock mass properties.

One of the various objectives of the site preparation works is to minimize the overall cleared area for construction purposes, i.e., construction lay down areas, access and construction roads etc. The site preparation strategy shall be developed such that the use of cut materials for reuse as site fill is optimized in order to reduce any off-site disposal.

To compensate for the steep inclines from the shoreline, the site will be established in a system of terraced levels to minimize earthwork and associated dust generation, whilst simultaneously satisfying the need to ensure that the LNG plant level is set to allow for haul road gradients, safety and process considerations. The final extent of cutting and rock excavation will be determined once the geotechnical and topographical surveys are completed. Recycling of the cut material shall be subject to the appropriate testing and approvals. Any required off-site disposal of excess cut materials shall be via an authorized disposal site located as near to the Facility as possible to minimize truck movements and impact to the local community.

Where viable, modularization of the facility shall be utilized. Module component design will be capable of withstanding the additional load imposed by transportation (both land and marine based) and potential environment loads e.g., seismic. The modules will also withstand dynamic, wind loads on all components, and include splash protection during marine transportation.

A naval architect and marine surveyor will be engaged to advise transportation accelerations to be used for the marine transit load analysis of the modules and vendor associated equipment items. For items where modularization is not considered viable, a traditional stick-built approach shall be utilized.



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3.2 Construction Phase

3.2.1 Construction Activities

Site construction activities for the development of the workcamp, liquefaction facility, and infrastructure will include:

- site clearing;
- preparation of lay down areas;
- site grading;
- site levelling;
- construction of fresh water supply system
- temporary site construction facilities and site office;
- construction of road network system within the plant areas;
- construction of all foundations, sub-structures including shoring and superstructures for all buildings;
- construction of storm management system;
- construction of sanitary and process waste collection disposal system;
- construction of cable, pipe trenches and ducts;
- tank foundations and associated berms; and
- landscaping.

Some of the construction work will be preceded by more detailed site investigations. Key studies, construction activities, construction methods and construction related site features are discussed in further detail below.

The required regulatory approvals will be obtained prior to commencement of construction activities (see Section 4.0). Further, prior to any on-site construction activities, a Project Health and Safety Plan (HASP), Environmental Management Plan (EMP), and Environmental Protection Plan (EPP) will be developed (see Section 3.7).

3.2.1.1 Best Management Practices

There are a number of provincial guidance documents that present best management practices for construction sites. These will be referred to in the EMP and will include at a minimum, the following:

- NS Standard Specifications. Highway Construction and Maintenance (NSTIR, 2011);
- Sediment and Erosion Control Handbook (NSE, 1988);
- Watercourse Alteration Protection; Erosion Protection; Wharves; Pipe Culverts; Arch or Open Bottom Box Culverts (NSE, 2013b); and
- Generic Environmental Protection Plan for Construction of 100 Series Highways (NSTIR, 2007).



3.2.2 Geotechnical Investigations

Due to the uncertainty of the locations of abandoned mines, a site investigation will be conducted prior to any earthworks to assess the pertinent geotechnical properties of the foundation soils and rocks.

The preliminary scope of work for the geotechnical investigation can be described as follows:

- Typically eight to 12 boreholes will be drilled per storage tank location depending on rock quality. The depth shall be adequate to confirm the presence of competent bedrock and to eliminate the presence of any voids or cavities within the rock mass. Typically 50 to 70 m deep boreholes would be required per tank together with shallower boreholes within the tank footprint for settlement control.
- Boreholes will be required for the compressor foundations, buildings and facilities.
- Rock cores will undergo an evaluation of rock type, rock strength, degree of weathering, joint spacing, shear wave velocity, etc.
- The top soils (including the glacial till) shall be sampled carefully using percussion sampling or push sampling if required.
- Where possible, especially where the top soils are deep, Cone Penetration Tests will be performed in addition to retrieving samples.
- The rock in-situ strength will be measured using techniques applying the Goodman jacks, with the use of a pressure meter and by dilatometer tests.
- Laboratory strength tests will include uni-axial compressive strength, tensile strength and deformation moduli determination.
- Durability of the rock will also be assessed.
- Cavities (e.g., mine workings) will be investigated using methods such as ground penetrating radar and the more sensitive micro-gravity technique, combined with focused site specific drilling.

3.2.3 Site Preparation, On-shore Cut and Fill, Blasting

Site clearing and grading will be undertaken to establish the terrace levels and roads within the plant. This will require some blasting. Explosives will not be stored on site, but rather will be transported to site on the day of the blast. Blast monitoring will be carried out where required.

The on-shore cut and fill operations will be carried out in accordance with the *Nova Scotia Occupational Health and Safety Act*, S.N.S. 1996, c. 7 and in compliance with the Project's EMP (refer to Section 3.7).

Overburden and underlying rock is planned to be retained and reused for landscaping and levelling of site to the required grade levels. Rock removed from the site will be tested for suitability to reuse. For materials that have acid producing potential, and/or are not suitable for reuse, a Sulphide Bearing Materials Management Plan (SBMMP) will be developed in consultation with the NSE to ensure materials are disposed in compliance with applicable regulatory requirements.



Any greywacke bedrock needing to be removed during construction of the LNG plant and associated facilities can be processed to serve as construction aggregate for use in concrete or as fill (contingent upon testing for net acid generating potential). With respect to other construction material needs, kame and esker deposits are known to be present (some local ones with existing gravel pits), along the New Harbour River just downstream of Ocean Lake, at Stormont, at Country Harbour Mines, Ogden, Roman Valley and at Upper South River. Existing gravel pits can be reopened or extended, and/or new ones developed, contingent upon completion of appropriate surveys and approvals.

Near fish habitat, blasting activities will be conducted in compliance with the Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky, 1998.)

Any structures such as wells, buildings and foundations that are located outside of the facility boundaries and within a designated radius of the blasting site and that may experience damage or impact due to seismic vibrations or air concussion will be surveyed prior to any blasting activities (pre-blast survey).

To minimize the potential for increased erosion and siltation of the nearby streams and the waterfront from site runoff while soils are exposed and un-stabilized and from movement of construction vehicles, erosion and sediment control measures will be implemented. These requirements will be established in the EMP and measures will be specified in site-specific erosion and sediment control plans (Section 3.7).

3.2.4 Temporary Construction Camp

At the start of the Project a temporary construction camp will be constructed. This camp will consist of 500 beds and will be progressively demobilized as the main camp is finalized. The main construction camp shall be built to hold a peak of 1500 to 2000 beds subject to the local community being able to accommodate 1500 to 2000 workers. This includes provision for subcontractors and vendors required at various stages of the Project. The expansion of the camp is expected to be in 500 bed stages until peak capacity is reached.

Due to space limitations on the permanent Project site, the construction camp will be constructed in an adjacent location (Figure 3.1-2). The construction camp will consist of a series of accommodation blocks, recreation facilities, dining and associated kitchen facilities, offices, utilities, a sewage treatment facility as well as an entrance with parking. Parking will be sufficient in size to all allow parking for busses and selected staff construction trucks. Welfare facilities as well as basic first aid and occupational health facilities will also be provided within the camp.

Power at the construction camp is expected to be provided by diesel generation sets as it is assumed that power will not be available from the grid. With respect to water, a potable water source will be identified and treated on-site. Water required for the pioneer camp is expected to be provided by local contractors and stored in tanks for use until the water supply pipeline from Meadow Lake is operational. Wastes generated from the construction camp will be treated at a



sewage treatment facility constructed within the Project footprint, with domestic wastes disposed of at regional waste facilities.

The precise delineation, size, and layout of the camp will be reviewed during FEED. Currently all components are planned for designated industrial park lands adjacent to the Project site; however, if it becomes necessary to temporarily locate portions of the camp in another location or to expand beyond the currently delineated camp boundaries, the specific location will be determined in consultation with the municipality and applicable regulators. If applicable, additional potential effects will be assessed and incorporated in the Project EMP and associated EPP. This would include any additional ecological surveys, mitigation, or monitoring that would be required.

Upon completion of the construction activities, Pieridae will develop and implement, in consultation with the municipality and regulatory agencies, a site rehabilitation plan for the temporary work camp. Pieridae is committed to remove all work camp infrastructure and fully rehabilitate and revegetate the site to its pre-development condition. Should the municipality prefer other after use concepts, the degree and type of the site rehabilitation will take this into consideration to the extent feasible.

3.2.5 LNG Facility

The construction period of the main plant area and marine facilities, including cargo offloading facility, will span approximately four years. The LNG site will provide rock suitable for concrete and foundation backfill and will therefore become the principal source of such needs at the site and marine facilities. This will involve some blasting, heavy excavation equipment, crushing and screening. A concrete batching plant will be established for the construction period. After site preparation, the activities will shift to installation of foundations and heavy haul roads linking the MOF with the site. Construction of the MOF will proceed simultaneously with the land-based Project components. This facility will be able to accommodate ocean going barges and self propelled Project cargo ships and module carriers. Within the MOF a Roll-on Roll-Off will be constructed to enable modules and goods to be offloaded to the site by use of marine barges as an addition to the jetty.

Prefabrication activities will proceed off site in parallel with civil works, so that, as foundations are completed, phased delivery of prefabricated structures, equipment skids, subassemblies, and modules can progress. Deliveries will be sequenced to support the installation, hook-up, and commissioning program. Modules, and heavy vessels and equipment will be delivered from the MOF direct to foundations, to the extent practicable, using Self Propelled Modular Trailers to minimize the double handling of heavy items and the associated safety risks.

Limitations on module sizing will need to be fully investigated during FEED, it is expected that due to the steep slopes and limitations these imply on the Self Propelled Modular Trailers that large size modules (in the order of 5000 t will not be used. Predominant module sizing is therefore expected to be in the 500 to 1000 t range within an 18 m wide by 30 m long by 12 m high envelope for ease of handling. Standardized structures e.g., Pre-Assembled Racks, suitable for sea transport over relatively short distances with minimal temporary support will be



used. Process and utilities equipment may be collected into skids and smaller assemblies, Pre-Assembled Units.

Construction will be work packaged from the outset so that the integrity of modules, subassemblies and skids can be better managed. Construction sequencing will be strongly focused on the testing and commissioning program that brings the plant into operation on schedule.

Construction of the LNG tanks will be performed under a turnkey subcontract by an LNG tank Engineering, Procurement, and Construction specialist company. This will be done in parallel with plant and utilities construction.

No dredging is anticipated in the construction of the marine facilities. The marginal wharf and causeway area will be formed by backfilling rock excavated from the Project area. The LNG berthing docks will be of piled construction. Appropriate dust and drainage control based on the avoidance of environmentally sensitive areas will be applied throughout.

3.2.6 Construction Water Usage, Water Supply, and Wastewater Management

Construction and commissioning activities (i.e., concrete production, hydrostatic testing) will require water. The peak water usage estimates are provided for the following activities:

- camp (525,000 litres/day (L/d));
- site preparation (50,000 L/d);
- concrete (10,000 L/d);
- hydrostatic testing and rinsing (50,000 L/d); and
- general water usage during construction (10,000 L/d).

3.2.6.1 Construction Water Usage

These various peak requirements do not all overlap at once but are separated into early, middle, and late stages of construction. The camp occupancy has been conservatively estimated at 3,500 inhabitants, although it is expected that some portion of the workforce will reside in the local community. Experience shows that water usage varies climatically. For the Project, this is estimated to be to 150 litres per person per day, which reflects the cooler weather in NS. Initially the camp occupancy will be smaller, but there will be significant usage for concrete making and site preparation, especially compaction. Later on the camp will be fully occupied and there will be water needed for hydrotesting, especially the tanks, leading to a sustained peak of usage of around 565 t / 565 m³/d. Water requirements beyond these levels (extreme peaks) will be managed by using on site storage and, where essential, import by water trucks. Trucking is generally an expensive alternative and is considered a last resort. A preliminary breakdown of water usage during construction is presented in Table 3.2-1.

Table 3.2-1 Construction Water Usage																			
	2015			2016			2017			2018				2019					
	Q1	Q2	Q3	Q4	Q1	Q2	Q3												
Camp Water Requirement																			
Camp occupancy	250	500	1000	1500	2000	2500	3000	3500	3500	3500	3500	3500	3500	3500	3500	2500	2000	1000	500
Camp Subtotal (L/d) [*]	37,500	75,000	150,000	225,000	300,000	375,000	450,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	375,000	300,000	150,000	75,000
Construction Activities Water Supply Requirement										-	-			-	-			-	-
Site Preparation (L/d)	50,000	50,000	50,000																
Concrete Works (L/d)	5,000	5,000	5,000	10,000	10,000	10,000	5,000	5,000	1,000	1,000	1,000	1,000	5,000	5,000	5,000	5,000			
Hydrotesting (L/d)									5,000	10,000	15,000	20,000	25,000	25,000	25,000	35,000	50,000	10,000	
General Use (L/d)	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Activities Subtotal (L/d)	65,000	65,000	65,000	20,000	20,000	20,000	15,000	15,000	16,000	21,000	26,000	31,000	40,000	40,000	40,000	50,000	60,000	20,000	10,000
Total (L/d)	102,500	140,000	215,000	245,000	320,000	395,000	465,000	540,000	541,000	546,000	551,000	556,000	565,000	565,000	565,000	425,000	360,000	170,000	85,000
Total (Tonnes or m³/d)	102.50	140.00	215.00	245.00	320.00	395.00	465.00	540.00	541.00	546.00	551.00	556.00	565.00	565.00	565.00	425.00	360.00	170.00	85.00

Note:

* Camp subtotal determined by multiplying 150 litres per person per day by the number of workers anticipated at the camp during each quarter.





3.2.6.2 Construction Water Supply

It is proposed that water for the construction phase will be provided by a water supply pipeline from Meadow Lake, described in Section 3.1.6. This would be constructed very early in the Project schedule, ideally within the first three months. Prior to that, water requirements will be met by trucking from off-site. Additional options may be identified during FEED.

Preliminary review of water sources available to the Project suggests that Meadow Lake is the most suitable water source. The selection of Meadow Lake was based on several factors, both environmental and engineering related, as described in Section 9.2.2.3. The water supply pipeline will be designed for a 1200 m³/d peak flowrate; however, with an expected average daily consumption of 500 to 600 m³/d.

The water intake structure will be installed at Meadow Lake in approximately 2 m of water. All in-water work would be conducted during low flow conditions, to the extent possible. The work area would be isolated with silt curtains to prevent sedimentation outside the in-take disturbance area. Work in the lake and near the shore will be subject to regulatory approvals. All work will be conducted in accordance with watercourse alteration permit conditions.

The 7 km long buried pipeline will be constructed from the pumping station to the LNG facility. It will be located adjacent to the M&NP natural gas pipeline to the extent possible. It is assumed that the pipeline could require up to a 15 m wide cleared ROW for construction. The ROW would be allowed to revegetate to 10 m wide during operation and would be kept clear of woody vegetation during the Project lifetime. The precise details of the raw water transmission main design will be reviewed during FEED.

It is anticipated that the pipeline route will not require blasting, based on a concept level review of available mapping. In places with shallow soils, the pipeline will be insulated and/or the local ground surface will be built up to cover the pipe with sufficient cover. The preliminary route is detailed in Figure 1.7-3.

The water supply pipeline will cross two known freshwater watercourses and numerous (10 to 15) wetlands. The watercourse crossings will be conducted by trenching, and would be conducted at the lowest flow period of the year. It is anticipated that one or both watercourses will be dry at the time of in-steam work. Construction in and near the watercourses and wetland will be subject to regulatory approvals. All work will be conducted in accordance with regulatory water/wetland alteration permit conditions.

3.2.6.3 Construction Wastewater Management

The on-site wastewater treatment plant will be constructed very early in the overall schedule with a target date of operation approximately nine months into construction. During the initial stages of site preparation, wastewater will be treated in modular systems and stored temporarily, prior to removal by vacuum truck for local treatment off-site at an approved facility. Volumes up to 150 to 200 m³/d may be treated this way (approximately 10 tanker trucks per



day). This is a temporary solution while the on-site wastewater treatment system is being constructed.

The on-site wastewater treatment plant is intended to receive the majority of potentially contaminated discharges and will be sized to accommodate the peak design flow of 600 m³/d. It is recognized that during construction there is some potential to produce slightly contaminated stormwater by incidental releases from construction equipment. Stormwater will be treated as either clean when it originates in stabilized areas, or potentially contaminated when from active working areas. Where appropriate, potentially contaminated site runoff will be locally segregated and directed into the wastewater management system, prior to disposal. Runoff from uncontaminated areas will not be treated prior to discharge although monitoring may be required. All water to be discharged to the sea will be routed via sedimentation ponds to ensure no sediment is discharged.

3.2.7 Construction Generated Waste

Construction activities will generate solid and drummed waste including:

- hazardous wastes arising from use of paints, oils, batteries etc.;
- sanitary and medical waste;
- oily waste;
- radioactive waste (spent sources from testing activities); and
- inert construction waste, including soil and rock.

Hazardous waste streams will be separated according to type (waste oils, paints, acid batteries, contaminated filters etc.) on site and stored within suitable containment prior to transport off-site for disposal at an approved facility.

The Project will also produce the following general types of emissions, discharges, and waste:

- air emissions, including Volatile Organic Compound (VOCs), Sulphur Oxides (SO_x), Nitrogen Oxides (NO_x), Particulate Matter (PM), and Greenhouse gasses (GHG); and
- wastewater (site-runoff, construction, and domestic).

There are some potential waste types that could be produced if historic mining contaminated soils or acid generating bedrock is encountered. Accidental spills are also a potential source of LNG, petroleum-oil-lubricants (POL), and small quantities of other hazardous chemicals. A summary of all Project emissions, discharges, and waste is presented in Section 3.5.

3.2.8 Construction Related Noise

During construction, noise will be generated through a variety of sources. Construction equipment includes a large number of types of machines and devices, varying widely in physical size, horsepower rating and principle of operation. Noise levels will vary with the equipment used. Examples for typical noise levels associated with construction equipment are presented in Table 3.2-2.



Equipment	Typical Noise Range (Decibels (A-Weighted) (dB(A)) at 15 m	Calculated Noise Level at 500 m
Loader	74-84	44-54
Bulldozer	82-95	52-64.8
Trucks	82-92	52-61.8
Pumps	68-72	38-42
Generators	72-80	42-50
Compressors	74-83	44-53

Table 3.2-2 Typical Construction Equipment Noise Levels at 15 m (50 feet)

Source: Harris, 1979

More information on construction related noise levels is included in Section 10.5 together with a discussion of proposed mitigation measures.

3.2.9 Construction Schedule

Anticipated commencement and completion dates for the various packages of construction are given in Table 3.2-3 below, it should be noted that these are preliminary and shall be highly dependent on the development of FEED, the overall Project and other influential factors such as approvals, and resource availability for example. Included within this are:

- temporary facilities (including the construction camp);
- all site preparation works;
- feed gas pipeline;
- two LNG trains and all associated utilities;
- three LNG tanks;
- all marine works for two berths; and
- administration and maintenance buildings.

Activity	Anticipated Commencement	Anticipated Completion
Temporary Facilities Installation	Q1 2015	Q4 2015
Early Civil Works	Q1 2015	Q4 2016
MOF Construction	Q3 2015	Q4 2016
Jetty Construction	Q1 2016	Q4 2017
Civil Works	Q1 2016	Q3 2017
Piping & Steel Erection	Q3 2016	Q1 2019
Equipment Installation	Q4 2016	Q3 2018
Module Fabrication	Q2 2016	Q3 2018
Module Installation	Q2 2017	Q1 2019
Electrical and Instrumentation Installation	Q2 2017	Q3 2019
LNG Tank Construction	Q2 2016	Q2 2019

 Table 3.2-3
 Phase 1 Anticipated Construction Commencement & Completion Dates



It is assumed that construction will include both production trains to be done concurrently. Actual timing of various components shall be dependent on many factors including amount of supply gas available, market demand and investment capital; which could extend the completion times.

3.2.10 Construction Related Traffic

An estimate of peak construction related traffic is presented in Table 3.2-4. Traffic volumes over the course of construction (2014 to 2019) will increase and decrease in accordance with employment estimates given in Section 3.8.1.

Vehicle Type	Number of Trips Per Day ¹	Parking Provided		
Buses	200 (local busing from camp to work site)	10		
	8 (Crew change – camp to Halifax)	10		
Cars	600 (Commuters)	76 0 ²		
	30 (Resident workers)	750		
	80 (management)	20		
	40 (Pool Cars)	10		
	20 (Visitors)	10		
Trucks	10 (General materials)	None (Delivery only)		
	160 (Civil works materials)	None (Delivery only)		
	15 (Service trips)	5		
Total	1,260 trips per 24 hours (350 per hour at morning and evening shift changes)	850		

 Table 3.2-4
 Estimated Daily Traffic and Parking Required At Peak Construction

Notes:

1. Includes one (1) trip each for travel to construction site and return.

2. 400 spaces for provincial workers commuting weekly or bi-weekly and using the bus on a daily basis.



3.3 Operation Phase

3.3.1 Characteristics of LNG and Natural Gas

Natural gas that has been cooled to -160°C and attains liquid composition is considered to be LNG. The purpose of liquefying natural gas is to reduce transportation costs. Liquefaction of natural gas can reduce the volume by 600 times. This state is maintained by utilizing cryogenic cooling and not pressurizing the gas. LNG has the following characteristics:

- liquid form;
- non-toxic and non-carcinogenic;
- odourless and colourless, resembling water;
- cryogenic temperature of -160°C;
- stored at just above atmospheric pressure;
- evaporates very rapidly and expands by 600 times at normal ambient temperature;
- density of under half of water;
- Workplace Hazardous Materials Information System (WHMIS) Class A (Compressed Gas) and Class B1 (Flammable and Combustible Material); and
- hazards include cryogenic burns to exposed skin and eyes and asphyxiation.

With a density just under half of water LNG floats on water. Vapourized LNG is primarily comprised of methane (CH₄), ethane and propane with small fractions of butane and pentane. When LNG is in a vapourized state it is still very cold and heavier than air. Should a spill occur, the vapourized LNG collects at the ground surface until it dissipates. When the vapourized LNG is warmed to approximately -110°C, it becomes lighter than air and will rise and dissipate. Hazards associated with vapourized LNG are related to flammability and asphyxiation potential. In addition, it can cause freeze burns when it comes in direct contact with exposed skin or eyes.

3.3.2 LNG Specification

The LNG produced from the Facility shall be destined to multiple markets; the composite LNG specification is summarized in Table 3.3-1 below. In order to retain conservatism in the assessment for the specification required for the LNG product, an allowance has been made to cater for BOG generation during storage, loading and transportation. The LNG produced is characteristically lean in nature, no spiking capability has been considered within the current design. Requirement for inclusion of such a capability shall be considered during FEED development once the feed gas composition is confirmed.



LNG quality parameters	Composite LNG Specification ¹	Standards used ²
LNG saturation pressure	50-150 mbar (g)	
Wobbe minimum-maximum	50 – 52.75 MJ/m ³ (s)	ISO 6976
Gross caloric value minimum-maximum (real gross dry)	39.6 – 41.6 MJ/m ³ (s)	ISO 6974 / 6976
Incomplete combustion factor	< 1.46	Part III, Schedule 3, Gas Safety (Management) Regulations 1996
Soot index	< 0.603	
Hydrogen maximum	0.1 mol%	
CH ₄ minimum	85 mol%	
Butane and heavier - maximum	2 mol%	
Pentane and heavier - maximum	0.1 mol%	
Nitrogen and inerts maximum	1 mol%	
Oxygen content maximum	40 ppmv	
CO ₂ content maximum	1.8 vol%	ISO 6974
Sulphur in Hydrogen Sulphide (H ₂ S) maximum	4.5 mg/Nm ³	ISO 6326 (or ISO 19739)
H ₂ S maximum	5 ppm	
Sum sulphur content in H ₂ S and carbonyl sulphide maximum	4,5 mg/m ³ (n)	ISO 6326 (or ISO 19739)
Mercaptan sulphur content maximum	5,4 mg/m ³ (n)	ISO 6326 (or ISO 19739)
Total sulphur content maximum	27 mg/m ³ (n)	ISO 6326 (or ISO 19739)
Water dewpoint	-10°C (72 barg)	
Hydrocarbon dewpoint	-2°C (70 barg)	
Potential hydrocarbon liquid content maximum	5 mg/m ³ (n) (-3 °C; any pressure)	ISO 6570

Table 3.3-1	Summary of the	e Composite LNG	Specification
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Notes:

mbar (g) = millibar (gauge); MJ/m³ (s) = megajoules per cubic metre (standard); mol% = Mol percent; ppmv = parts per million (volumetric); vol% = volume percent; ppm = parts per million; mg/Nm³ = milligrams per (normal) cubic metres; mg/m³ (n) = milligrams per cubic metre (normal); barg = bar gauge.

2. ISO = International Standards Organization.

3.3.3 Inlet Facilities and Gas Compression

It is assumed that the LNG facility will receive feed gas from the M&NP pipeline through a letdown station and a fiscal quality metering station. No liquids are normally expected in the feed gas, therefore no slug catching facilities have been provided. However, there is the requirement for feed gas compression given the assumed plant inlet pressure of 43 barg as it is required to operate the liquefaction unit in the range of 60 to 70 barg. Since feed gas compressor will be installed, compressor protection from liquids will be achieved by compressor suction knock out drums. The compressors will be electric motor driven and after-cooling shall be required. The configuration of the compressors and the number of compression stages shall be determined during the FEED stage.



The inlet area may also include a pig trap to allow inspection of the pipeline by intelligent pigs. This is to be confirmed in FEED.

3.3.4 Gas Treatment Facilities

In order to ensure the inlet gas is suitable for liquefaction, trace contaminants must be removed in the gas treatment facilities. Contaminants include mercury, water, heavy hydrocarbons, benzene and carbon dioxide (CO₂). This is achieved by separate mercury removal, acid gas removal and dehydration units provided within each train. Any resulting by-product streams will be appropriately addressed with regard to their proper disposal. Sulphurous compounds (such as H_2S , mercaptans, etc) are removed to a sufficient degree to meet the LNG product specification. Where they are removed, they are transferred to the acid gas stream. The acid gas stream is currently envisaged as passing to an incinerator where harmful species will be fully oxidized before being exhausted to atmosphere at a sufficient height to be dispersed and avoid harmful levels in the surroundings. It may be proven that incineration is not required to achieve avoiding harmful levels; this will be evaluated further in FEED.

3.3.4.1 Mercury Removal

The mercury removal unit adsorbs mercury from the feed gas using non-regenerable mercury removal beds filled with activated carbon adsorbent to avoid mercury amalgam corrosion of aluminium components downstream. The exhausted adsorbent will need to be removed periodically (approximately every 3-6 years) and treated off-site by specialists to enable recovery of the mercury. An after filter is located downstream of the beds to remove any potential entrained bed materials. With respect to potential emissions, the mercury absorbers will be protected from overpressure by pressure relief valves that will be routed to the wet gas flare header.

3.3.4.2 Acid Gas Removal

It is necessary to remove CO_2 from the feed gas to prevent freezing in the cryogenic sections of the plant, the removal is achieved in the Acid Gas Removal System (AGRS). CO_2 is present in the feed gas in concentrations of up to 2.1 mol% and requires removal to a concentration of 50 ppmv. The design concentration of CO_2 will be 3 mol%. H₂S is also present in the feed gas and will require the removal of a few ppmv to meet the LNG specification. The technology selected for acid gas removal uses amine based chemical absorption (nominally methyl-di-ethanol-amine solvent) thus necessitating storage of amines on-site. The amine storage tanks will include a blanketing system to prevent emissions.

The waste acid gas will contain predominantly CO_2 and water. These will be either vented to the atmosphere (air quality limits permitting) or incinerated depending on the final composition of the acid gas.

The basic schematic for a typical acid gas absorption process can be seen in Figure 3.3-1. Feed gas from the mercury removal unit is fed to the bottom of the absorber and flows upward contacting the counter current lean solvent stream. The gas exits the top of the column sweet, stripped of acid gas, and saturated with water.



The lean solvent preferentially absorbs CO_2 and H_2S from the gas and is then termed "rich solvent". The rich solvent, at high pressure, is dropped in pressure and sent to a regenerator, where these absorbed components are removed by heating and/or stripping with steam, generated by the reboiler. The lean solvent is routed back to the absorber to complete the process loop.

As components are absorbed by the solvent, the temperature of the gas and solvent phases will increase due to heat of absorption. The heat released is proportional to the amount of gas absorbed. Side coolers can be used on the absorber to limit the temperature rise and aid in absorption, if necessary.

The solvent is cleaned of any impurities, and degraded amine by filtering a slip-stream of the lean amine stream to the absorber. Fresh solvent is supplied from storage, provided by a tank common for the two trains, blanketed with nitrogen to prevent degradation.

3.3.4.3 Dehydration

Within the dehydration unit, molecular sieves will be used to remove water from the gas stream to prevent it freezing in the liquefaction train. Initially feed gas from the AGRS is cooled and any condensed water is knocked out prior to entering the dehydrators. Molecular sieves (likely comprising of a crystalline alkali metal adsorbent) remove the residual water in the gas, which results in a residual wastewater stream that will be routed back to the AGRS to be used as water make-up to minimize demineralized water consumption. The adsorption towers shall be configured so that the regeneration of one can be achieved whilst full through put is handled by the remaining towers to allow for continuous operation.

3.3.4.4 Natural Gas Liquids (NGL) Extraction

Traces of heavy hydrocarbons will also need to be removed. The process for achieving this will be determined in the FEED phase once final inlet gas compositions are confirmed. Depending on the nature and quantities of natural gas liquids produced, the resultant stream will be either stored for later transportation to market or disposed of by incineration. The expected lean pipeline gas specification indicates that sufficient quantities of Natural Gas Liquids (NGL) for refrigerant extraction will not be available.

The preliminary design for this unit receives vapour from the dehydration unit, which is cooled in the NGL inlet gas/gas exchanger; any resulting liquid is separated in the cold separator vessel. The gas outlet from the cold separator is then reduced in pressure in a turbo-expander and the resulting two-phase stream is fed to an absorber column. In the absorber the gas is scrubbed with a circulating liquid hydrocarbon stream to remove heavier hydrocarbons and the resulting gas stream passes out of the top of the column. From here, the gas stream is heated first against the deethaniser overhead and then in the NGL inlet gas/gas exchanger (to cool the unit feed gas) before being compressed (first in the recompressor section of the turbo-expander and subsequently in the treated gas compressor) and then passed to the liquefaction unit.

Benzene is removed in the NGL extraction unit and the resulting NGL stream containing the benzene is stored for off site disposal. For the current feed gas composition, this stream is



relatively small and is thus envisaged as being removed by truck. Depending on the final amount and composition, this stream may be sent for off site disposal or sold-on as a product.

3.3.5 Natural Gas Liquefaction Unit

The liquefaction technology selected as the basis for the conceptual work is the propane (C3) pre-cooled mixed refrigerant (MR) process (C3MR). This process uses two main refrigerant cycles. The first is a single component refrigerant cycle using propane (C3) to achieve pre-cooling of the natural gas and MR. The second is an MR cycle which liquefies and sub-cools the feed gas. The MR is composed of nitrogen, CH_4 , ethane (and/or ethylene), and propane.

It is envisaged that the total 10 Mtpa of LNG producing capability will be installed in two phases, one train per phase. Each of the two trains will produce approximately 5 Mtpa of liquid natural gas at a temperature of around -162°C. The key elements of the liquefaction trains are the refrigerant compressors which will utilize gas turbine drivers of approximately 160 MW per train.

The LNG technology selected as the basis for the conceptual work is proven and has been used in over 70% of the existing LNG production facilities.

A schematic summarizing the liquefaction process is shown in Appendix B-1 (Generic Liquefaction Schematic).

Treated feed gas is first pre-cooled using propane refrigerant at descending pressure levels and corresponding lower vaporization temperatures.

After being cooled by the propane refrigerant, the feed gas enters the Main Cryogenic Heat Exchange (MCHE) where it is condensed and then subcooled against MR.

The propane circuit is a closed loop system. Propane vapour from the vaporizers at each pressure level is fed to the propane compressor, where it is compressed. The propane refrigerant is then de-superheated, condensed and sub-cooled against ambient cooling before being routed to the various propane vaporizers.

Low temperature refrigeration is provided by a closed loop MR system. This mixture of nitrogen and hydrocarbons is used to liquefy and subcool the natural gas in the MCHE.

The low pressure MR vapour from the warm end of the MCHE is compressed to high pressure before being cooled against ambient cooling and then partially condensed against successive levels of propane. This is then routed to the MCHE to liquefy and subcool the natural gas. All pressure relief (emissions) from the refrigerant/liquefaction process will be routed to the dry gas flare system.

3.3.6 LNG Storage

LNG from the MCHE is let down in pressure to approximately 0.050 barg and flashed in the storage tanks. This flash gas is compressed by the BOG system and routed to the fuel gas system. The degree of end flash is set by adjusting the MCHE outlet temperature. Storage



tanks shall be full containment storage tanks at near atmospheric pressure. This technology represents the best available for the service.

A total of three tanks will be required for the 10 Mtpa plant, with two being installed for the first phase. Each tank will be able to store up to a net capacity of 210,000 m³ of LNG which equates to a gross capacity of around 230,000 m³. The final sizing of the tanks will depend on the results of FEED, although they will be no larger than described here.

Full-containment tanks typically feature a primary liquid containment open-top inner tank and a steel or concrete outer tank. The outer tank provides primary vapour containment and secondary liquid containment. In the unlikely event of a leak, the outer tank contains the liquid and provides controlled release of the vapour via tank pressure relief valves. The LNG tanks will be approximately 90 to 110 m in diameter and 40 to 50 m in height (with platforms above that height).

The tanks are designed and constructed to retain natural gas in liquid and gaseous form in the unlikely event of a leak of the inner tank. Any vapours, or BOG, that are generated within the storage tanks are normally captured and compressed for use as fuel gas by the power plant.

A foundation heating system may also be used depending on the foundation selected in the next phase of the Project.

Submerged motor cryogenic pumps, used to send the LNG product to the jetty heads will be installed within the tanks. These typically operate below 10 barg and will pump a total of 12,000 m³/h of LNG to the carriers. A smaller submerged motor pump may also be installed in at least one of the tanks to circulate LNG around the loading system to keep it cool and to prevent gas building up.

The BOG compressors will be installed in a building to protect them from the environment and to provide some attenuation of noise generated.

3.3.7 Refrigerant Storage

Hydrocarbons (ethylene/ethane and propane) used in the refrigeration process of the LNG liquefaction trains will need to be stored on-site for make-up purposes.

The bullets will be of the pressurized containment type; although this will need to be confirmed during the next phase of the Project subject to a quantitative risk assessment. The bullets will be installed in a mounded area with transfer of refrigerant from bullets to the LNG trains shall be via transfer pumps.

Sourcing of the refrigerants, either importation by road via iso-containers or ability for production within the facility shall be reviewed during FEED and is dependent upon the finalized feed gas composition.



3.3.8 Flare Stacks

The flare system is provided for the reliable and safe disposal of hydrocarbon vapour and liquid streams that result from upsets and emergencies. In addition the flare systems are also capable of handling hydrocarbon streams that result from operating conditions such as start-up, shutdown, venting, draining, gas purging, heating and cooling of equipment and/or piping. If vapours containing significant water concentrations are relieved to the same system as cold dry vapours excess hydrate formation and freezing could occur which could block parts of the system. The flare systems design is therefore based on segregation of wet or potentially wet hydrocarbon vapour and dry vapour. Due to the very low pressure reliefs from the LNG storage and loading area, further segregation is also required for these releases. The three flares included in the plant design are:

- a warm/wet high pressure flare;
- a cold/dry high pressure flare; and
- a cold/dry low pressure flare.

The high pressure flares will be elevated pilot lit flares located on a common derrick. The flare stacks are demountable and the flare stack height is estimated to be approximately 120 to 180 m above ground level. A common high pressure spare flare stack will be included in the common derrick. A single, low pressure, cold/dry storage and loading flare will be constructed. This flare will be located in an area adjacent to the LNG tanks and will be approximately 30 to 40 m high.

3.3.8.1 Wet Gas Flare System

Warm vapours, mainly from the inlet facilities, AGRS, fuel gas system and hot oil system are grouped into a single header, without low points in which liquid may collect, before passing to the wet flare Knock Out (KO) drum for separation.

Vapour from the wet flare KO drum is then directed to the wet flare. The system is continuously purged with fuel gas introduced at the ends of the main collection headers to prevent air ingress into the flare stack. Nitrogen connections are provided as a backup purge source.

The wet flare KO drum will also receive liquid from the wet liquid disposal system (this is designed to handle warm hydrocarbon liquid from manual drains in the process units). All warm hydrocarbon liquid from collection networks are grouped into a single header to the wet flare KO drum where any light components are flashed off. The residual content of the wet flare drum, that may ultimately need to be disposed of, would be any relieved material that is not volatile enough to weather off and be ignited at the flare tip. This could be water or amine solution if there is a liquid relief case in the AGRS, it will contain heavy hydrocarbon elements (pentane and heavier). Although difficult to quantify, this volume should be relatively small and rarely generated. The liquid from the bottom of the wet flare KO drum would be removed to off-site for disposal at an approved location.


3.3.8.2 Dry Gas Flare System

All the cold dry vapour from collection networks (mainly from process units downstream of the dehydration unit) are grouped into a single header passing to the dry gas flare KO drum. Vapour from the dry gas flare KO drum is then directed to the dry flare. The system is continuously purged with fuel gas introduced at the ends of the main collection headers. Nitrogen connections are provided as a backup purge source.

The dry gas flare KO drum will also receive liquid from the cold liquid disposal system. This system is designed to handle cryogenic hydrocarbon liquids from emergency releases as well as liquids drained from plant operation.

The dry gas flare KO drum will be sized for the liquid from emergency scenarios, which will be held in the drum and then vaporised using warm defrost gas.

Any heavy hydrocarbons collected in the dry gas flare KO drum that are not vaporised by the defrost gas will be manually drained to the dry liquid blowdown vessel for transfer to the wet flare KO drum.

3.3.8.3 Low Pressure (LP) Flare

The Low Pressure (LP) flare system collects vapour released from the LNG storage and loading system and is an independent system due to its low back pressure requirement. The LP flare system is not provided with a KO drum as the relief flows are BOG from storage or ships and will not contain any liquid or be subject to condensation.

3.3.8.4 Spare Flare System

A common spare flare is provided to allow maintenance of the wet or dry flare stack and tips.

3.3.9 LNG Truck Loading Facility

Space has been reserved on the plot for the possible addition of an LNG truck loading terminal in order to serve the local community. A total of up to four LNG truck loading bays are envisaged. The truck loading facility would be separated from the main plant with a dedicated entrance and security.

3.3.10 Utilities, Infrastructure, and Support Systems

In addition to the facilities mentioned above, the following will be required for the safe operation of the LNG plant and marine terminal:

- programmable logic controller based control system;
- fire and gas system;
- emergency shutdown system including possible links to the nearby Sable Plant;
- security systems and closed circuit television;
- control building;
- substations;
- field auxiliary rooms;
- fire station;



- fire pump buildings;
- warehouses and storage buildings;
- rotating equipment shelters;
- air and nitrogen generation plant; and
- additional infrastructure as may be required to support safe operation of the facility.

3.3.11 Resource/Material Requirements

A preliminary listing of process materials input/output is presented in Table 3.3-2.

Inputs	Process/Facility	Outputs
Ship servicing materials and fuel Sea water Construction materials	Marine facility	LNG product Sea water for firewater system back-up Waste from service boats
Natural gas Propane Ethane / ethylene	LNG plant	LNG Solid waste Combustion products Acid gas streams Fugitive emissions
Air Raw water Wastewater Natural gas Acid gas	Utilities	Nitrogen Potable water Treated water Combustion products
Natural gas Diesel	Power plant	Electrical power Combustion products

 Table 3.3-2
 Process Materials Input/Output

3.3.11.1 Energy Balance

The following energy balance for the facility is preliminary and is based on the Pre-FEED design work. For 10,000,000 t of offloaded LNG (average annual production per train, based on average feed gas composition) the predicted energy balance is:

•	Input energy (feed gas from pipeline)	6.07E+11 MJ;
•	Output energy (in LNG product)	5.50E+11 MJ; and
•	Consumed energy (fuel gas)	5.7E+10 MJ.

Fuel gas is used in the process to drive the gas turbine refrigeration compressors, the main power plant gas turbines and incineration of acid gas exhaust. The energy quoted above is based on gross calorific value measured according to ISO 6976, reference conditions of 15°C and 1.01325 bar (a).



3.3.12 Operational Water Requirements

The facility will be predominantly air cooled and as such will not require large volumes of raw, fresh water to be extracted. Any need for water cooling of equipment will utilize the closed system packages dedicated for that purpose.

It is envisaged that the water will be sourced from the Meadow Lake via a pipeline. The total service water requirement will be approximately 500 m³/d, with a peak of 1200 m³/d. Project water volume requirements have been estimated based on a conservative approach for the purpose of pipeline design (600 m³/d) in order to accommodate somewhat higher water usage during construction (see Section 3.2.6). Table 3.3-3 presents approximate water demand volumes with either a single train or both trains operating.

	Average Daily (m³/day)	Peak (Design) Daily (m³/day)	Average Monthly (m ³ /month)	Notes
Phase 1	300	720	9,125	Water demand if only one train is operating.
Phase 2	500	1,200	15,208	Total water demand under two train operations.

 Table 3.3-3
 Operational Water Demand

To cover the peak demand rates water will be stored in dual service firewater / service water tanks, the final size of the tanks is to be determined in FEED.

The service water system is configured to supply a variety of intermittent users, with a nominal breakdown of normal water consumption as follows:

- 40% for demineralized water;
- 40% for potable water;
- 10% for fire water; and
- 10% for utility stations.

The raw water lift pumps will supply water to the service water Reverse Osmosis packages. Service water produced by the Reverse Osmosis unit is then sterilised before being stored in the service and fire water tank.

From the service and fire water tank, the service water pumps will deliver water to the remineralisation package, the demineralization package and the utility stations in the plant.

3.3.12.1 Demineralised Water

Service Water is treated in the demineralization package then sent to the demineralised water storage tank.

The demineralised water storage tank will be Nitrogen blanketed to eliminate oxygen ingress into the process and minimize the chance of any bacterial growth. The demineralised water pumps will distribute water to the AGRS (for solvent make-up and flushing equipment), utilities



(compressor closed circuit cooling system water top-up/changing), and the gas turbines (periodic washing of gas turbine blades).

3.3.12.2 Potable Water

Water supplied from the service and fire water tank requires further conditioning to meet potable water standards.

Drinking (potable) water will be produced to meet World Health Organization (WHO) standards suitable for domestic usage, emergency showers and eyewash stations for the whole facility.

Potable water is demineralised and is stored in the potable water tanks. The drinking water is pumped from the tank and distributed to the facility. All distribution piping is above ground. To reduce the trace heating load and to avoid stagnation, there is a continuous flow of water around the distribution system. Dead legs shall be minimized.

3.3.12.3 Fire Water System

The fire water systems provide water to hydrants and monitors in the event of a fire on site. The service and fire water tank receive water from the service water system under level control.

Service water/jockey pumps will keep the fire water ring main pressurized as well as circulate water through the system to minimize tracing demands. The fire water ring main covers the extent of the facility and is designed to ensure that even if sections are isolated for maintenance, circulation can be maintained throughout the rest of the circuit.

The service and fire water tank will provide hold-up for the main fire water pumps and the service water/jockey pumps. The main fire water pumps will take feed from the bottom of the tank while the service/jockey pumps will take supply from a level in the tank such that the working volume required for firefighting is retained.

In the event the fire water tank is emptied during a fire incident, the system will be made up with sea water from pumps located at the jetty area.

3.3.13 Hazardous Materials

Part 8 of the *Canadian Environmental Protection Act* (CEPA) 1999 on environmental emergencies (sections 193 to 205) provides various authorities to address the prevention of, preparedness for, response to and recovery from environmental emergencies caused by uncontrolled, unplanned or accidental releases, and to reduce any foreseeable likelihood of releases of toxic or other hazardous substances.

These regulations allow Environment Canada (EC) to require the preparation of environmental emergency plans (E2 plans) for toxic or other hazardous substances (EC, 2011). The primary objective for requiring environmental emergency planning is to have the appropriate risk management practices adopted and implemented to reduce the potential risks associated with the manufacture, storage and use of toxic and other hazardous substances in Canada.



Schedule 1 of the E2 Regulations contains a list of substances of particular concern. Minimum storage quantities have been established for these substances at or above which the Minister may require notice of identification of the substance and place, as well as preparation of E2 plans. Quantities of substances below the mass threshold do not need an emergency management plan (EC, 2011).

Various fuels and potentially hazardous material will be used during the life of the Project. These include:

- gasoline;
- diesel;
- propane;
- POLs;
- acetylene;
- oxygen and other compressed gases;
- form oil;
- paints;
- epoxies;
- concrete additives;
- glycol/methanol;
- cleaner; and
- solvents.

Chemicals which are associated with the operations phase of the LNG Project are:

- natural gas;
- sulphurous compounds such as H₂S, mercaptans;
- mercury;
- methyl-di-ethanol-amine solvent;
- benzene;
- mixed refrigerants (nitrogen, CH₄, ethane, ethylene and propane); and
- air emissions, including VOCs, SO_x, NO_x, PM, and GHGs.

A preliminary chemical inventory is presented in Appendix B-3 that compares the substances listed above to the EC chemical schedule (EC, 2011). This table displays known toxicity (human and ecological receptor). A complete inventory will be developed and updated as the Project proceeds. All hazardous materials will be monitored and subject to the hazardous materials management plan located in the EMP/EPP (Section 3.7), including a spill contingency plan. Hazardous materials will be stored and handled in accordance with all regulatory requirements. The locations of all hazardous materials kept on site will be shown on a plan drawing. Chemicals will be stored separated according to class in appropriate enclosures with WHMIS labels. All chemical and fuel storage will be located inside containment areas with 125% of the total volume of the stored liquid.



3.3.14 Wastewater Management

After construction, the on-site wastewater treatment facility will continue to be used near the design capacity of $600 \text{ m}^3/\text{d}$ to treat plant water, meeting any environmental requirements. The operation phase water management systems will also include potentially contaminated, oily water, and domestic water.

Stormwater will be treated as either clean when it originates in clean plant areas, or potentially contaminated when from process areas. Water from process areas may be further segregated into first flush that will be monitored for contamination before either treatment or discharge to sea. Similar to the construction phase, runoff from uncontaminated areas will not be treated prior to discharge although monitoring may be required.

All uncontaminated water to be discharged to the sea will be routed via sedimentation ponds to ensure no sediment is discharged.

3.3.15 Solid Waste

During operation, the Project will generate solid waste arising from construction, operations, maintenance and domestic activities, including:

- hazardous wastes arising from use of paints, oils, batteries etc.;
- sanitary and medical waste;
- oily waste;
- radioactive waste (spent sources from testing activities); and
- exhausted catalysts and adsorbents.

Some non-hazardous waste and perhaps oily waste may be disposed of on-site using the incinerator.

Hazardous waste streams will be separated according to type (waste oils, paints, acid batteries, contaminated filters etc.) on site and stored within suitable containment prior to transport off-site for disposal at an approved facility.

Accidental spills are also a potential source of LNG, POL, and small quantities of other hazardous chemicals. A summary of all Project emissions, discharges, and waste is presented in Section 3.5.

3.3.16 Operation Related Noise

Typical LNG liquefaction plants contain equipment that will cause high noise levels. This includes the large refrigeration compressor trains, the boil off gas compressors, the power generation gas turbine exhaust stack and some utility equipment. In addition, intermittent noise sources will emit high noise levels. This involves for example the emergency flaring and operation of pressure relief valves; both represent infrequent events of short duration.

Based on previous LNG experience, CB&I conducted a preliminary noise study for the Project (CB&I, 2013b). The study predicts that on-site noise levels at the LNG facility will meet the



criteria noise level of 85 Decibels (A-Weighted) (dB(A). However, in some on-site locations, such as the compression area, certain utilities areas, and particularly within buildings, noise levels are expected to generally range between 95 dB(A) and 105 dB(A). In the event of an operational upset, on-site noise levels could increase to 115 dB(A).

During FEED, opportunities for operation related on-site noise mitigation will be investigated including use of adequate building designs, equipment related noise abatement measures (e.g., use of enclosures, insulators, silencers), and operational policies (e.g., health and safety requirements such as mandatory protective gear in certain work locations and during specific operational procedures).

More information on operation related noise levels is included in Section 10.5 together with a discussion of noise levels at off-site receptors and proposed mitigation measures.

3.3.17 Air Emissions

Operation of the LNG facility will generate emissions to air, arising from combustion processes as well as venting from equipment. Combustion emission products will include CO_2 , Carbon Monoxide (CO), NO_x, SO_x, unburnt VOCs and PM. Vented emissions will include nitrogen and fugitive VOCs.

Table 3.3-4 provides a summary of expected emissions during operation.

					<u> </u>		
Equipment Name (Point source of release)	Total Number of Equipment Items (origins of pollutants)	Description of emission source (origin of pollutant)	List of pollutant components	Components mass flowrate (g/s)	Component concentration (mg/Nm ³)	Annual discharge of component (t/y)	
			60	17.000	4.004.000	500.000	Ba
				17,960	1,964,989	566,386	mg
Incinerator for AGRS	2 (1 incinerator per LNG	Acid gas vent	Nitrogen Dioxide (NO ₂)	2.74	300	86.48	Fig
	train)		со	2.28	250	72.06	_
			Sulphur Dioxide (SO ₂)	42.00	4,595	1,324	
			NOx	69.4	51	2,186	Fig
			SO ₂	n/a	n/a	n/a	
Refrigerant compressor gas turbine – Frame 7	4 (2 machines per LNG train)	Gas turbine exhaust	СО	17	12.5	536	
	,		CO ₂	57,476		1,812,564	
			Unburnt hydrocarbons	4.8	7	300	
	6 machines (total for Fuel gas powered gas phase 2) turbine exhaust	NOx	46	51	1,443	Fig	
		6 machines (total for Fuel gas powered gas phase 2) turbine exhaust	SO ₂	n/a	n/a	n/a	
Power generation gas turbine – Frame 6			со	11	12.5	354	
			CO ₂	37,934		1,196,291	
			Unburnt Hydrocarbons	3	7	198	
			CO ₂	2,204	182,652	69,490	
Pilot/ purge gas for flares	4 flares (Wet, dry, spare &	Fuel das	NO ₂	0.818	68	26	— Fig
Filol purge gas for liares	BOG)		СО	6	475	180	
			CH4	40	3,259	1,240	
			NOx	4.01	1,914	1.445	_
Emergency diesel generator set	To be confirmed during FEED studies. Diesel er	Diagol onging ovhquaturat	CO	0.3	143	0.108	Fig
Emergency dieser generator set			Unburnt Hydrocarbons	0.16	80	0.059	
			CO ₂	38,750	185,000	13,950	

Table 3.3-4 Summary of Expected Emissions During Operation

Notes:

1. g/s = grams per second.

2. $mg/Nm^3 = milligrams per (normal) cubic metres$

3. t/y = tonnes per year



Comments

ased on design level of sulphur in Feed gas: 50 g/Nm³.

gures are total for Phase 2.



Table 3.3-5 provides dimension estimate of point sources. Stack heights will be modified as required to meet environmental guidelines.

Point Source	Dimension Estimations
Incinerator for AGRS	Elevation: ~ 40 m
	Diameter: ~ 5 m
Refrigerant compressor gas turbine (Frame 7)	(Current basis is that if AGRS incinerator is
	required, stack shall be combined with Refrigerant
	Compressors)
Power generator gas turbine (Frame 6)	Elevation: ~ 40 m
	Diameter: ~ 4 m
Pilot/purge gas for flares (wet, dry and spare flare)	Elevation: ~ 100 m
	Diameter: ~ 1.2 m
Pilot/ purge gas for flares (LP flare)	Elevation: ~ 40 m
	Diameter: ~ 1.6 m
Emergency diesel generator set	Elevation: ~ 40 m
	Diameter: ~ 0.4 m

 Table 3.3-5
 Dimension Estimates for Point Sources of Emissions

3.3.17.1 Emissions from the Flare Due to Start-up Operations and Trips (Phase 1)

In the first year of operation, there are expected to be considerably more spurious plant trips and subsequent start-up operations than in the following years. The emissions both in the first year and a typical year have been estimated as tabulated below (Table 3.3-6). Start ups and plant trips are characterized as follows:

- <u>Plant start-ups</u>: operationally vent to maintain stable, controllable operation as the production rate is increased from zero to the minimum practical plant turndown.
- <u>Plant trip</u>: spurious trips or emergencies when blow down of any or all parts of the plant may be required with consequent releases to flare.

List of pollutant Components	Typical Releases for Average Year	Typical Releases for First Year
CO ₂	3735	24511
NO ₂	1.4	9.1
CO	9.7	63.8
CH ₄	67	437

Table 3.3-6 Total Releases (tonnes/year) for Typical Year and for First Year

3.3.17.2 Fugitive Emissions

Total fugitive CH₄ emissions will be approximately 1306 t CH₄ per year, based on 10,000,000 t throughput and emission factor (130.563 standard cubic feet/million standard cubic feet (scf/MMscf) processed) from Table 6.5 American Petroleum Institute (API) GHG Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Gas Industry (API, 2009).



3.3.18 Marine Vessel Operations

As part of the Pre-FEED work, CB&I and Royal Haskoining DHV prepared a shipping study to summarize the relevant nautical issues for the Project at a conceptual level (CB&I, 2013c and CB&I and Royal Haskoining DHV, 2013). The design of the marine facilities, including the access channel and manoeuvring area is for a large part determined by the size of the LNG carriers, which will be handled at the jetty. Sufficient space and depth shall be available for safe and easy maneuvering of all the vessels under all operational conditions. The following sections discuss the dimensions of the access channel and the maneuvering area. It is emphasized that the results are based on theoretical design guidelines and on a limited amount of site data. In a later design stage (FEED), shipping studies shall be carried out to determine the final dimensions and depths of the access channel and maneuvering area, all in combination with additional information regarding environmental conditions (e.g., waves, currents, etc.), and operational requirements (e.g., tug assistance) and other related aspects.

3.3.18.1 LNG Carriers

Expected LNG carriers are:

- membrane type ranging 145,000 to 266,000 m³; and
- spherical type ranging 145,000 to 177,000 m³.

The spherical LNG carriers with over 177,000 m³ capacity are not yet on the market but manufacturer Moss is advertising that they have the flexibility to develop spherical LNG carriers up to 265,000 m³. The typical vessel dimensions are compared in Table 3.3-7 and spherical LNG carriers will be in the same range as for the large membrane vessel with similar capacity. As the vessels dimensions are similar, it is not expected that this will have any considerable effect on the jetty design.

Туре	LNG Volume (m ³)	LOA (m)	B (m)	T (m)	Displacement (t)
Membrane	145,000	285	44	12.1	111,000
	266,000	345	55	12.2	180,000
Spherical	145,000	290	49	11.3	110,000
	177,000	300	52	11.7	140,000

 Table 3.3-7
 Typical LNG Carrier Dimensions

Notes:

LOA = Length Overall (boat specification)

B = Breadth. The width at the widest point as measured at the nominal waterline

T = Draught. Maximum depth of the keel, when fully loaded.

The spherical LNG carriers have a larger wind area than membrane LNG carriers of the same size; however, this will not have an impact on the dimensions of the access channel or the maneuvering area where very wide areas are already available. The only impact this would have on this facility is the capacity and number of the tugs and the size of the mooring hooks on the berthing and mooring dolphins.



Based on typical windage areas, the spherical LNG carrier when compared to the membrane LNG vessel has approximately 25% greater end-on windage area and approximately 20% greater side windage area. This is mainly due to the above deck windage area caused by the large spherical domes.

3.3.18.2 Access Channel

The new terminal is located in a relatively wide and open bay close to where two sub-sea pipelines come ashore (Figure 3.3-2). In Figure 3.3-2, the natural approach route is in between the two red lines. The blue shaded areas have a depth less than -20 m (Chart Datum (CD)), the white areas are deeper than -20 m (CD). Refer to Section 3.3.18.4 for details of the access channel in relation to the sub-sea pipelines and associated emergency procedures.

A water depth of over -20 m (CD) is adequate for a LNG Carrier with a draught of 12 m. Guidelines suggest a minimum depth of 1.5 times the vessel draught in waves of over 1 m in height. Assuming that waves in the approach are over 1 m this suggests a minimum required depth of -18 m (CD) in the approach. The approach starts offshore at the TT buoy where the channel is over 2,400 m wide. At the inshore end of the channel the available width between the -20 m (CD) contour is over 1,200 m.

With the largest LNG carriers having a breadth of not more than 55 m, the width of the available channel is at least 20 times the breadth of the vessel. Guidelines suggest a (single lane) channel width of (maximum) six times the breadth of the largest vessel. Therefore the available width of the approach can be considered more than adequate.

The approach is approximately 15 km long. The point at which the vessel can abort the approach and return to open sea without assistance is half-way along the approach channel, near the TT4 buoy. Such an evasive man oeuvre is illustrated by the green line in Figure 3.3-2, the short turn is with maximum rudder angle; the wider turn is with approximately two-thirds of the maximum rudder. When the latest point to abort is passed and a calamity occurs, the vessel may proceed to the maneuvering area in front of the jetty. This area is relatively deep and wide and may provide adequate space for the vessel to recover with the assistance of tugs. Such possibilities will be further investigated during the FEED.

Fast-time and real-time vessel maneuvering simulations were carried out and both confirmed the feasibility of the normal approach (no emergencies) in wind speeds up to 14 to 17 metres per second (m/s). In the calm wave conditions the tugs will not be limited in their operations. Wind directions from open sea (northeast to southwest) will likely generate high waves in the approach. Wind waves and swell in the approach will limit the operability of the tugs and can result in downtime.

During arrival the approach channel is used to reduce speed. As the vessel becomes more difficult to control at reduced speed the presence of a stern tug connected to the LNG carrier is a necessity, additionally an escort tug will sail with the LNG carrier at the bow but without a tow line connected. Once inside the maneuvering area, with calm water, the LNG carrier can stop



using its own engine and initially be controlled by the stern tug while the bow tug and additional mooring tugs make their tow line connection.

The stern tug is considered to be able to make fast at a speed of 6 to 10 knots in waves with heights up to 2.5 m. With higher wave conditions in the approach the LNG carrier may have to wait offshore until conditions improve. Alternative approach procedures may be developed based on practical operational experience and further training of pilots and tug masters.

For the simulations, assumptions were made for waves and current as no actual data of the local conditions was available.

3.3.18.3 Maneuvering Basin

Inside the bay, in front of the new terminal, there is a relatively wide area for the vessels to turn and maneuver (Figure 3.3-3) to the jetty. The area has a charted depth between the 10 m and 20 m contour. The number of soundings in the nautical chart is too limited to get full information on the bed level although the few soundings given are all over 14 m. In calm water the 14 m depth is generally adequate for the maneuvering of vessels with a draught of 12 m or less. Nevertheless, wave conditions and a full bathymetric survey are required to confirm conditions and available depths in the bay.

Guidelines suggest that a turning basin for tug-assisted vessels should have a diameter of (maximum) two times the length of the vessel. The largest LNG carriers have a length of not more than 345 m. Figure 3.3-3 indicated circles have a diameter of 700 m. The circles just indicate that the required space is available. When assuming that the depth is adequate, the vessels have even more than enough space in the maneuvering area. The exact location of turning is determined by the pilot and master depending on the vessel, tugs and actual conditions.

The LNG carriers will maneuver and turn inside the bay as close as possible to the terminal as practically possible taking safety distances into account and depending on actual conditions of current, wind and waves. The maneuvering to and from the berth at arrival and departure will be fully controlled by tugs.

For the inside berth the available space is adequate, though more confined than for the outer berth, also turning is likely to take place further away from the berth.

From a maneuvering point of view it is beneficial to rotate the berths towards a more southerly direction. However, the berth orientation is also closely linked to the direction of the waves which are expected to have influence on the mooring conditions.

During loading of the LNG Carriers, a 200 m exclusion zone is defined by code around the loading jetty. It is the area in which a potential hazard would occur if there was a loss of containment during loading. The restrictions would be to avoid ignition sources in that area during loading (e.g., no vehicles within the zone, limited personnel, permitted zone).



3.3.18.4 Sub-sea Pipelines

There are two sub-sea gas pipelines positioned in the approach channel at a depth of more than -20 m (CD). The LNG carriers are able to sail over these pipelines. However, they would pose a risk if anchors are used in an emergency and then be dragged over them. Approaches to avoiding any such risk will be investigated during FEED and the TERMPOL review process (Section 3.3.19) and may involve specific protocols to be followed during vessel approaches such as temporary disabling the anchor controls, or the use of additional tugs.

3.3.18.5 Tugs, Line Boats & Pilot Boat

Tugs

The maximum wind load is reached with the large $(177,000 \text{ m}^3)$ spherical LNG carrier. In a Beaufort 7 wind the required approximate effective tug capacity is 110 t at the stern and 110 t at the bow of the LNG carrier. Using a commonly accepted reserve capacity for the tugs of 30%, results in a required tug capacity of 160 t bollard pull at the stern and 160 t at the bow. This capacity can be achieved by using four tugs of about 80 t bollard pull.

The need for ice breaking capacity of the tugs depends on the local ice conditions. Two inlets, more inland of the new terminal, are reported to have none or minor ice build-up. However, nautical publications do report that sea ice can be present in February and March.

Line Boats

Two line boats are required to assist with the mooring operations.

Pilot Boat

One pilot boat, with good sea-keeping performance, is required to transfer the pilot.

3.3.18.6 Aids to Navigation

The approach is already marked with Aids to Navigation for the present local traffic. The LNG carriers are of larger dimensions than the present traffic. For the LNG carriers additional Aids to Navigation are required to indicate:

- The 10.4 m wreck in the vicinity of TT6 buoy (one buoy).
- The 8.5 m shoal to the south southeast of Bear Trap Head (one buoy).
- The 15 m contour to delineate the area of the maneuvering basin (two to three buoys).
- The location where the sub-sea pipelines crosses the 20 m depth contour.
- The easterly boundary of the Black Ledge at the 15 m contour (two buoys).
- The Finchley Shoal (rock) 4.9 m (one buoy).

Depending on the actual bathymetry in the maneuvering basin and the delineation of the 15 m contour the marking of the 8.5 m shoal may be omitted.

The buoys shall be of similar size and type as presently used in the area. The implementation shall have to be coordinated with the local authorities.



3.3.18.7 Non-project Shipping

Further inland from the new LNG terminal are two inlets with various pier and quay facilities. The west inlet is Country Harbour which has a fish packing industry. The berth has a depth of 6.7 m. Older documentation also mentions berths with depths up to 12.8 m available. Country Harbour is reported to be ice free from the entrance to four nautical miles inward. Isaac's Harbour on the east side is currently closed for commercial operations, but has some berths available with depths up to 4.9 m. Ice in Isaac's Harbour is generally cleared from the harbour by shifting winds.

It can be expected that other non-project shipping in the region will be limited as there are limited and small facilities only.

3.3.18.8 Marine Construction Vessels

For marine construction vessels the main issue will be the local working conditions with respect to wind and waves / swell at the construction site. The approach is wide and deep but downtime could potentially be experienced due to weather conditions.

Depending on the dimensions of the construction vessels they may be able to enter into Country Harbour for shelter and receiving material provided over land. The nearest main port is Halifax which is approximately 100 nautical miles away.

Typical equipment for construction will include barges (some with mounted cranes), specialist pile-drilling rigs and a shear leg vessel (likely to be the largest piece of construction equipment).

A shear leg is a floating two-legged lifting device used for lifting very heavy pieces of equipment and is often used to support large engineering projects afloat. Shear legs are ideal for installing pre-fabricated units in sheltered waters, e.g., Smit Taklift 4

Alternately a floating vessel with a rotating crane may be used, such as the Mersey Mammoth; which has a lifting capacity of 250 t and typical dimensions of 60m long by 23.5 m wide.

3.3.19 **TERMPOL** Review Process

Goldboro LNG will be participating in the voluntary TERMPOL review process, i.e., the Technical Review Process of Marine Terminal Systems and Transshipment Sites.

The process "focuses on a dedicated design ship's selected route in waters under Canadian jurisdiction to its berth at a proposed marine terminal or transshipment site and, specifically, to the process of cargo handling between vessels, or off-loading from ship to shore or vice-versa" (TC, 2001).

The process considers a transshipment facility as a designated location for the transfer of cargo between vessels, including bulk oil, chemicals, liquefied gases and any other cargoes which may be identified by TC as posing a risk to ship, public or environmental safety (TC, 2001). The issues addressed under TERMPOL somewhat overlap with this environmental assessment; as



such, the TERMPOL process will involve a detailed and comprehensive review of the Goldboro LNG shipping and navigation issues, while the EA assesses these issues at a conceptual level.

Pieridae met with TC representatives in January 2013 (see Section 13.1) to discuss the general process, information requirements, and scheduling. Pieridae intends to formally initiate the process upon completion of the EA, early on during FEED as much of the information required for TERMPOL will then be generated. Similarly, input from the participating regulators will be required during FEED for Pieridae to detail its design and operation plans in accordance with regulatory requirements, codes and guidelines.

In conducting a TEMPOL Review, Pieridae's submission will have to demonstrate that:

- "the operator's or owner's safety management system is in accordance with recognized safe management procedures;
- arrangements are planned to conduct on-going operational audits of the safety and management system;
- major accident hazard in the context of the proposed operation have been identified; and the risks therefore have been evaluated and measures taken to reduce those risks to an acceptable level using the best available technology." (TC, 2001).



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SOURCE: CBI/Royal Haskoning DHV, 2013



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SOURCE: CBI/Royal Haskoning DHV, 2013



3.4 Decommissioning Phase

Pieridae is committed to an orderly and comprehensive decommissioning of the facilities once it reaches its design life and when necessary upgrades are no longer economical. An earlier decommissioning may be considered should the markets no longer support an economic operation of the plant. If no opportunity for utilization of the facility or parts thereof is identified, complete decommissioning will be undertaken, including the removal of all buildings, roads, storage facilities, and site services. Upon removal of all infrastructures, the site will be rehabilitated. A decommissioning plan will specify decommissioning objectives, approach, activities, schedules, and the site rehabilitation. The plan will be developed in consultation with the municipality and regulatory agencies.

3.4.1 Decommissioning Plan

Prior to the decommissioning and abandoning of the Goldboro LNG facilities, Pieridae will develop a decommissioning plan. The plan will specify decommissioning objectives, approach, activities, schedules, and site rehabilitation and will be developed in consultation with the municipality and regulatory agencies.

In particular, objectives of the decommissioning plan will be to:

- identify applicable municipal, provincial, and federal regulations and standards;
- identify and consider objectives of local municipality and adjacent landowners;
- define the decommissioning objective;
- protect public health and safety;
- rehabilitate the plant site in accordance with regulatory standards;
- reduce or eliminate potential adverse environmental effects beyond decommissioning; and
- develop a material management strategy to maximize reuse/recycling options on and off-site or via a material processing facility, and to avoid/minimize disposal in approved landfills.

As a minimum, the plan objectives will define the removal of all hazardous substances, equipment and storage tanks. Should the plan objective be the complete decommissioning of the site, activities will include the removal of all buildings, roads, storage facilities, and site services. Upon removal of all infrastructures, the site will be rehabilitated.

3.4.2 Removal of Buildings, Equipment and Infrastructure

Prior to removal of the buildings and facilities, all remaining stored materials will be removed from the site in accordance with provincial and federal regulations and guidelines pertaining to handling of hazardous and non- hazardous materials. Materials will be sold to markets or properly disposed of through licensed waste operators.

If no suitable after use is identified, removal of all buildings and infrastructure will be undertaken in full compliance with existing regulatory standards. A demolition permit will be obtained from



the municipality. Contractors will be required to follow applicable regulations for material separation, disposal at licensed waste sites, and sales to recycling markets.

The removal of products and storage materials, the demolition of the buildings and removal of infrastructure will be subject to environmental supervision and inspection for compliance with decommissioning plan and regulatory standards.

3.4.3 Site Rehabilitation

Site rehabilitation objectives depend on the intended after use of the property, which could be for example another commercial use or the return to a forestry use or a natural state. Pieridae is committed to rehabilitate the site in accordance with regulatory standards and in consultation with the municipality and neighbouring landowners.

Following the removal of buildings, infrastructure and products a qualified environmental expert will assess the site with respect to contamination that may have occurred as a result of the material storage, handling or decommissioning activities. Should any site contamination be identified, site remediation will be undertaken in order to meet all NSE standards for the intended after use. The site remediation, if required, will be supervised and documented by a qualified environmental expert.

The Goldboro LNG Facility will be designed with spill containment and protective measures to prevent contamination of the site. The operations will therefore not result in long term effects that will preclude rehabilitation and re-use of the site.



3.5 Waste Management, Emissions

The Project will produce the following general types of emissions, discharges, and waste:

- solid waste (construction & domestic);
- air emissions, including VOCs, SO_x, NO_x, PM, and GHG;
- wastewater (construction, process, and domestic); and
- noise.

There are some potential waste types that could be produced if historic mining contaminated soils or acid generating bedrock is encountered. Accidental spills are also a potential source of LNG, POL, and small quantities of other hazardous chemicals. A summary of emissions, discharges, and waste is presented in Table 3.5-1.

Source	Туре	Description
Construction Phase	9	
Operation of vessels, temporary plants and vehicles	Emissions to Air: • CO, CO ₂ , VOCs, SO _x , NO _x , PM	 Limited emissions of combustion gases from operation of vessels, vehicles, diesel generators and other temporary plants (e.g., concrete, asphalt). Minor emissions of VOCs from fuel storage and refueling. Magnitude will be proportional to numbers of mobile equipment items and number of vehicles per day during construction (approximately 600 vehicles at peak).
Construction traffic	Emissions to Air: • dust	 Temporary dust emissions from road traffic to be controlled below regulatory guidelines by standard best management practices. Magnitude will be proportional to ground conditions and number of vehicles per day during construction (approximately 600 vehicles at peak).
Temporary concrete and asphalt batch plants; aggregate transportation	Emissions to Air: • dust & VOCs	 Temporary dust emissions to be controlled below regulatory guidelines by standard best management practices. Minor emissions of VOCs from asphalt.
Clearing, grubbing, grading and excavation for all activities	Emissions to Air: • dust	 Temporary dust emissions arising from exposed soils to be controlled by standard best management practices. Magnitude will be proportional to total area of site (approximately 150 hectare (ha).
Marine vessels (cargo), tugs	Emissions to Air: • VOCs	Minor VOC emissions from fuel storage/bunkering.
Marine vessels (cargo), tugs	Wastewater: ballast water 	Marine vessels will conduct ballast water operations off- shore in accordance with Canadian and US guidelines.
Domestic wastewater system	Wastewater: • sanitary wastewater	 On-site use of sewage treatment "package plant" during construction. Sewage will be treated to comply with regulatory requirements and monitored, prior to discharge into Isaac's Harbour. Magnitude will be proportional to the number of employees during construction.

Table 3.5-1 Emissions, Discharges and Waste



Source	Туре	Description
Pipe/ vessel strength testing	Wastewater: • hydrotest water	• A procedure for management and disposal of hydrotest water will be developed in compliance with Federal requirements.
Site runoff	Wastewater:sedimentation in site runoff	• Sedimentation from stormwater runoff will be controlled by standard best management practices. Magnitude will be relative to total area of site (approximately 150 ha).
Blasting / excavation in bedrock	Wastewater: • acid rock drainage • noise	 Project may encounter acid generating bedrock. A SBMMP will be developed to ensure Provincial guidelines are met. Temporarily loud noise of short duration during site preparation and contouring; mitigation through scheduling of blasting activities.
Marine construction	Wastewater: siltation 	 Siltation during construction of marine terminal and shoreline protection activities will be controlled by silt curtain and boom.
General machinery operation	Noise	 Low levels of noise (below provincial guidelines) from site machinery are anticipated at site boundary.
Pile driving & blasting	Noise	 Temporarily loud noise and acoustic vibration in both aquatic and terrestrial environments that may carry for large distances. Options for minimizing and managing piling noise will be reviewed.
Various activities	Solid waste: • various non- hazardous wastes	 Solid non-hazardous waste will be separated into recyclable/ non-recyclable waste streams on site and stored temporarily within suitable containment prior to transport off-site for disposal at an approved facility. Magnitude will be proportional to number of employees during construction (3,500 employees at peak).
Various activities	Solid waste: • various hazardous wastes	• Hazardous waste streams will be separated according to type (waste oils, paints, acid batteries etc.) on site and stored within suitable containment prior to transport off-site for disposal at an approved facility. Magnitude will be proportional to number of employees during construction (3,500 employees at peak).
Excavation	Solid Waste: • surplus soils • contaminated soil/sediment	 The Project will seek to re-use all suitable soil and rock generated during cut and fill operations. Project may encounter historic mine tailings on land or in marine sediments, containing high concentrations of contaminants. A preconstruction survey will be undertaken to confirm their presence/absence and used to develop an appropriate SBMMP.
Operation Phase		
Vehicle maintenance, operation & transportation	Emissions to Air: • dust & VOCs	 Temporary dust emissions to be controlled below regulatory guidelines by standard Best Management Practices. Minor emissions of VOCs. Magnitude will be proportional to number of permanent employees (approximately 200 employees).



Source	Туре	Description
Flaring, pressure relief valves	Emissions to Air: • CO, CO ₂ , SO _x NO _x , VOCs, PM, natural gas	• Emissions of combustion gases from infrequent planned and unplanned flaring. Emergency venting of natural gas from LNG tanks. Also some minor release of fugitive natural gas and refrigerants from leakage and very minor release of VOCs from POL & seal oils. Magnitude will be proportional to gross LNG storage volume of 690,000 m ³ total in three 230,000 m ³ tanks.
Incinerator	Emissions to Air: • SO _x	 Minor emissions of SOx if incineration of H₂S emissions from Acid Gas Recovery Unit are required.
Gas turbines	 Emissions to Air: CO₂, NO_x, CO,VOCs, PM 	Combustion emissions arising from operation of a 180 MW power plant and refrigerant compressor drivers.
Tugs	Emissions to Air:VOCs	Minor VOC emissions from fuel storage/bunkering.
LNG tankers	Wastewater: ballast water 	 Marine vessels conduct ballast water exchange operations offshore in accordance with Canadian, US and international guidelines. Some unexpected local release of ballast could occur. Expected magnitude relative to number of tankers per year (160 per year).
Wastewater treatment system	Wastewater: • treated sanitary/ domestic wastewater	 On-site plant for partial treatment of sanitary wastewater, followed by off-site disposal at an approved location. Magnitude will be proportional to number of permanent employees and total area of site (approximately 100-200 employees and 150 ha site).
Site runoff	Wastewater: sedimentation in runoff 	 Uncontaminated site runoff separated from potentially contaminated runoff and directed to pond/ ditch drainage system for "settling" and discharge directly into the environment.
Flaring and pressure release valves (all Project components)	Noise	 Infrequent unplanned loud noise production typically up to 110 dB(A) at the base of the flare and 145 Decibels (Unweighted) (dB(Lin)) for blowdown valves measured at 1 m from the source.
Operation of equipment	Noise	 Continuous noise emissions from rotating equipment, notably compressors and power generators. Noise modeling will be undertaken and suitable abatement measures implemented if required.
Various activities	Solid waste: • various non- hazardous wastes	 Solid non-hazardous waste will be separated into recyclable/ non-recyclable waste streams on site and stored temporarily within suitable containment prior to transport off-site for disposal at an approved facility. Magnitude proportional to scale of steady state operations and maintenance activities.
Various activities	Solid/ drummed waste: • various hazardous wastes	 Hazardous waste streams will be separated according to type (waste oils, paints, acid batteries, contaminated filters etc.) on site and stored within suitable containment prior to transport off-site for disposal at an approved facility. Magnitude proportional to scale of steady state operations and maintenance activities. Occasional truck movements of condensate will require disposal/ re-use off-site.



Source	Туре	Description
Accidental Events	-	<u>.</u>
LNG spills	LNG	• LNG releases due to loss of containment will result in rapid vaporization of liquid. Risks are therefore primarily to human safety and asset damage from fires/ explosions rather than directly to the environment.
Firewater	Wastewater: • firewater	• Firewater contaminated with entrained chemicals including fire extinguishant held within retention pond to restrict discharge to sea.
Spills (on land)	POL and other hazardous chemicals	 Potential for containment failure and accidental spills of minor volumes of POL and other hazardous chemicals. Risk to be minimized through bunding/double skinning of hazardous liquid containers, development of spill response plans and employee training.
Spills (in the marine environment)	POL and other hazardous chemicals	 Potential for marine accidents to release minor volumes of POL and other hazardous chemicals to sea. Risk to be minimized through implementation of TERMPOL recommendations and development of comprehensive contingency plan. Potential risk relative to number of tankers per year (approximately 160 per year).



3.6 Malfunctions and Accidents

3.6.1 Unplanned Events

The Goldboro LNG plant and marine terminal will be designed, constructed and operated in accordance with codes and standards specifically created for LNG facilities. This includes the requirements set out in the *Code of Practice – Liquified Natural Gas Facilities of the Nova Scotia Department of Energy* (NSDE, 2005). The Code has been developed pursuant to the *Nova Scotia Energy Resources Conservation Act*, the *Pipeline Act* and the Nova Scotia Gas Plant Facility Regulations. It intends to supplement both the requirements of the Nova Scotia Gas Plant Facility Regulations and CSA Z276, the CSAs LNG standard.

These codes and standards require the consideration of multiple levels of safety in the design, construction and operation of LNG facilities to reduce the risk of malfunctions and accidents to an acceptable level. Nevertheless, such unplanned events may occur during all phases of the Project. As part of the EA, the following potential accident and malfunction scenarios have been identified involving the land and marine environments:

- spill of fuels, lubricants, chemicals or hazardous material;
- fire;
- LNG leaks and fire;
- vessel collision;
- failure to properly exchange ballast water; and
- worker accidents.

To address, manage and respond to these events, environmental management plans with detailed emergency response plans will be developed for the Project and specific components and activities (Section 3.7). Further, as part of the Project development, potentials for malfunctions and accidents are being addressed throughout the planning and design process. As such the Pre-FEED Project design included comprehensive hazard identification (HAZID) and risk assessment studies (CB&I, 2013c and 2013d). These studies will be detailed during FEED (Section 3.6.3) and, as far as the marine components are concerned, in the context of the TERMPOL review process (Section 3.3.19).

Potential effects of the above scenarios on the environment (Valued Environmental Component (VEC)) are discussed in Section 10.17.

The text below provides a brief discussion of the LNG industry's safety record (Section 3.6.2). A brief discussion on accident scenarios associated with LNG leaks Pre-FEED efforts and considerations related to malfunctions and accidents is presented in Section 3.6.3 followed by a discussion of Pre-FEED HAZID and risk assessment (Section 3.6.4). A description of the other scenarios listed above is provided in context of the effects assessment in Section 10.17.



3.6.2 Background Information on the Safety of LNG Facilities

The LNG industry is regarded to have the best safety record of any of the energy industries. This was demonstrated by the 2008 study by Benjamin K. Sovacool, "*The costs of failure: A preliminary assessment of major energy accidents, 1907–2007*", Energy Policy 36 (2008). This study showed that the LNG industry proved to be the safest in the energy industry both in terms of social and economic costs in the past century.

This is further supported by a number of recent studies into LNG safety undertaken for the US Department of Energy (available at <u>http://www.fossil.energy.gov</u>) which includes amongst its conclusions that "Risks from accidental LNG spills, such as from collisions and groundings, are small and manageable with current safety policies and practices." (US Department of Energy, 2013).

3.6.3 Accident Scenarios involving LNG Leaks and Fires

3.6.3.1 LNG Properties and Behaviour

Release of cryogenic or low temperature hydrocarbon liquids due to spills, leaks, or intentional draining can expose facility personnel to several hazards. These hazards include oxygen deficiency and freezing injuries but the primary hazards are related to the flammability of LNG and the vapour clouds generated on release of LNG to the environment. These flammability hazards may be manifested as pool fires, flash fires, jet fires or vapour cloud explosions, although LNG spills rarely pose an explosion risk unless the vapour cloud generated by the spill occupies a confined space.

Leaks of cryogenic hydrocarbon liquids (i.e., LNG) from pipe work or equipment will rapidly boil on contact with warmer surfaces such as concrete or soil. The rate of boiling is rapid initially but decreases as the surfaces in contact with the liquid cools.

The gas evolved mixes with the surrounding air to form three types of mixtures:

- 1. Near the surface of the liquid, the mixture of gas and air will be too rich in hydrocarbons to burn.
- 2. A distance away from the liquid surface, the mixture of gas and air will be too lean in hydrocarbons to burn.
- 3. Between these two non-flammable mixtures, there is a flammable air-gas mixture. The flammable range of natural gas in air is approximately 5 to 15% by volume. Ignition of this mixture will result in a flame, which travels to the source of the gas. Released gas is safe from ignition only after it has diluted to a concentration below its Lower Flammable Limit.

Atmospheric water vapour will condense to form a white cloud or fog as the air and cold gas mix. The flammable air-gas mixture can exist inside or outside of the visible cloud.

LNG vapours will be heavier than air at temperatures of -107°C or below and will tend to spread out laterally along the ground rather than rise vertically. As the cloud warms above -107°C, its



density becomes less than air and the cloud will rise. The dispersion of the cloud depends on atmospheric and wind conditions as well as the rate at which the vapour is released or generated. Gas, at concentrations above its lower flammable limit can exist for a considerable distance from its source.

If a leak of LNG is ignited soon after onset of the release, then a pool fire will develop. The pool fire size is determined by the LNG release rate and the threats to persons or facilities are determined by the size distance from this fire. If ignition is delayed, a LNG vapour cloud will develop and disperse as it expands and/or moves downwind. This cloud could then be ignited in an area remote from the release point where the vapour cloud concentration is still at or above the lower flammable limit of five percent vapour. If the cloud was ignited, it would burn back to its source. As a result, two exclusion zones are required for LNG facility siting; a vapour dispersion exclusion zone and the thermal radiation exclusion zone. The CSA Z276 standard provides the criteria for design releases that take into account the worst potential incidents. The boundaries of the exclusion zones set by the code put restrictions on occupancies and activities permitted within them.

Natural gas has a characteristic relatively low reactivity and low burning speed. Because flame speeds in unconfined natural gas clouds (about 4 to 10 m/s) are far below those that would produce dangerous overpressure unconfined clouds of natural gas generated by an outdoor leak or LNG spill present little danger of explosion. In addition, natural gas is lighter than air and quickly dilutes into the surrounding air forming an air-gas mixture below its lower flammable limit.

Natural gas presents the greatest safety risk when gas leaks or LNG spills occur in confined areas. Confinement, such as an enclosed compressor building, can allow flammable vapour to accumulate and increases the possibility of ignition and the risk of localized damage. Once ignited, pressure will build in the enclosed area; however, flame speeds decelerate rapidly beyond the boundaries of the confinement and limit the extent of potential damage and injuries. The risk of explosion in a confined space is minimized by providing good ventilation in structures that contain or possibly contain natural gas. Ventilation allows the naturally rising natural gas to escape and dilute below its flammability range. Gas detection will initiate direct control to limit release duration and prevent ignition of the release leading to fires and explosions.

Natural gas produced from LNG is odourless. The sense of smell should not be relied upon to detect the presence of natural gas. Odourizer is typically only added just inside battery limits of the regassification process on the natural gas send-out pipeline. For this reason, fixed and potable combustible gas detection equipment is provided within the natural gas and LNG process and handling areas.

LNG leaks or releases do not leave any residues and do not cause long-term environmental impacts like oil spills. As such, accidental LNG leaks and releases do not require environmental clean-up. Consequences are limited to short term impacts to flora, fauna and humans in the immediate neighbourhood of the release and within site boundaries, mainly as a result of low temperature.



This Project will be consistent with the requirements of The LNG Code of Practice which has been found to be based on the requirements of CSA Z276-01, "*Liquefied Natural Gas (LNG)*-*Production, Storage and Handling*" and on NFPA 59A "*Standard for the Production, Storage and Handling*" of *Liquefied Natural Gas (LNG)*". Where differences exist between the CSA and NFPA Codes the more conservative requirement will generally be adopted. In the event that the less conservative requirement is adopted then a safety case evaluation shall be developed to justify the decision. Current revisions of both the 2011 edition of CSA Z276, and the 2013 edition of NFPA 59A will be used.

The CSA Z276 standard provides the criteria for design releases that take into account the worst potential incidents. The boundaries of the exclusion zones set by the code put restrictions on occupancies and activities permitted within them.

Other hazards such as lack of oxygen and low temperatures would occur in the immediate area of the LNG release and will be confined to the site. These hazards extend to distances much less than the exclusion zones required by the CSA.

3.6.4 Pre-FEED Hazard Identification (HAZID) and Risk Assessment

During Pre-FEED design development CB&I developed the health, safety and environmental protection philosophy for the Goldboro LNG (CB&I, 2013d). The document explains how health, safety and environment (HSE) protection have been and are going to be addressed in subsequent design stages. A key aspect of this philosophy is the full integration of health, safety and environmental considerations into all aspects of the design, including materials, process and equipment selection, and site and layout choices.

As part of the HSE Philosophy, a HAZID study was undertaken. The aim of the HAZID study is to methodically identify the Project hazards and the defences (avoidance, prevention, control & mitigation measures) in place against those hazards. Actions identified are assigned an owner who is responsible for the action and resolution thereof. Due to the early nature of the design phase, many of these items have been placed on the FEED Contractor so as to ensure that these are not overlooked as the Project develops.

The Pre-FEED HAZID work also included a Gas Dispersion Analysis Report (CB&I, 2013e). The report analyzed four principal hazards arising from storage and use of hydrocarbons (both gas and refrigerants) on the liquefaction plant:

- flammable gas clouds from leaks producing a flash fire on ignition;
- pool or jet fires generating high thermal radiation on structures, process plant, buildings or people;
- explosion overpressures from ignition of a flammable gas cloud in a congested region of the facility; and
- Boiling Liquid Expanding Vapour Explosion (BLEVEs) arising from failure of a vessel containing a pressurized liquid above its boiling point.



The purpose of the accident consequence modelling described in this report in support of the overall Project planning was to:

- Determine if CSA Z276/NFPA 59A requirements regarding thermal radiation protection distances and flammable vapour clouds could be met by the proposed facility design, at the proposed site.
- Provide hazard analysis results that might be of assistance to the general layout of the facility.

The thermal radiation and vapour dispersion calculations have been prepared in compliance with the code requirements of CSA Z276 LNG - Production, Storage, and Handling, and referenced Codes, notably NFPA 59A. The code requires that the lower flammable limit and thermal flux levels be modeled. The lower flammable limit is the lower flammable limit at which natural gas will ignite and burn (approximately 5% by volume for natural gas in air) in the presence of an ignition source. Ignition can occur at concentrations between 5% and 15% in natural gas and would result in a flame front that travels to the source of the gas. The code requires that the vapour dispersion be modeled for each scenario to the lower flammable limit.

The thermal flux level is a measure of radiant heat. The code requires that thermal flux (i.e., radiant heat) be modeled to TFLs of 5 kilowatt per square metres (kW/m^2), 9 kW/m^2 and 30 kW/m^2 . The characteristics of these various flux levels are:

- 5 kW/m² a second degree burn can occur on exposed flesh after 30 to 60 seconds exposure;
- 9 kW/m² wood will auto-ignite after prolonged exposure to radiant heat in this range, but equipment damage is unlikely; and
- 30 kW/m² wood will auto-ignite quickly and damage will occur to equipment.

Using these characteristics, the code prescribes exclusions for various land uses.

In addition to satisfying the mandatory LNG code requirements, the proximity of process equipment has also been considered. The effects of LNG spills both in the form of thermal radiation (or flux) and vapour dispersion have been calculated using software acceptable to the requirements of CSA Z276-01, (i.e., PHAST v5.7).

The hazard evaluation is based on a plant design featuring full containment LNG storage tanks and fully welded hydrocarbons service pipe work, thus minimising the potential for leaks of flammable fluids. The following cases have been considered in the Pre-FEED design and the associated HAZID and Risk Assessment:

3.6.4.1 Thermal Radiation

- Natural Gas release from the process piping in the gas seception area assuming a 60mm hole as per CSA Z276-01 Table 2 (Design Spills).
- Ten minute LNG release from a 60 mm leak in the rundown line piping within the liquefaction area that could occur during plant operation. The assumption is that the



liquefaction plant will be shut down after 10 minute from commencement of the spill. Spilled LNG will be channeled from the process area floor to an impoundment sump where ignition may occur.

- LNG release from the storage to ship transfer piping, assuming a 60 mm hole. The assumption is that the transfer pumps will be shut down after ten minutes from commencement of the spill. Following pump shut down the LNG contained in the transfer piping will also spill out of the transfer pipe. All spilled LNG will be channelled into a sub impoundment sump where it will later ignite.
- Thermal radiation at the property line and adjacent tanks, as a result of an ignited discharge from the LNG storage tank relief valves.
- Thermal radiation at property line, adjacent tanks and other equipment, as a result of a 60mm leak and fire from refrigerant (ethane and propane) make up lines from refrigerant storage to the liquefaction area.

3.6.4.2 Vapour Dispersion

- Natural gas release from the process piping in the gas reception area assuming a 60 mm hole as per CSA Z276-01 Table 2 (Design Spills).
- Natural gas release from the process piping in the liquefaction train area assuming a 60mm hole.
- Refrigerant (propane) release from the process piping in the gas reception area assuming a 60 mm hole.
- Ten minute LNG release from a 60 mm leak in the rundown line piping within the liquefaction area that could occur during plant operation.
- Ten minute release into spillways and sub-impoundment resulting from the largest design spill (60 mm hole) within the LNG storage tank area.
- Propane release from the make up piping from the refrigerant storage area to the liquefaction train area assuming a 60 mm hole.

The hazard assessment has demonstrated that the fire impacts from all the design basis accidents considered are within the confines of the plant boundary and meet the requirements of CSA Z276 Table 1. The hazard assessment has also demonstrated that the flammable vapour clouds that could be generated by a design basis release down to a gas concentration of 50% lower flammability limit or less are confined within the plant boundary or the area of the pipe track immediately to the east of the eastern plant boundary fence that would constitute an area where no building would be permitted. The fire and dispersion calculations were based upon initial estimations of the likely locations of critical plant items and with no allowance for equipment layout adjustment or additional mitigation measures that might be put in place to minimize the magnitude or probability of leaks once FEED development of the plant design commences;

The gas dispersion analysis report therefore indicates that all risks can be mitigated to an acceptable level and in accordance with CSA Z276 (CB&I, 2013d). The analysis represents the first step in quantifying consequences of accidental scenarios. Further quantitative analysis of thermal radiation from fires, explosion overpressures and the potential for BLEVEs covering



both the onshore process facility and the marine loading facility will be carried out during FEED to ensure compliance with CSA Z276.

3.6.5 Hazard Management System

Based on the Pre-FEED HSE Philosophy, the Project will adopt a hazard management system which operates as follows:

- systematically identify HSE hazards, using HAZIDs, Hazards and Operability Analysis (hazards analysis techniques for systems, hardware, and procedures) (HAZOPs), Hazards in Construction (HAZCONs), technical reviews, etc.;
- eliminate hazards where practicable;
- provide suitable measures to prevent, detect, control or mitigate hazards that cannot be eliminated;
- provide adequate means for personnel escape, temporary refuge and recovery from major accidents;
- evaluate risks to personnel via qualitative or quantitative risk assessment; and
- assess the benefits of identified risk reduction measures.

Engineered equipment and systems shall be provided within the plant with the objective of:

- preventing the occurrence of hazardous events;
- controlling and terminating accident events should they occur; and
- protecting persons, both on and off site, from the impacts of an accident event should it occur.

At this point in the design process, the principal systems identified and to be provided for this purpose are:

- fire, gas, and leak detection systems to detect and alarm of the presence of flammable vapour in air as the result of an accidental release;
- spill control systems to capture and safely contain spills and leaks of flammable liquids including cryogenic fluids;
- fixed, mobile, and portable firefighting equipment to protect personnel, equipment, and facilities in the event of a fire in the facility;
- passive fire and cryogenic spill protection systems to protect critical plant structures and equipment in the event of fires or cryogenic liquid spills;
- blast resistant buildings and structures to protect personnel and preserve critical systems in the event of a gas cloud explosion;
- clearly defined, unobstructed, and illuminated escape routes to places of safety throughout the plant covering all areas where personnel may be located during plant operation;
- elimination of potential ignition sources from all areas where flammable gas releases could occur during normal operation or as a result of accidental leaks;
- security systems including site access control;



- oily waste water, domestic waste water and drinking water treatment facilities;
- on site permanent waste handling/storage equipment;
- on site permanent environmental and emissions monitoring equipment; and
- plant emissions and discharges register.

Engineering design reviews of temporary construction HSE facilities will also be performed.

It is of note that the Project will be designed such that risk levels at the boundary would not necessitate any restrictions on land use there. As a matter of good planning and design practice, it would not be recommended to locate either a very sensitive 'risk receptor' such as a primary school or a high risk facility, such as an explosives factory, immediately adjacent to the plant. Otherwise a low to medium risk industrial facility could be sited 'next door' without the need for any additional protective measures.



3.7 Health, Safety and Environmental Management

Good HSE performance is critical to the Project. To establish specific HSE objectives and ensure their implementation, the Project will include a comprehensive HASP and an EMP. The latter will also entail contingency and emergency response plans.

A detailed emergency response plan for the Project will be developed and implemented as part of a regionally coordinated approach to emergency preparedness and response. Consultations will be conducted with the local fire department as well as other local and provincial authorities prior to the finalization of the emergency response plan and start up of the facilities. This plan will be developed in accordance with all relevant provincial requirements for emergency response plans.

Further, inherent to the Project design will be numerous environmental management features. They are the result of a design philosophy with full integration of HSE considerations into all aspects of the design, including materials, process and equipment selection, as well as site and layout choices. Hazardous area classification is a key component of this and is inherent within the electrical design approach. The objective of which is to reduce to an acceptable level the probability of coincidence of a flammable atmosphere and an ignition source.

3.7.1 Public and Worker Health and Safety Plan (HASP)

A HASP will be developed for the site that will cover all phases and elements of the LNG Project. The HASP will be developed by a health and safety professional to ensure adequate precautions are taken for the protection of workers and the general public. The HASP will be modified over the life of the Project as new information becomes available for improved worker protection. The objectives of the plan will be to:

- define activities which are likely to represent risks to worker safety and health, requiring planning, design, inspection or supervision by an engineer, competent person (as defined by regulations) or other professional;
- identify worker and public protection measures;
- establish supervisor and employee training requirements according to the Project plan including recognition, reporting and avoidance of hazards, and knowledge of applicable Standards and the Project-specific HASP;
- provide general guidelines for controlling the most commonly identified hazardous operations, such as: cranes, scaffolding, trenches, confined spaces, hot work, explosives, hazardous materials, leading edges, etc.;
- identify hazards and preventive measures that are implemented in a timely manner;
- provide a process for reporting near-misses and accidents;
- implementation of WHMIS procedures and training;
- establish Project-specific emergency response plans;
- define the requirement for a designated competent person responsible for and capable of implementing the program/plan; and
- establish a communications plan to provide preventative and emergency information to the general public.



Each contractor, sub-contractor and consultant retained for the Project will be required to submit for review, a Project-specific HASP for its workforce, and will be responsible for its implementation. Audits will be completed to ensure compliance with the Project-specific HASP.

3.7.2 Environmental Management Plan (EMP)

To make sure that the protection of the environment is managed effectively, a comprehensive EMP will be developed to communicate to all Project participants and stakeholders the commitment and efforts to be undertaken to prevent, manage and minimize any potential environmental impacts related to the Project.

The EMP will be developed for the construction, operation and decommissioning phases, and will be the principle component to safeguard that mitigation is implemented as directed by all applicable regulatory requirements with a particular purpose to:

- support the Project's commitments to minimize environmental effects;
- document environmental concerns and appropriate protection measures; and
- provide instructions to relevant Project personnel regarding procedures for protecting the environment and minimizing environmental effects.

The Project will involve a wide range of activities necessitating the implementation of mitigation measures that will be developed as the Project proceeds. All mitigation recommended in the EA, as well as any regulatory requirements, or conditions of permits/approvals, will be implemented via the mechanisms outlined in the EMP. The EMP will also provide implementation guidelines to help ensure compliance with the monitoring and follow-up commitments and requirements identified through the environmental assessment process.

The EMP represents Project-inherent features and procedures and, together with the Environmental Management Features (Section 3.7.3) and Project Description (Section 3.0), serves as the basis for the effects assessment. Where required and applicable, the effects assessment supplements the EMP with more detailed or new mitigation and environmental management measures. Key components and minimum content and subjects of the EMP are summarized in Table 3.7-1. Pieridae is committed to elaborate on and detail the EMP prior to commencement of the construction phase based on the outcome of the regulatory review and approval process and the final Project design.

It is of note that the EMP is considered a dynamic "living" document that will continuously require revision due to site activities, adjustments to the approach, changes in legislation, monitoring results, etc. It will be incumbent on the Proponent to make sure that routine reviews of the document are completed and that the contents remain current over the entire length of the Project.



EMP Components	Key Content and Subjects (Minimum)		
Definition of roles and responsibilities.	 Overall Project management structure. Safety Health and Environmental Coordinator. Contractors. Other staff. 		
General and site-specific EMP components.	 General EMP: Risk Management Plan (RMP) (incl. tailings management). SBMMP. Waste management plan. WHMIS implementation. Hazardous material management (transportation, handling, storage; incl. designated storage areas). Blasting activities. Equipment maintenance and fuelling. Material storage (incl. designated storage areas) and handling. Work yard development. EMPs for specific site locations / facility components: Marginal wharf. Construction camp. Watercourses (crossings & diversions). Wetlands. Water intake facility (Meadow Lake) and associated pipeline. Water treatment facility. 		
General and site-specific EPP components.	 Clearing and grubbing. Stormwater management. Wastewater management. Erosion and sediment control plan. Work in/near watercourses. Work in/near marine environment. Dust control. Noise control. 		
Environmental Effects Monitoring (EEM).	 Air quality. GHG emissions. Facility lighting / bird strikes. Groundwater resources (including wells). Surface water quality. Marine water quality. Flora species of special status. Wetland. Marine habitat (if required). Archaeological construction monitoring and contingency plan. 		
Environmental Compliance Monitoring (ECM) / Inspections.	Effluent quality and quantity.Wastewater discharge quality.Noise levels.		

Table 3.7-1	Environmental Manage	ement Plan (EMP)
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EMP Components	Key Content and Subjects (Minimum)
Environmental Inspections and Quality Assurance/ Quality Control.	Government and proponent inspection.Proponent inspector training.
Environmental Audits.	 Key impacts of Project. Evaluation of Project against environmental policies (internal). Documentation. EMP and HASP documents and updates. Employee awareness of environmental issues.
Contingency and Emergency Response Planning (Operational Emergencies and Natural Events).	 Generic: Emergency Response Plan. Hazard analysis and risk determination. Project-specific policies and procedures for events such as: fires; explosions; spills; transport accidents; equipment malfunctions; and severe weather. Minimum plan requirements (prevention, preparedness, equipment, response, recovery/clean up). Marine jetty (including LNG loading). Vessel operation (e.g., arrival/departure; mooring; hotelling; refuelling). Marginal wharf (e.g., tug and pilotage vessel operations). Power plant. LNC starspone
	 Ling storage. Liquefaction trains (including flares).
Training and education.	 Inspection staff training. Health and safety training (see HASP). Emergency response training (re.: fire, spills, explosions etc). WHMIS training. Handling and storage of hazardous materials. Environmental management / awareness training. Archaeological awareness and sensitivity training.
Communications and reporting.	 Document control (distribution and updating of EMP). Public information and communication. Reporting (environmental report with summ.ary of monitoring results and compliance audits report).

3.7.3 Environmental Management Features

The Project design includes a series of design features and implementation protocols to avoid, minimize and remediate adverse effects and minimize risks. These environmental management features are planned, pre-emptive measures developed from experience and based on good design practice and in anticipation of likely site conditions and effects. Together, with the EMP and the Project description (components, construction phase, operation phase and


decommissioning phase), this information serves as the basis for the effects assessment. Where required and applicable, the effects assessment supplements the environmental management features with more detailed or additional mitigation and management measures. These additional measures are identified in the context of the effects assessment for individual VECs (Section 10.0). An overview of mitigation and environmental management measures is presented in each effects assessment of Section 10.0. Pieridae's commitments to mitigation and monitoring are summarized in Section 12.0 and Section 14.0 respectively.

Key environmental management features that have been included in the conceptual Project design (Pre-FEED design) are presented in Table 3.7-2. For engineering and design considerations specific to the Project's hazard management system refer to Section 3.6.4. It is of note, that the environmental management features will be refined and expanded during the ongoing Project design stages.

Environmental Management Feature	Description	Objective	
Surface water management systems; site drainage infrastructure (construction, operation, decommissioning phases).	 On-site stormwater management system including retention pond, if necessary. Oil/water separators. If required, a controlled outlet structures with monitoring point. 	 To limit post development site-runoff to pre-development levels. Monitoring of effluent quality. To provide shut down mechanism in case of emergency (spill containment). 	
On-site wastewater treatment facility (construction, operation, decommissioning phases).	 Wastewater collection system. On-site treatment facility for wastewater stream. Controlled outlet structures with compliance monitoring point. Shut down mechanism (spill containment). 	To prevent discharge of untreated wastewater to receiving water bodies. To allow for monitoring of effluent quality and shut down. To contain potential spills and mitigate impacts to the receiving environment.	
Hazardous waste management system (construction, operation, decommissioning phases).	 Designated storage location(s) for hazardous materials. 	Compliance with national policy. Control of hazardous materials used in the operation of the LNG facility.	
On-site emergency response unit and systems.	 On-site emergency response unit equipped and trained to address fires, explosions, spills, and hazardous material management. Fire water supply system. Process control and ESD protocols. Field telephone, general alarm equipment. Emergency escape lighting. Regular drills to practice emergency team response time. 	 Immediate response in case of emergencies. Provide multiple systems for emergency management. Prevent potential loss of life and impacts to the environment. Proactive management of emergency response teams. 	
Spill prevention and response system.	 Motion sensors in LNG loading arms. Automated disconnection / shut off loading mechanism. Emergency valve shutdown in case of loss of power or key input signals. Sectionalise gas and liquid inventories to limit the quantity of material released on loss of containment. LNG spill containment wall. Secondary containment for all on-site fuel storage /filling areas. 	 Prevent exposure for workers, public and the receiving environment. Provide backup systems and control systems for power loss. Multiple systems for containment of LNG in the event of a site wide incident. 	

 Table 3.7-2
 Key Environmental Management Features



Environmental Management Feature	Description	Objective	
Uninterrupted power supply.	 Emergency power system. Automatic power transfer of essential services. 	 Help protect against extreme weather events where loss of power could have created an incident. Prevent an automatic shut down of the LNG facility. 	
Air quality/emission controls.	 Emergency pressure valves. Flare systems to incinerate fugitive gaseous emissions. Flares designed to produce minimal smoke. High efficiency (98%), low noise flare tip. Flare, vent, and drain systems are segregated in case of individual failure. Flare gas metering. Flare gas monitoring point. Selective catalytic reduction post engine technology (to control NO_x emissions for marine diesel engines). 	 To minimize air emissions. To prevent worker, public and environmental exposure to air emissions. To minimize the contribution of the Project to acid gases. To provide compliance reporting on emissions to regulators. To provide chemical characterization of the emissions from the LNG facility. To provide chemical emission rates for the LNG facility. 	
Energy efficiency (GHG management).	 High energy conversion efficiency technology (power plant). Computerized combustion controls. Waste heat recovery units for process or space heating. 	 Minimize the Project contribution to GHG. High temperature combustion minimizes the by-products (benzene, CH₄, CO) and provides cleaner by-products. Cogeneration (combined heat and electrical processes) minimizes the LNG carbon footprint. 	
Noise abatement.	 Mufflers at high noise machinery. Housing of equipment in enclosures with insulation (combined with winterisation). 	Limit the occupational exposure for workers to noise in the LNG facility. Limit exposure to off-site receptors. Limit the exposure of wildlife to noise from the LNG facility.	
Erosion control features (construction and decommissioning phases).	Erosion and sediment control plans to prescribed soil stabilization requirements, silt fences, sediment traps etc.	 Avoid soil erosion and increased sedimentation loadings in freshwater and marine environments and to prevent transfer of contaminated soils and sediments off-site. 	

3.7.4 Adaptive Management

An adaptive management process will be followed to ensure a continuously safe, environmentally sound, and economically efficient facility operation. Adaptive management is typically applied to manage uncertainty and to provide a mechanism for learning and adaptation in Projects dealing with complex natural systems.

As described in Section 3.7.2 and Section 3.7.3, a number of monitoring, inspection, and auditing mechanisms will be in place to review the accuracy of the effects predictions, the effectiveness of the environmental controls and the compliance with applicable Project objectives, standards, guidelines, and policies. The adaptive management process guarantees that corrective action will be taken when deficiencies in the Project implementation are identified. It also ensures that the Project benefits as knowledge of the site advances.



Adaptive management will be applied throughout all phases of the Project and in particular with regard to the mitigation measures. As soon as monitoring identifies that mitigation measures are not performing satisfactorily, the adaptive management process will guide its improvement or replacement in conjunction with adaptive management practices in the Project Operations Plan. Key steps in the process encompass:

- identification of non compliance/ underperforming mitigation measure;
- evaluation of significance;
- analysis of cause;
- identification and evaluation of possible corrective actions;
- implementation of corrective action; and
- monitoring of effectiveness of corrective action.

Criteria and parameters applied in the identification of non-compliance are discussed in the individual effects assessments and associated discussion of monitoring and follow-up measures (Section 10.0 and Section 12.0).



3.8 Workforce and Capital Expenditure

3.8.1 Workforce

3.8.1.1 Construction

An estimate of total workforce during major stages of construction is presented in Table 3.8-1 below.

Year	Activities	Employees
2015	Mobilisation, Site Preparation, Early Civil Works	550
2016	Civil Works (Foundations, Buildings, Underground Services)	2,800
2017	Module Installation and Hook-Up, Associated Mechanical, Electrical & Instrumentation	3,500
2018	Module Hook-Up, Electrical & Instrumentation, Commissioning	2,700
2019	Commissioning, Hand-Over, Demobilisation	400

3.8.1.2 Operation

The current operations manpower assumption is based on two 12 hours day and night shifts staffed by three crews. Each crew will work a six days on and three days off pattern.

It is anticipated that a total of approximately 140 operations, maintenance and management personnel will be required to operate and maintain a single LNG Train (Phase 1) all year round on a rotational basis. This number would be expected to increase by 36 to operate and maintain Phase 2. Therefore, for the proposed Facility (Phase 1 and Phase 2) the combined workforce represents 176 operations, maintenance and management personnel.

It is expected that the plant general manager will be supported by an organisation that includes the following:

- administration manager;
- safety & security manager;
- operations and maintenance manager;
- environmental manager;
- training manager; and
- medical services.

All workforce requirements will be refined during FEED and subsequent Project development.

3.8.2 Capital Expenditure

Current estimations value the capital expenditure of the Project at approximately \$8.3 billion (CDN Dollars). This includes all works from the commencement of detailed design through to commissioning completion works. This value is a Quarter 1 2013 estimation, to an accuracy of $\pm 40\%$ and no allowance for forward escalation, exchange rate variations, insurance etc., have been made within this amount.



3.8.2.1 Procurement Approach

Design development at times shall be driven by constraints imposed by the required lead times of specialist items. Such items are commonly denoted as Long Lead Items and the design of these items shall be expedited to allow for early order placement so as not to affect the overall Project schedule, examples include the MCHE and refrigerant compressors. Market competition at time of order enquiries and placements for both equipment and Fabrication Yards shall be subject to detailed analysis during the FEED development.

3.8.2.2 Local Spending

It will be important to work closely with the local communities to ensure the Project does not create any negative impacts on the surrounding areas due to the potential impact that a Project of this size can produce.

The key Project target would be to leave local communities in an equivalent or better position than before the Project began. This Project can impart value to the community by providing employment to local personnel, offering training programs, involving local businesses in the Project, and providing community services, among other activities. Some examples of community services include non-profit organizations, volunteer services, planned community events, charitable works and adopt-a-school programs.

The construction phase shall involve specialised construction capabilities, self-performing work by contractor and letting of works to be subcontracted to local, or specialist international contractors.

Subcontractors would be utilised for specialty works or where there is a major cost and/or schedule benefit to the Project, such as the following areas:

- site preparation including clearing and grubbing, bulk earthworks and roads and drainage;
- jetty and MOF installation;
- civil works including piling (if any), excavation and backfill, foundation works, grouting and LNG tank concrete works;
- module fabrication works Pre-Assembled Units, Pre-Assembled Racks and buildings;
- buildings including supply and construction of warehouses, administration buildings, etc.;
- insulation and coatings including fireproofing, pipe and equipment insulation;
- electrical and instrumentation including cable installation, instrument installation, loop checking and pre-commissioning works; and
- module shipment, heavy haul and transport.